The Vocabulary and Style of Engineering Research Abstract Writing

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Students in the Advanced Faculty of Engineering (*senkoka*) at colleges of technology (*kosen*) are required to write their graduation thesis abstracts in English; likewise, they are encouraged by their advisors to submit English research abstracts to overseas conferences to present their research. However, although many *senkoka* students have a large English vocabulary, they are often unaware of writing styles and phrases used in research paper and presentation abstracts by particular engineering fields. In this paper, I will share findings from a pilot study that investigated the vocabulary levels and writing styles of abstracts written by *senkoka* students at one *kosen* compared with that of online engineering research abstracts from IEEE conferences. Results showed that students knew many difficult, low frequency words but experienced a gap in vocabulary knowledge among easier, higher frequency words. On the other hand, online published presentation abstracts relied more on high frequency words with a steady decrease in low frequency technical vocabulary. When online abstracts were analyzed based on a division of engineering disciplines into the three fields of chemical engineering, electronics and information engineering, and mechanical engineering, field-specific writing patterns were discovered in the structure of the abstracts.

Introduction

"What does an abstract look like?" may seem like an innocuous question to the average English as a Foreign Language (EFL) teacher; however, abstract writing can indeed prove a challenge to novice writers working in a foreign language. Typical EFL writing classes for university-level students focus on paragraph writing, starting with the topic sentence, supporting sentences, and concluding sentence. However, the abstract may not necessarily follow the same paragraph rhetorical pattern. How, then, should one teach abstract writing to EFL students? One possible solution is to focus on the kind of abstract writing expected of the EFL students by the target academic discipline. In other words, focus on generic characteristics (Swales, 1990) in an English for Specific Purposes (ESP) context may prove most salient for EFL instructors.

The student population in the present study was a group of second year *senkoka* (advanced faculty of engineering) students studying a combination of mechanical and systems engineering at a college of technology (*kosen*) in central Japan. *Senkoka* students are required to write engineering research abstracts, but not the entire graduation thesis, in English, as part of their bachelor's degree graduation requirement. Although second year *senkoka* students are roughly the same age (e.g., 21-22 years old) as typical fourth year undergraduates, *senkoka* students are capable of graduate-level research due to the specialized coursework required at the *kosen*. *Senkoka* students are also encouraged to accompany their research advisors on overseas research trips and often present their research at overseas conferences in English, usually as an individual poster presentation. Thus, *senkoka* students are asked by their advisors to write research abstracts in English for this purpose.

Previous research (Apple, 2012) found that *senkoka* students typically knew roughly 70% of the first 3000 words of English and had an average overall English vocabulary of approximately 8000 words. However, students generally knew more low-frequency vocabulary words that occur at the 7000- to 8000-word level than relatively higher frequency words at the 4000- to 5000-word level. Whether this sudden increase in low-frequency word knowledge around the 8000-word level would help or hinder the writing of engineering abstracts for international engineering conferences was unknown. The purpose of this study was therefore to examine not only the style of abstracts *senkoka* students might be expected to write for an overseas conference, but also the degree to which their vocabulary knowledge matched that needed for such abstracts.

Academic Abstract Writing Models

A general academic abstract style based on analysis of journal abstract writing instructions was suggested by Borko and Chatman (1963). This has led to the conception of two basic types of abstracts: informative and descriptive.[2] The descriptive abstract works as a brief summary without mentioning specific results: science and engineering students are cautioned to "actively avoid" using it (Silyn-Roberts, 2013, p. 56). Informative abstracts, on the other hand, typically include a brief explanation of the reason for the study, the problem the study addresses, the method used to collect data, the results or observations, and implications or recommends for the future (The Writing Center, 2012). This

Table 1
A Comparison of the Moves in the IMRD Model and the CARS Model

Move	IMRD	CARS
1	Introduction	Establishing the territory
1a		Claiming centrality, and/or
1b		Placing your research within the field, and/or
1c		Reviewing previous research
2	Methods	Establishing a niche
2a		Counter-claiming, or
2b		Indicating a gap in previous research, or
2c		Question-raising, or
2d		Continuing a tradition
3	Results	Occupying the nice
3a-1		Outlining the purpose, or
3a-2		Announcing present research
3b		Announcing principle findings
3c		Indicating article research structure
4	Discussion	

style corresponds to the style generally used for scientific papers, the well-known introduction, method, results, and discussion model (IMRD).

Abstract writing may also follow a different model known as "create a research space" or "CARS" model, which was originally posited to represent a well-written academic paper introduction section (Swales, 1990; Swales & Feak, 2001). The CARS model comprises three main segments, or "moves," each of which may consist of several separate steps. The moves of CARS are usually labeled "Establishing research territory," "Establishing a niche," and "Presenting present research." Unlike the IMRD model, CARS virtually ignores research methodology and discussion of the significance of the findings, focusing instead on the importance of the study in the context of the specific research field or discipline (Table 1). Previous studies (e.g., Lores, 2004) have discovered the use of both the IMRD model and the CARS model in humanities and social science abstracts.

Science and Engineering Abstract Analyses

The few extent papers regarding genre analysis of science and engineering abstracts have typically been carried out to determine the degree to which the abstracts fit a pre-determined structure. For example, about half the medical journal abstracts analyzed in one study were deemed "well-structured," and deviations from the expected IMRD norm were labeled "discoursal flaws" (Salager-Meyer, 1990/2009). Partially as a result of such analysis, medical research journals introduced the so-called "structured abstract," which forced authors to use IMRD-style subsections and headings in abstracts (Hartley, 2004). In fact, science and engineering researchers are generally advised to conform to the IMRD model for abstracts, and for the paper as a whole. Engineering researchers who seek publication by the largest academic society in the world, the Institute of Electrical and Electronic Engineers (IEEE), have been advised to include five sections in their paper abstracts: (a) context, (b) problem addressed, (c) methods, (d) results, and (e) conclusion (Pierson & Pierson, 1997, p. 303). These five sections roughly correspond to the traditional IMRD structure of a research paper.

On the other hand, science and engineering university students in North America have been given conflicting advice. For example, computer software engineers studying at Carnegie Mellon University have been advised to consider: (a) motivation for the work, (b) problem to be solved, (c) approach of the research, (d) results of the study, and (e) conclusions, implications, and generalizability (Koopman, 1997). Meanwhile, students majoring in astrophysics and mechanical engineering at Rensselaer Polytechnic Institute are told to include: (a) objective, (b) methods, (c) results, and (d) conclusions, but not to include a literature review. Indeed, students are advised to avoid any reference whatsoever to previous research studies and to highlight the objectives and results of their own studies. This last piece of advice even suggests that the very first sentence of the abstract should start with the phrase "This paper" or "This study" (The Center for Communication Practices, n.d.).

However, the question of the extent to which professional engineering abstracts actually follow the above recommendations remains. While studies of second language (L2) academic abstracts are plentiful, such studies have typically focused on specific language, such as evaluative speech acts, subjective language, and personal judgments (Stotesbury, 2003); verb usage (Salager-Meyer, 1992), and relative pronoun clauses used to signal authorial stance (Hyland & Tse, 2005). The present study focuses specifically on engineering abstracts written for engineering conferences, to which *senkoka* students from Japanese *kosen* typically apply in the hopes of presenting their research to an international audience. The paper intends to answer the following questions:

1. Do Japanese *senkoka* students possess adequate vocabulary to produce professional engineering conference abstracts?
2. What, if any, stylistic differences exist among abstracts in the three disciplines of engineering related to the *senkoka* students' programs of study?

Methods

Data Collection

Data collected for this study came from two sources: *senkoka* students and online abstracts from engineering conferences.

Student data. The study comprised 15 *senkoka* students (all male)[3] in their final year of the two-year *senkoka* program at a *kosen* in central Japan. All 15 students had studied English and were taking Presentation in English, an elective skills-based course that focused on engineering presentation design and practice. The instructor (the researcher in this study) had previously taught the same students in two previous years of the main five-year program of the same *kosen*. The average combined TOEIC score of students was 535, with a low score of 400 and a high score of 755. Thirteen of the students were enrolled in the advanced mechanical engineering program, which combined aspects of mechanical design and systems control engineering. Two were enrolled in the advanced electronic and information engineering program, which combined aspects of electrical systems, electronic design, and computer programming. Two mechanical engineering students gave permission for their abstracts to be analyzed for this study.

Selecting engineering abstracts. For the purposes of this paper, the first step was to identify abstracts that were written by researchers in approximately the same engineering disciplines as the *senkoka* students. From the online proceedings of eight conferences held in 2010 by the Institute of Electrical and Electronics Engineers (IEEE), 139 abstracts were selected at random. The abstracts were written by researchers based in 34 different countries and were freely available through the IEEE Explore web site (http://ieeexplore.ieee.org/). Because the *senkoka* at the *kosen* in the study was divided into three main study disciplines of chemical engineering (C), electronic and information engineering (EI), and mechanical engineering (MS), only abstracts related to those three disciplines were selected. There were a total of 40 chemical engineering abstracts, 50 electronic and information abstracts, and 49 mechanical engineering abstracts.

Analysis Used

The data were analyzed in two ways. The first analysis compared the vocabulary size of the 15 *senkoka* students to the vocabulary frequency levels present in the 139 abstracts. A genre analysis was then used to examine the structure of the abstracts.

Vocabulary analysis. Vocabulary levels were measured in two ways. Student levels of vocabulary knowledge were measured by implementing the original Vocabulary Size Test (VST, Beglar & Nation, 2007). The VST comprises 14 levels of vocabulary knowledge based on the British National Corpus (BNC) and is available as a free download (http://www.victoria.ac.nz/lals/about/staff/publications/paul-nation/Vocabulary-Size-Test-14000.pdf).

Vocabulary from the online conference abstracts in this study was examined using the AntWord profiler program and the AntConc concordancer program (Anthony, 2012). Both programs are available as free downloads and previously have been tested for use by engineering students (Anthony, 2005). The AntWord profiler listed the most frequently used vocabulary items in abstracts from each of the three engineering disciplines as well as that of all three disciplines combined. The AntConc program listed collocations of input vocabulary items as well as identified the location of the vocabulary within the abstracts. Abstracts from two students provided a representative sample of the work of the 15 students in the English presentation class; these were analyzed using the AntWord profiler program. The vocabulary from online abstracts and student abstracts was then compared to identify differences in vocabulary usage.

Abstract style analysis. In order to determine the basic structure of engineering abstracts, a specific word was chosen as a starting point to identify the "moves" within the abstracts. The word "paper" was chosen and input into the AntConc program in order to determine the location of the word within the abstract. Phrases including the word "paper," such as "This paper" and "The present paper," were taken as an indicator of the move "purpose" or "objective." Using the "purpose" move as a starting point, the moves of the abstracts were identified and categorized as either following the IMRD model or the CARS model.

Results

Vocabulary Analysis

First, the vocabulary size of the students was examined using the VST. On average students knew approximately 8,200 words in English. Words known per level were plotted (Figure 1). Results indicated that the students' vocabulary knowledge decreased steadily as the frequency level of words decreased; however, a sudden uptick at the 7,000- and 8,000-word levels suggested that students knew more 7,000- and 8,000-level words than 5,000- and 6,000-level words. In other words, *senkoka* students tended to know more low-frequency, difficult vocabulary words than more frequent, less difficult vocabulary words.

Next, the 139 abstracts were examined for vocabulary levels using AntWord Profiler, which compared the vocabulary present in the abstracts to the first 12 levels of the British National Corpus (BNC). The combined total number of tokens for all abstracts was 19,199, with a type/token ratio of .20. The average number of words per abstract was k = 139; C abstracts averaged more words (k =

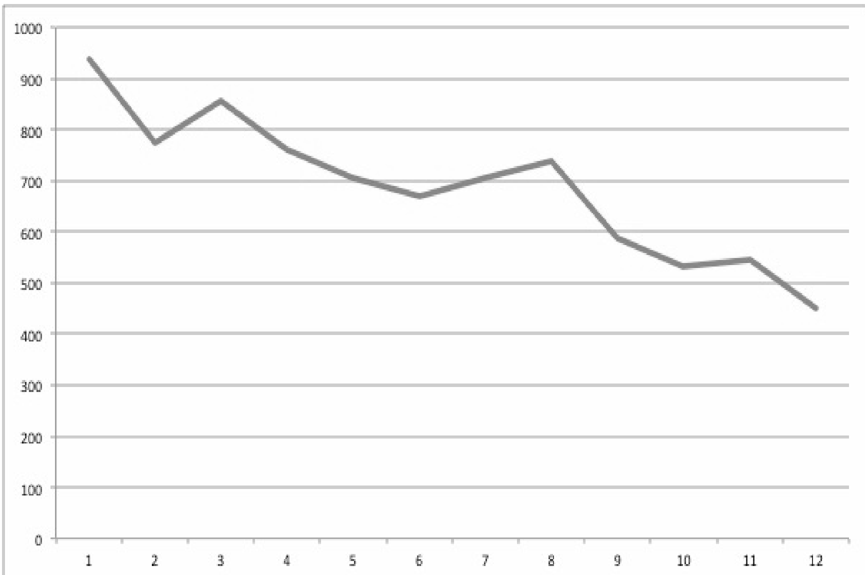

Figure 1. Average number of words known per level of the Vocabulary Size Test by *senkoka* students. (N = 15). Estimated levels are on the x-axis, and estimated words are on the y-axis.

162) than MS (k = 129) and EI (k = 128) abstracts. Analysis indicated that the top 12,000 words of the BNC covered 93.1% of the vocabulary levels of words used in the 139 abstracts (Table 2). EI abstracts had the highest level of coverage (95.5%) and C abstracts the lowest (90.6%).

To compare *senkoka* students' abstract writing to the IEEE online conference proceedings abstracts, the two sample abstracts from MS students were input into the AntWord Profiler. Both abstracts had been accepted by international engineering conferences. Results indicated that the 12,000 words of the BNC covered 93.6% of the first sample and 95.1% of the second sample (Table 3). The overall vocabulary coverage percentages of the MS students' abstracts were comparable to that of the MS online proceedings abstracts; however, the percentages of 2,000-, 7,000-, and 8,000-level words in the student abstracts were greater than the percentages of the same levels in the online MS abstracts.

Genre Analysis

The word *paper* was chosen as the starting point for identifying moves in the 139 abstracts. Interestingly, *paper* was found in only five of the 40 C abstracts; instead, the word *study* was found in 22 abstracts. Because the 15 *senkoka* students who

Table 2
Coverage of BNC 1,000-12,000 Levels in Select Engineering Conference Proceedings Abstracts

Abstract	1k	2k	3k	4k	5k	6k	7k	8k	9k	10k	11k	12k	Total
Combined	65.1	12.5	4.0	3.6	2.5	1.2	.7	1.1	.8	.9	.4	.3	93.1
Chemical	61.5	11.8	4.1	3.9	2.8	1.2	.9	1.1	1.2	1.0	.5	.6	90.6
EI	69.4	13.3	3.7	3.0	1.8	.9	.7	1.1	.3	.9	.5	.1	95.5
MS	64.3	12.5	4.2	3.9	2.8	1.4	.7	1.3	.8	.7	.2	.3	93.2

Notes. Total of 139 abstracts; combined word count was 19,199 tokens.

Table 3
Coverage of BNC 1,000-12,000 Levels in Two Sample Student Abstracts

Abstract	1k	2k	3k	4k	5k	6k	7k	8k	9k	10k	11k	12k	Total
Sample 1	68.7	17.4	2.0	.5	.5	1.0	1.0	2.0	0.5	0	0	0	93.6
Sample 2	61.3	21.1	5.6	1.4	.7	0	0	4.9	0	0	0	0	95.1

supplied data to the present study belonged to the EI and MS programs, the C abstracts were not analyzed for moves and instead the EI and MS abstracts were subjected to genre analysis, making the total number of abstracts for this section n = 99. The EI and MS abstracts were input separately into AntConc and the concordance plots for *paper* were examined. The word *paper* occurred in 68% of the 50 EI abstracts (n = 34) and 71% of the 49 MS abstracts (n = 35). In the interests of space, a truncated screenshot of only the MS abstract concordance output is presented here as example AntConc concordance plot output (Figure 2). The abstracts were then analyzed using the location of the word *paper* as a basis for identifying the *objective* move of the 69 EI and MS abstracts in which the word occurred.

In the 34 EI abstracts that used *paper*, three clear patterns emerged. Twenty abstracts followed a pattern of moves similar to the IMRD model: (a) explain the problem through reference to prior studies, (b) suggest a possible solution, (c) establish the objective of the paper, (d) describe methods and materials, and (e) summarize findings. Four of the abstracts followed a pattern similar to CARS: (a) introduce the field of inquiry, (b) explain the problem and its relevance, (c) discuss possible solutions, and (d) establish the objective of the paper. The CARS-like pattern of moves was used primarily in discussion papers that provided little or no empirical data. Ten of the abstracts followed neither of the two expected models. Instead, they tended to repeat the objective and focus on methodology: (a) establish the objective of the paper, (b) explain an existing method of research, (c) highlight problems with existing methods, (d) propose a new method to improve on the existing method, and (e) repeating the objective of the paper, occasionally with a brief summary of findings. The pattern of moves for these ten abstracts resembles the “Establishing a niche” and “Occupying the niche” steps of the CARS model; however, the focus on objective in the first move, even before placing the study within the field of inquiry, breaks the pattern.

The 35 MS abstracts that used *paper* had an even more pronounced pattern of moves. Twelve of the abstracts followed the IMRD model closely: (a) establish recent trends of inquiry, (b) highlight problems with existing methods,

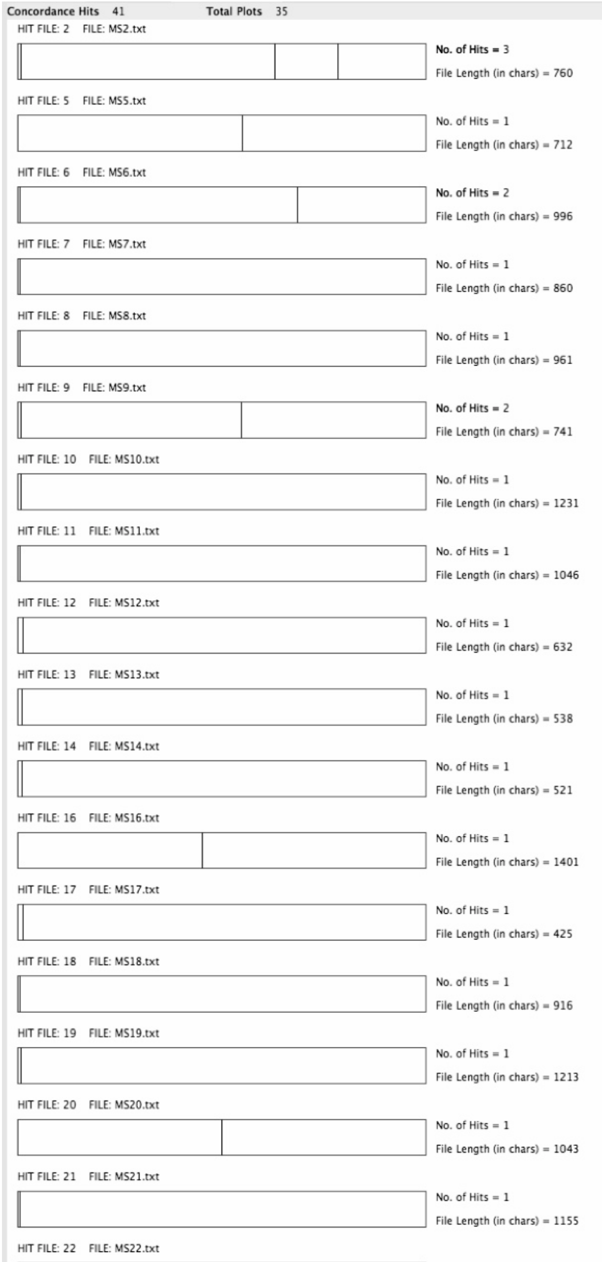

Figure 2. A concordance plot output from the AntConc program of the word “paper” ($n = 41$) in 35 select mechanical and system engineering abstracts. The vertical line indicates the approximate location of “paper” in the abstracts.

(c) introduce a new method to be demonstrated, (d) describe methods and materials, (e) present findings. However, twenty-three of the abstracts followed what could be called an "inverted CARS" model: (a) establish the objective of the paper, (b) describe methods and materials, and (c) explain the benefits of the proposed method over existing methods. In most of the "inverted CARS" abstracts, no findings were presented. Two of the 21 abstracts following this pattern of moves repeated the objective of the paper in the final sentence, and one of them repeated the objective three times throughout the abstract. The phrase "The paper," "The present paper," or "This paper" appeared in the first sentence of twenty abstracts.

Because the *senkoka* students in the study were primarily MS students, a further analysis was done for author voice. In contrast to both C and EI abstracts, which relied entirely on the passive (V + ed) construction, the MS abstracts relied heavily on the active voice. In fact, the pronoun *we* appeared 25 times in 19 abstracts; two abstracts used *we* four times. *We* occurred most frequently in the description of methods and materials. The use of the authorial voice is thus quite distinct in the abstracts of different engineering disciplines.

Discussion

The first question of the study, whether *senkoka* students have adequate lexical knowledge to write abstracts for international engineering conferences, was answered in the affirmative. The students in the study clearly possessed adequate knowledge of English vocabulary to write an appropriate abstract in their respective disciplines. A problem, however, was suggested by the analysis of the two sample student-written abstracts. While the overall vocabulary levels of the abstracts matched that of online conference proceeding abstracts, the student-produced abstracts contained more 7,000- to 8,000-level words and fewer 3,000- to 6,000-level words than the online conference proceedings abstracts. I will hazard an educated guess that much of the discipline-specific technical vocabulary known to students occurs starts at roughly the 7,000-word level. The *senkoka* students had all progressed through the *kosen* system, in which junior high school graduates attend five years in an engineering program designed to train specialists in a specific discipline. Though the *senkoka* students had a firm grasp of the basic 2,000 words of English, they did not have as much knowledge of the next three levels (i.e., 3,000- to 5,000-word levels) of English vocabulary. This finding supports previous studies indicating a dearth of vocabulary items in junior and senior high school text books in Japan (Chujo, 2004, 2007). While *senkoka* students in this study had knowledge of low-frequency, technical English vocabulary specific to their engineering disciplines, the gap in English vocabulary knowledge may result in *senkoka* students' English presentation abstracts being more lexically dense than typical engineering abstracts.

The genre analysis of the online engineering conference abstracts provided the answer to the second research question: there were, indeed, differences in abstract styles, both within and among disciplines. Overall, the style of EI abstracts most closely followed the IMRD model, while MS mostly matched CARS. However, a significant number of abstracts in both disciplines blurred model boundaries. This was especially common in the MS abstracts, in which the focus on the objective of the paper even prior to situating the study in the field of inquiry was outside either of the expected two models of abstract writing.

On the other hand, the pattern of moves for what could be termed an "OMBu Model" (objective, methods, benefits) does match the explicit directions given by Rensselaer Polytechnic Institute, a major engineering institute in the US:

> Rephrase the first sentence so that it starts off with the new information contained in the paper, rather than with the general topic. One way of doing this is to begin the first sentence with the phrase 'this paper' or 'this study.' (The Center for Communication Practices, n.d., "How do you write an abstract?").

Despite the lack of corroborating evidence, it seems likely that the use of the inverted CARS pattern in MS abstracts had been explicitly taught to mechanical engineering students. The rejection of the importance of the "gap" in the previous literature and the immediacy of the focus on the objective of the present study are not expected by either the IMRD or CARS model. Given the frequency with which this inverted objective-centered pattern was evident in engineering abstracts, instructors teaching engineers how to write abstracts in English may wish to set aside established notions of what constitutes an abstract and examine instead the generic conventions most commonly found within documents from specific engineering discipline of their students. The style and moves of abstract writing need to be approached from an ESP, or academic discipline-specific perspective, rather than from a more generic "English for academic purposes" humanities point of view.

Conclusion

This study is an initial attempt to examine engineering abstracts produced by Japanese *kosen* students. While a number of interesting points have been raised, mitigating factors may make it difficult to generalize the study results. The number of participating engineering students was small (n = 15); vocabulary levels and abstract data from a larger student sample may show different results. The corpus of engineering abstracts was also moderately small (n = 139; k = 19,199 tokens), taken from a single year of online conference proceedings. Expanding the number of abstracts taken from proceedings from several different years may result in different patterns of abstract writing. Finally, abstracts examined in this paper were from conference proceedings papers; abstracts from engineering journals may show different characteristics. Nevertheless, this study represents a first attempt at examining engineering abstracts as they actually are, rather than as writing instructors assume they are or think they ought to be.

Notes

1. Portions of this paper were previously presented on September 7, 2013, at the JALT CUE ESP Symposium, Japan Advanced Institute of Science and Technology (JAIST), Kanazawa, Japan.
2. The "structured" abstract, which divides the abstract into several subsections, each with a heading (e.g., Background, Aims, Method), has been proposed as a third type of abstract (see Hartley, 2004). However, I consider this to

be a variation of the informative abstract, as the structured abstract simply requires the IMRD sections to have headings.

3. A total of 21 students were enrolled in the Presentation in English course, including three students of advanced chemical engineering. However, six students declined to join the study, leaving *n* = 15. None of the advanced chemical engineering students provided data.

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