

ARTICLE



Genre-based AWE system for engineering graduate writing: Development and evaluation

Hui-Hsien Feng, National Kaohsiung University of Science and Technology

Evgeny Chukharev-Hudilainen, Iowa State University

Abstract

Automated writing evaluation (AWE) systems have been introduced to ESL/EFL classes in the hopes of reducing teachers' workloads and improving students' writing by providing instant holistic scores and corrective feedback (Jiang & Yu, 2020; Link et al., 2014; Ranalli & Yamashita, 2019; Warschauer & Ware, 2006). When it comes to genre-specific writing, general AWE feedback may be insufficient because communicative purposes should be achieved, for which feedback is needed beyond grammar and mechanics. However, very few genre-specific AWE systems based on rhetorical move analysis have been developed. Therefore, the present study reports on the development and evaluation of a genre-based AWE system to facilitate Taiwanese engineering graduate students' writing of research abstracts. This AWE system provides automated feedback on two linguistic features, lexical bundles and grammatical categories of verbs (i.e., tense, aspect, and voice), associated with moves in abstracts. The feedback was designed to be co-constructed between learners and computers in order to promote interaction. The effectiveness of the AWE system was evaluated following Chapelle's (2001) computer-assisted language learning evaluation framework. The findings revealed positive effects; with appropriate guidance, the AWE system was able to draw participants' attention to and enhanced their use of these two linguistic features to achieve the communicative purposes of rhetorical moves in their abstracts.

Keywords: *Automated Writing Evaluation, Genre-based Pedagogy, Lexical Bundles, Grammatical Categories of Verbs*

Language(s) Learned in This Study: *English*

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Introduction

The ability to produce effective English writing has become essential for academic success in many countries. Following the conventions of academic writing in English can be challenging for novice writers. This challenge can be compounded for non-native speakers of English. For example, writing English research article (RA) abstracts is a difficult but mandatory task for Taiwanese engineering graduate students (Feng, 2013) as English is typically taught as an academic subject in Taiwan. Without further assistance, it is difficult for them to use English in discipline-specific writing tasks.

Genre analysis (Swales, 1990) has been employed to uncover language patterns in a particular genre in order to achieve shared communicative purposes (i.e., rhetorical moves). Through the data-driven learning (DDL) approach (Johns & King, 1991), authentic language use in specialized corpora could be leveraged for teaching genre-specific writing (Lee & Swales, 2006; Sun, 2007). Also, corpus-informed pedagogical materials have been developed for genre-based teaching (Anthony, 2017; Chang & Kuo, 2011; Cortes, 2013; Gratez, 1982; Hsieh & Liou, 2008).

Common automated writing evaluation (AWE) systems, such as [Criterion](#), [Grammarly](#), and [Pigai](#), have

been developed to assist L2 learners by providing instant feedback on multiple drafts. However, the feedback on grammar and mechanics is insufficient to cope with genre-specific content because it is more complex to maintain genre conventions than grammatical accuracy. Some genre-specific AWE systems have been developed, such as Research Writing Tutor (Cotos et al., 2015) and AcaWriter (Knight et al., 2020), which focus their feedback on moves and show definitions and example sentences upon request. However, without explicit linguistic guidance, it can be challenging for EFL learners to use appropriate linguistic cues to demonstrate inclusion in the genre community.

Therefore, this study aimed to present the development and evaluation of a genre-based AWE system for engineering RA abstracts in an EFL context. The AWE feedback targeted certain linguistic features within their rhetorical moves to assist Taiwanese engineering graduate students in achieving specific communicative goals. Furthermore, the AWE system was evaluated with Chapelle's (2001) computer-assisted language learning (CALL) evaluation framework to ascertain its appropriateness and effectiveness for teaching genre-specific writing to EFL writers.

Literature Review

Since the 1960s, automated writing evaluation (AWE) systems have been developed to reduce the amount of time and effort for assessing writing required by human raters (Deane, 2013; Page, 1966, 2003; Warschauer & Ware, 2006). AWE systems usually evaluate a number of features in a submitted text, such as grammar, mechanics, lexis, and discourse features (Attali & Burstein, 2006; Burstein et al., 1998; Cheville, 2004; Deane, 2013; Deane & Quinlan, 2010; Dikli, 2006;). Early research has revealed high agreement between human raters and AWE systems (Attali et al., 2010; Lee et al., 2008, 2010; Shermis & Hamner, 2013; Vantage Learning, 2007; Wang & Brown, 2007).

In view of the potential of AWE systems, studies have investigated the implementation of AWE systems, such as Criterion, Grammarly, and Pigai, in ESL/EFL classrooms to support language teachers and learners (Chen & Cheng, 2008; Jiang & Yu, 2020; Koltovskaia, 2020; Lavolette et al., 2015; Li et al., 2015; Li et al., 2017; Liao, 2016; Link et al., 2014; Link et al., 2020; Liu & Kunnan, 2016; Ranalli, 2018; Ranalli & Yamashita, 2019; Wang, 2015; Wilson & Czik, 2016; Zhang, 2020; Zhang & Hyland, 2018). Also, *CyWrite* (Chukharev-Hudilainen et al., 2019), a flexible AWE system with the capacity for keystroke logging and eye-tracking in order to record learners' writing processes, has been implemented in ESL classrooms (Feng et al., 2016; Ranalli et al., 2018, 2019). So far, largely positive results have been reported regarding the use of AWE systems in language classrooms with appropriate instructions and teacher feedback.

However, for genre-specific writing, such as research articles, these types of feedback are insufficient because the language for expressing ideas in specific genres has more to it than simply producing sentences with accurate grammar and vocabulary. As Swales (1990) stated,

A genre comprises a class of communicative events, the members of which share some set of communicative purposes. These purposes are recognized by the expert members of the parent discourse community, and thereby constitute the rationale for the genre. This rationale shapes the schematic structure of discourse and influences and constrains choice of content and style. (p. 58)

Therefore, writers need to demonstrate a sense of belonging to a discourse community by designing their texts according to the norms established in this community in order to deliver messages efficiently. Making sentences merely grammatically correct does not necessarily suffice to convey the meaning and thus achieve the communicative purposes.

To raise students' genre awareness, the use of "linguistic features of language varieties" and "communicative purposes and effects" in genres of academic discourse has been investigated (Bawarshi & Reiff, 2010, p. 42), and the findings have been applied to teaching ESL/EFL learners (e.g., Cotos, 2014; Hsieh & Liou, 2008; Lee & Swales, 2006; Sun, 2007). Swales (1990) proposed applying genre analysis to English academic research writing. Specifically, he developed the Create-A-Research-Space (CARS)

model to teach the structure of the introduction section of research articles to ESL graduate students in the U.S. He used the term *move* to describe how introduction sections of RAs are structured. Swales (2004) defined *move* as “a discoursal or rhetorical unit that performs a coherent communicative function in a written or spoken discourse” (p. 228), and the term *step* was proposed for the strategies used for achieving the functions.

Only a few genre-specific AWE systems based on the results of move analysis have been developed so far, such as Research Writing Tutor (RWT) in the U.S. (Cotos et al., 2015) and AcaWriter in Australia (Knight et al., 2020). For example, RWT was designed according to the genre analysis of 900 RAs representing 30 disciplines. Through natural language processing techniques, moves are automatically identified and color-coded in students’ drafts and the proportion of the use of each move is displayed in pie charts. The definitions of each move and step are provided and illustrated with sample sentences. Students are encouraged to revise their drafts to fulfill the communicative goals (Cotos et al., 2015). While RWT uses Swales’ CARS model for move identification in the introduction section and proposes novel move schemata for other sections, AcaWriter identifies moves mainly for abstracts/introductions with the CARS model (Knight et al., 2020). AcaWriter also provides automated move identification for other genres, including reflective writing for pharmacy students (Lucas et al., 2019), report writing for business students (Shibani et al., 2019), and essay writing for law students (Knight et al., 2018).

Besides the identification of moves, genre analyses of research discourse have taken several linguistic features into consideration, including lexical bundles and grammatical categories of verbs within moves. Lexical bundles are defined as “the most frequently occurring sequences of words” (Biber, 2006, p. 134) and thus considered “frequency-based” formulaic language (Durrant & Mathews-Aydinli, 2011, p. 59). The recurrent nature of these language patterns is especially beneficial for language learners to communicate with readers with ease because they are not only efficient and necessary—they help writers show a sense of inclusion in a community (Coxhead & Byrd, 2007). Some studies have explored the use of phraseology with rhetorical moves in abstracts (Anderson & Maclean, 1997; Chang & Kuo, 2011; Gratez, 1982; Hsieh & Liou, 2008; Yoon & Casal, 2020) and introductions (e.g., Cortes, 2013; Durrant & Mathews-Aydinli, 2011) in RAs. For instance, Gratez (1982) presented common phrases identified in the introduction and conclusion moves of 87 abstracts; AWSuM (Academic Word Suggestion Machine) provides suggestions for lexical bundles after users choose the discipline, section, and intended move (Mizumoto, 2017). As Cortes (2013) stated, both moves and lexical bundles are useful “as building blocks” for publication writing (p. 35). Therefore, it would be advantageous to probe into this area and integrate it in genre-based AWE systems for research writing.

On the other hand, the use of grammatical categories of verbs within moves is another essential linguistic feature to investigate. Verb categories including person, tense, aspect, modality, and voice have been investigated in some studies (Cross & Oppenheim, 2006; Gratez, 1982; Salager-Meyer, 1992; Tankó, 2017; Tseng, 2011; Wang & Tu, 2014). For English language learners whose native language is tenseless such as Chinese (Bastiaanse, 2013; Hinkel, 1997; Lin, 2006), the proper use of tense (and, by extension, aspect and voice) to indicate time and manner of an action in English should be explicitly taught. Besides, as Bhatia (1993) stated, “[c]hoices of tense and article were not solely dependent on syntactic and semantic considerations, but also involved rhetorical judgments, including the knowledge of the subject matter and its conventions” (p. 7). Thus, it would be beneficial if the detection of verb categories were implemented in genre-based AWE systems.

Besides the detection of linguistic features offered by AWE systems, the design of AWE systems may benefit from being grounded in the Interaction Hypothesis (Gass & Mackey, 2006; Long, 1983) and the Noticing Hypothesis (Schmidt, 1990) to increase students’ opportunity for L2 learning. When learners use an AWE system, they interact with the system by noticing the feedback provided and then revise (or do not revise) the flagged errors to negotiate meaning through modifying their output. The use of AWE may enhance two types of interactions, as defined in Chapelle (2003): (a) interpersonal interaction as the communication between computers and learners and (b) intrapersonal interaction as the communication

within a learner's mind. These two types of interaction have been found to enhance the efficacy of L2 learning in technology-assisted learning environments (e.g., Blake, 2000; Du et al., 2016; Kern, 1995; Smith, 2003). In terms of promoting noticing in a CALL situation, "enhanced input," such as highlighting, underlining, or changing colors of the texts, and adding written or visual information, can be used to raise students' attention toward the target language (Chapelle, 2003, p. 52). The way AWE feedback is provided greatly influences the probability of interaction between the system and user. If there was no noticing or revision by the user, modified outputs and the next iteration of interaction would not occur. Therefore, providing human-computer co-constructed feedback could add another mechanism of promoting noticing to maximize the opportunities for interaction.

To evaluate whether AWE systems promote language learning, Chapelle's (2001) CALL evaluation framework based on instructed SLA perspectives can be applied because it takes "learners' performance during CALL activities" as empirical evidence for evaluation (p. 53). The six criteria for this framework are "Language learning potential, Learner fit, Meaning focus, Authenticity, Positive impact, and Practicality" (p. 55). It should be noted that Language learning potential is the most important element because the occurrence of learning is the key outcome for developing these CALL applications (p. 58). Few studies have applied this framework to evaluate AWE systems (Cotos & Huffman, 2013; Saricaoglu, 2019). Saricaoglu (2019) evaluated her Automated Causal Discourse Evaluation Tool (ACDET), a module in *CyWrite* to facilitate ESL students' learning of causal discourse practices, by examining two dimensions: Language learning potential and Meaning focus. These criteria provided a window for a comprehensive look at learning outcomes from the use of ACDET.

The current study aimed to investigate the learning outcomes of another such genre-based AWE system implemented as a module in *CyWrite* by applying two criteria from Chapelle's (2001) CALL evaluation framework. Thanks to the flexibility of *CyWrite*, this novel AWE system was rapidly developed by the authors of the present paper, is grounded in genre analysis, and targets two linguistic features within moves (namely, lexical bundles and verb categories) to facilitate Taiwanese engineering graduate students' writing of RA abstracts. The system was designed specifically for providing human-computer co-constructed feedback. The research questions guiding this study are as follows:

1. Language learning potential—How does this genre-based AWE system's feedback affect students' noticing of and focusing on the use of grammatical categories of verbs?
2. Language learning potential—How does this genre-based AWE system's feedback affect students' noticing of and focusing on the use of lexical bundles?
3. Meaning Focus—How does this genre-based AWE system's feedback affect students' focus on the meaning of the moves in abstracts?

Methodology

Research Context

In Taiwan, non-English major undergraduate students only study English in foreign language courses. Also, English is not always a criterion for admission into graduate-level programs. As a result, graduate students are not equipped to write English academic prose for their dissertations/theses, conference presentations, and international journal publications. Generally, engineering students in Taiwan are perceived as not needing English proficiency to succeed, but at the same time they are expected to present their work internationally, making the language barrier both a burden and a potential obstacle for graduation.

Participants

The participants in this study were recruited from the engineering college at a university in Southern Taiwan. They were invited by email to attend a three-week academic writing workshop. Although 20 students volunteered, only 13 of them fully participated in the workshop. Among the 13 students (one

female), two were PhD students, and the rest were MS students. Their majors were Mechanical Engineering ($n = 3$), Civil Engineering ($n = 3$), Environmental Engineering ($n = 3$), Engineering Science and Technology ($n = 1$), Innovative Design Engineering ($n = 1$), Computer and Communication Engineering ($n = 1$), and Electrical Engineering ($n = 1$).

Genre-based AWE System: A Module in CyWrite

The genre-based AWE system was implemented as a module within the *CyWrite* system. The module detected two linguistic features (namely, grammatical categories of verbs and lexical bundles) and analyzed their occurrence within the moves in abstracts, then generated human-computer co-constructed feedback. The inclusion of grammatical categories of verbs was due to the fact that the participants' L1 was Mandarin Chinese, which is tenseless. Additionally, providing the participants with lexical bundles as “building blocks” (Cortes, 2013, p. 35) in RA writing was expected to be beneficial.

To analyze the use of the two linguistic features in each move, a corpus of 480 articles in engineering was compiled and computational methods were utilized to extract the features (Feng, 2015). The working definition of lexical bundles associated with a move in this study was a four-gram (i.e., four-word lexical bundle) that occurs at least once in the abstract, at least five times in an RA section, and in at least three different texts. Examples of the retrieved lexical bundles were “the aim of this,” “was carried out in,” “it is shown that,” and “results of this study” (Feng, 2015).

As for the grammatical categories of verbs, the automatic detection of tense (present, past, and future¹), aspect (simple, progressive, and perfect), voice (active and passive), and the use of modal verbs was facilitated by developing a set of rules in the *CyWrite* Analyzer (the part in the system that executes *CyWrite* rules; Chukharev-Hudilainen & Saricaoglu, 2014; Feng et al., 2016). The rules were designed, specifically, to identify finite clauses and to classify main verbs in the indicative mood (Feng, 2015). For example, in the methodology move, the use of past-simple-passive was detected most often; the use of modal verbs occurred most frequently in the discussion/conclusion move (Feng, 2015). The results of these automatic detection procedures were then applied to feedback provision in this genre-based AWE system.

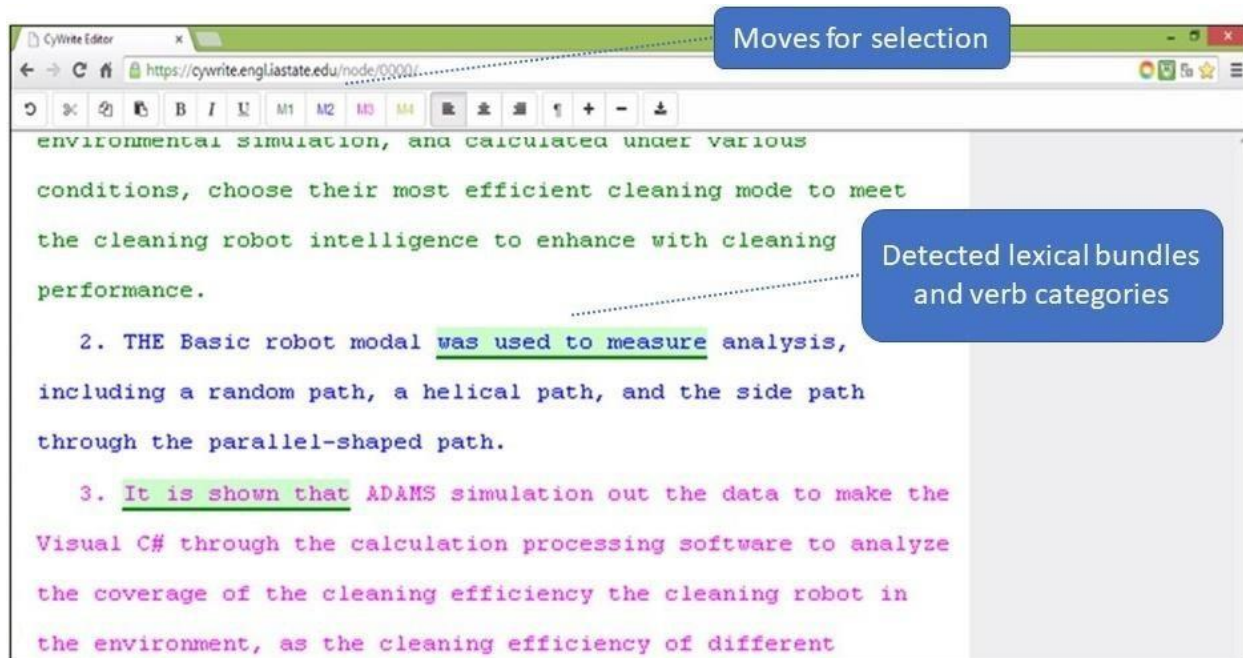
The display of feedback was designed based on the Interaction and Noticing Hypotheses (Gass & Mackey, 2006; Long, 1983; Schmidt, 1990) by offering salient feedback with highlighting and underlining of the focused linguistic features to promote interactions between users and the AWE system. [Figure 1](#) is a screenshot showing the AWE system interface and how its feedback is displayed.

When students use a targeted linguistic feature (e.g., a lexical bundle) detected by the AWE system, it initially underlines and highlights the feature in red. The students then need to decide which rhetorical move the sentence fulfills by highlighting the sentence with a particular color. To interact with the system, students select spans of text to designate the intended moves: Move 1 (Introduction) in green, Move 2 (Method) in blue, Move 3 (Results) in pink, and Move 4 (Discussion/Conclusions) in yellow. Once the intended move is designated by the student, the system then verifies whether the detected linguistic feature belongs to the designated move. If so, the highlighting and the underlining become green; if not, they stay red. Students would notice the changes in color to decide on their next step. In this way, students would be encouraged to think about how they should use lexical bundles or verb categories correctly in their abstracts.

In the example shown in [Figure 1](#), the student wrote the lexical bundle “was used to measure” and it was originally highlighted in red. Since this lexical bundle was only associated with Move 2 (M2), the feedback would show “This phrase should be used in M2” when clicked by the student. Then the student needed to decide which move the sentence belonged to. If the student annotated the sentence as M2, then the color of the lexical bundle would turn green, as shown here; if the student annotated it as any other move, then it would stay red. Note that unlike previously mentioned AWE systems, this system did not detect the moves automatically. Instead, students were responsible for labeling the moves themselves to increase the opportunities for interactive learning through the process of co-constructing feedback with the system.

Figure 1

An Example of the AWE Feedback Provision and Move Highlighting by a Student



Instruments and Data

The utilized instruments and collected data for answering the research questions are described below.

Drafts Before and After the Workshop

Students wrote their research abstracts related to their current projects. The first draft was produced before the academic writing workshop, and the final draft included the students' revisions of their abstracts developed in the last week of the workshop.

Questionnaire

The responses to the questionnaire were collected at the end of the workshop to obtain insights from students. The questionnaire was prepared as a Google Form, and a link to the questionnaire was provided to the students. In this paper, we are only reporting on six Likert-scale questions that were asked to the participants. The survey administered to participants also included other questions, which are not relevant for present purposes. Those additional questions were collected as part of a larger study.

Semi-structured Interviews

The purpose of the semi-structured interviews was to explore participants' attitudes toward and learning gains from the AWE system. The individual interviews lasted for about 30 minutes and were conducted in Mandarin after the completion of the workshop. The participants were shown the questions and asked whether there was anything they were not willing to answer. Their approval for audio recording the interviews was obtained before the interviews started. The interview questions were about why/how students revised certain lexical bundles, verb categories, and moves, and whether/how they managed to develop the structure of their abstracts.

The Academic Writing Workshop

The goal of the 3-week, 18-hour workshop was to help students understand the use of the linguistic features discussed above. Before the workshop, the students wrote a "baseline" abstract about their current research.

During the workshop, the students learned about the relevant concepts, self-collected a small corpus of RAs in their fields, and learned to operate the AWE system. Finally, they used the AWE system to revise their “baseline” abstracts and completed the questionnaire and the interviews.

Data Analysis

For students’ abstract drafts, two steps of analysis were conducted. Firstly, for both drafts, the moves for each sentence were manually annotated, and the correctness of lexical bundles and grammatical categories of verbs was documented. Second, the analyses from the first step were compared to investigate changes in move frequency, lexical bundles, and grammatical categories of verbs between the two drafts. In terms of the questionnaire, responses were gathered in an Excel spreadsheet for analysis. Descriptive statistics were calculated.

The transcripts were analyzed by applying a two-cycle coding method, as suggested by Saldaña (2009). To keep originality and avoid inexperienced interpretation, “in vivo coding” (p. 74) and “themeing the data” (p. 139) were used for the first cycle of coding. In vivo coding uses original words from the participants as codes, and themeing the data allows for grouping data into units and provides a code for each unit in a phrase or sentence. After the data were analyzed with the first cycle of coding methods, the codes were grouped into categories. The second cycle of the coding approach is “focused coding” (p. 155), which takes the categories to a higher level: themes. Applying this method helped the researchers be objective when handling unexpected results.

Results

The genre-based AWE system for facilitating Taiwanese engineering graduate students’ RA abstract writing was evaluated according to two criteria in Chapelle’s (2001) CALL evaluation framework, Language learning potential and Meaning focus.

Language Learning Potential for AWE Feedback on Grammatical Categories of Verbs

The participants’ two drafts of abstracts, questionnaire responses, and interview transcripts were analyzed to investigate whether the AWE feedback led to students’ noticing of and focusing on the use of grammatical categories of verbs. It should be noted that the AWE system only provided feedback on the verb categories that were appropriate for the genre, or mostly confined to certain moves. From the genre analysis conducted for developing the AWE system, the perfect aspect was typically found in the Introduction move and modal verbs usually occurred in the Discussion/Conclusion move, whereas the progressive aspect and the future tense were rarely used (Feng, 2015).

In the first drafts, the grammatical categories of 12 main verbs were identified by the AWE system and only four (33.3%) of them were used correctly by the students. In the final drafts, the grammatical categories of 14 verbs were identified, and ten (71.4%) of them were used correctly. [Table 1](#) shows that students had 100% correct usage of the perfect aspect, and 63.6% correct usage of the modals. They did not use the future tense and the progressive aspect as they did in the first drafts. For instance, a student initially used “will affect” to introduce the methodology of their study, but they then revised it to “was carried out” in the final draft.

Table 1

Correct and Incorrect Use of Grammatical Categories of Verbs in Students' First and Final Drafts (N = 13)

Verb Categories	First Draft		Final Draft	
	Correct	Incorrect	Correct	Incorrect
Perfect aspect	4	0	3	0
Modals	0	5	7	4
Future tense	0	1	0	0
Progressive aspect	0	2	0	0
Total	4	8	10	4

Three questions from the six-point Likert scale questionnaire asked students whether they noticed and focused on the use of grammatical categories of verbs. [Table 2](#) provides descriptive statistics for the responses, and the results showed the participants agreed that the feedback was clear to them ($M = 3.9$). They also reconsidered their sentences after receiving the feedback ($M = 4.0$). They agreed that they were able to revise their sentences regarding grammatical categories of verbs based on the received feedback ($M = 3.7$).

The analysis of the interviews also provides evidence of students' noticing and focusing on the use of grammatical categories of verbs. Eight students (62.5%) reported that they noticed their use of verb categories and they tried their best to change their usage to better communicate their meaning when they interacted with the AWE system. For example, one participant said, "I found that I kept using the present tense," and spent a considerable amount of time figuring out what the appropriate verb categories to be used in each sentence were. Another student was able to identify verb categories based on the purpose of a sentence. The student pointed out that "because of the feedback of the AWE system, I added 'ed' [to specify past tense]." The excerpts above provide evidence that the feedback highlighting the linguistic features raised some students' awareness of the use of verb categories in abstracts.

Students became aware of the use of grammatical categories in each move because of the feedback offered by the AWE system. They agreed that they reconsidered their sentences following receipt of the AWE feedback. They also deleted some incorrect usage and retained/added some correct usage of the grammatical categories of verbs. Although students' usage of grammatical categories of verbs in each move in abstracts was not always correct, the above results demonstrated the potential of the AWE feedback for improving students' use of grammatical categories of verbs in abstracts.

Table 2

Descriptive Statistics for the Responses to the Questionnaire Regarding the Feedback on Grammatical Categories of Verbs (N = 13)

Question	<i>M</i>	<i>Mdn</i>	<i>Min</i>	<i>Max</i>	<i>SD</i>
1. Do you agree that the AWE feedback on verb categories is clear for revision?	3.9	4	3	5	0.6
2. Do you agree that the AWE feedback made you reconsider your use of verb categories?	4.0	4	2	5	0.9
3. Do you agree that you can revise your use of verb categories based on the AWE feedback?	3.7	4	1	5	1.1

Language Learning Potential for AWE Feedback on Lexical Bundles

Language learning potential was investigated through the changes that students made based on the AWE feedback they received and their thoughts after using the AWE system. To investigate whether AWE feedback leads to students' noticing of and focusing on the use of lexical bundles, students' two drafts, questionnaire responses, and interview transcripts were analyzed.

Only two lexical bundles ("in this paper we" and "in this paper the") were detected in the first drafts, while as many as 30 lexical bundles were detected in the students' final abstract drafts, such as "aim of this study," "was used to measure," "an increase in the," and "should be considered in." On average, 2.3 lexical bundles per abstract were detected ($Max = 5$, $Min = 0$, $SD = 1.8$).

Three questions from the six-point Likert-scale questionnaire asked students whether they noticed and focused on the feedback regarding the use of lexical bundles. [Table 3](#) provides descriptive statistics for the responses. The results showed that the participants agreed the AWE feedback was clear to them ($M = 3.8$). They also reconsidered their sentences when receiving AWE feedback ($M = 4.1$) and were able to revise their sentences accordingly ($M = 3.9$).

The analysis of the transcripts of the semi-structured interviews provided some insights regarding students' noticing of and focusing on the use of lexical bundles. All participants reported that they noticed their use of lexical bundles, but only six (46.2%) reported that they were able to increase the frequency of lexical bundles by incorporating what they found in their self-compiled corpora. One participant mentioned that they would look up words in a dictionary first and then search for the phrases they could use from their corpus. However, the rest of the participants felt that using appropriate lexical bundles was somewhat difficult at this stage despite their readiness to utilize them. The results above demonstrated that all students noticed and focused on the feedback regarding the use of lexical bundles from the AWE system, but only some were able to follow through with revisions to their abstracts according to the feedback received.

Table 3

Descriptive Statistics of the Responses to the Questionnaire Regarding the Feedback on Lexical Bundles (N = 13)

Question	<i>M</i>	<i>Mdn</i>	<i>Min</i>	<i>Max</i>	<i>SD</i>
1. Do you agree that the AWE feedback on lexical bundles is clear for revision?	3.8	4	2	5	0.8
2. Do you agree that the AWE feedback made you reconsider your use of lexical bundles?	4.1	4	3	5	0.8
3. Do you agree that you can revise your use of lexical bundles based on the AWE feedback?	3.9	4	1	5	1.21

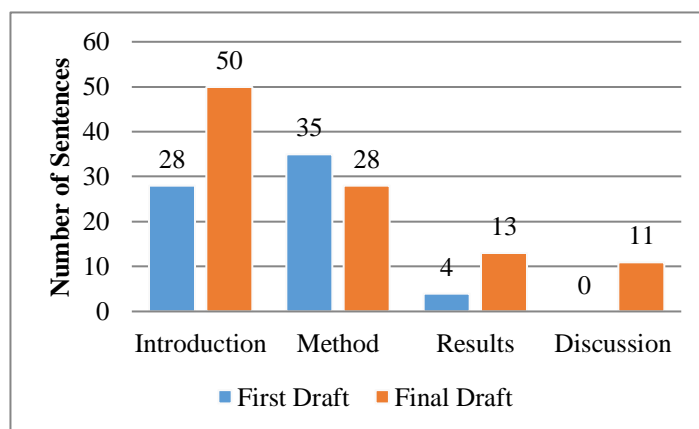
Meaning Focus – Evidence Indicating the Students’ Focus on the Meaning of the Moves in Their Abstracts

To explore whether students focused on the meaning of the rhetorical moves in their abstracts, their two drafts and interview transcripts were analyzed. First, the counts of sentences representing each move were retrieved. In comparing the two drafts produced by the students, it was noted that the overall sentence count increased from 80 ($M = 6.2$, $SD = 3.6$) to 112 ($M = 8.6$, $SD = 3.6$). [Figure 2](#) provides the total sentence count by moves in their two drafts. It seems that the students attempted to provide more information about the background, results, and discussion, and to remove some methodology information after learning about the rhetorical structure of abstracts in the workshop.

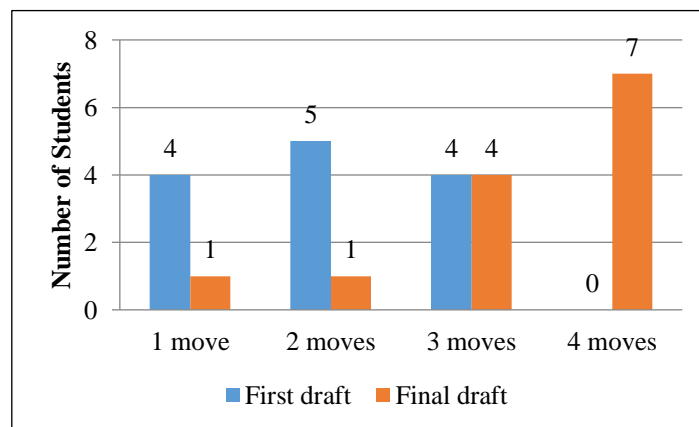
Additionally, the number of moves used in each abstract was calculated. [Figure 3](#) shows the number of moves in the two drafts. As displayed, between drafts, the number of students using one move or two moves decreased, the number of students using three moves remained the same, and the number of students using all four moves greatly increased from zero to seven. That means that all students attempted to revise their abstracts and seven students’ abstracts reached a complete four-move structure.

Figure 2

Changes of Total Sentence Counts of Moves in the Two Drafts (N = 13)

**Figure 3**

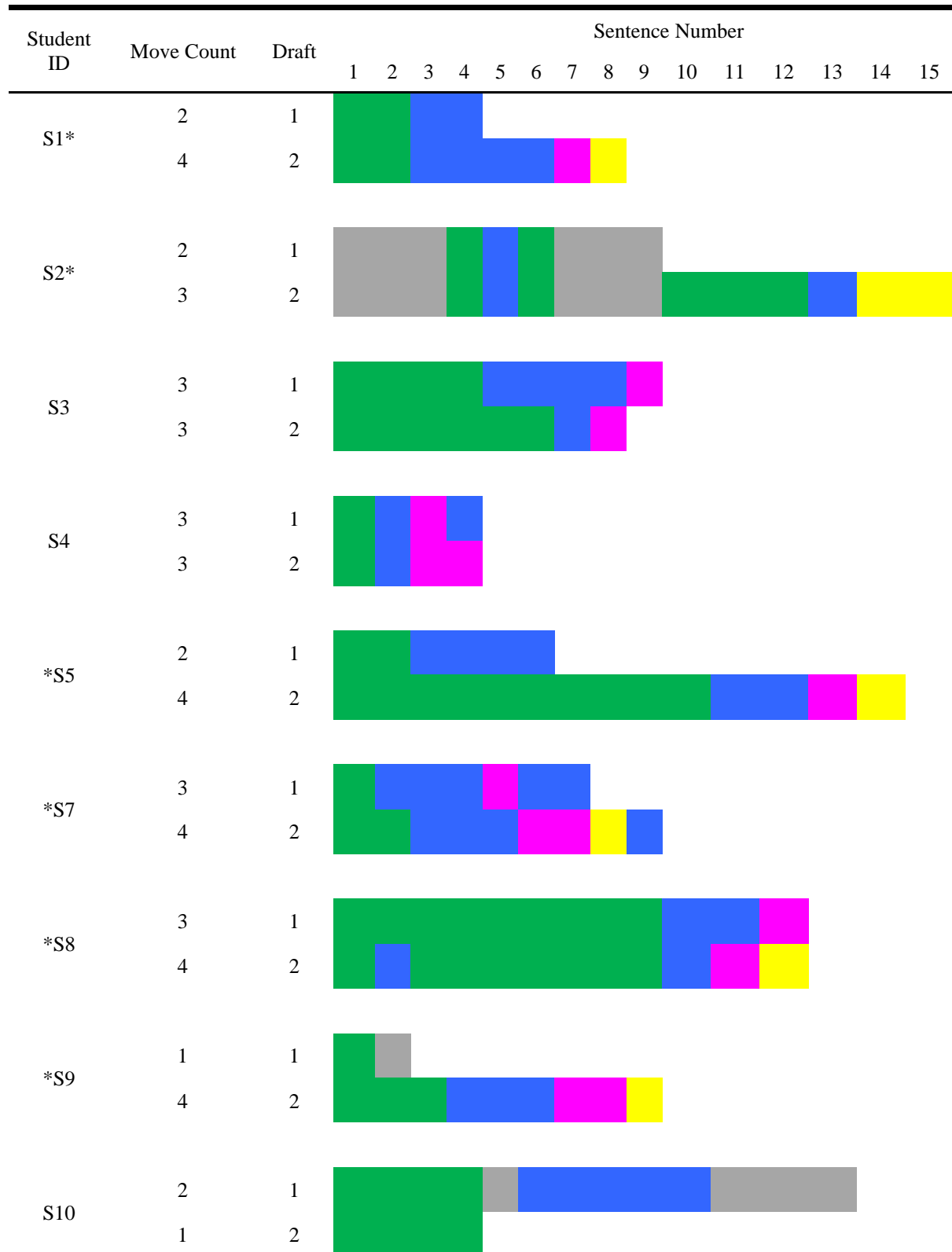
Numbers of Moves in the Two Drafts (N = 13)

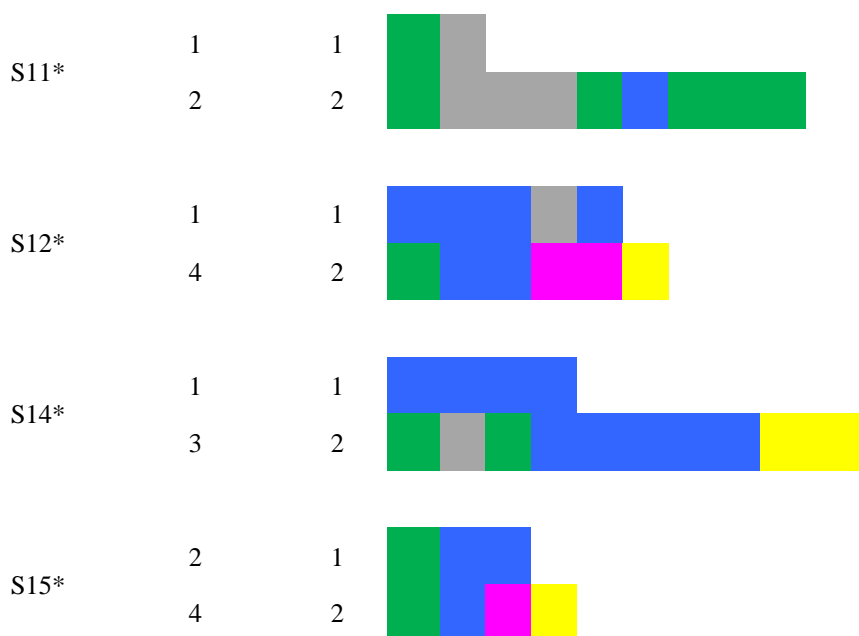


To further investigate the extent to which the moves were realized in the students' drafts, [Figure 4](#) visually illustrates the sequences of moves. Four moves were color-coded: Introduction in green, Methodology in blue, Results in pink, and Discussion/Conclusion in yellow. The gray color represents a sentence that did not fit any moves. It was found that the majority of the students ($n = 10$, 76.9%) intended to add or revise their sentences for the moves they had not covered in their first draft, and seven students (53.8%) completed their abstract structures with four moves. For example, S8 only had three moves in their first draft. After attending the workshop, they added the sentence "Therefore, the membrane can remove the dye from wastewater" as the conclusion (Move 4) in their final abstract.

Figure 4

The Sequence of the Moves in the Two Drafts (N = 13)





Notes. *The total move counts improved. Green = Introduction move, Blue = Methodology move, Pink = Results move, and Yellow = Discussion/Conclusion move. Gray = unclassifiable sentence.

In the semi-structured interviews, 12 students (92.3%) acknowledged that they tried to improve their abstract structures. They added, revised, and changed the sequence of their sentences, and seven students (53.8%) achieved the use of all moves in their final drafts. One participant talked about their process of sentence revision for the Introduction move:

First, I have a move, for example introduction, in mind. And I know what I want to express in Chinese... Yeah, I really wanted to make this sentence similar to a sentence in the Introduction move in an abstract of a journal article, so I revised it several times. This research is done so I clearly know what happened in my research.

It can be seen that this participant started with the meaning of their Introduction sentence (as expressed in Chinese), and then tried to express this meaning in English to achieve the rhetorical purpose of the Introduction by undertaking multiple revisions. Moreover, two participants (15.4%) reported that they shifted their sentences around in order to “match the same sequence as a professional abstract.” Finally, one participant recalled their writing process when using this AWE system as follows:

At the beginning I only had the Methodology move, but then I added more sentences with other moves in mind. Later on, I revised every sentence and strived to make the meaning of each sentence match the intended move better.

In other words, to improve their abstracts, students tried several ways of achieving the intended communicative purposes. From the analysis of their two drafts and the transcripts of the interviews, it was found that, through the use of the AWE system, students were able to add, revise, or change the sequence of their sentences to express their meaning and to better present a complete abstract structure.

Discussions & Conclusion

The purpose of this study was to develop and evaluate a genre-based AWE system for assisting Taiwanese engineering graduate students with the writing of RA abstracts. This study presents a novel design of the

AWE system considering users' native language and promoting interaction for language learning through co-constructed feedback. Similar to previous studies (Cotos, 2014; Saricaoglu, 2019), the use of genre-based AWE systems yielded positive findings in terms of Language learning potential and Meaning focus as evaluated according to Chapelle's (2001) framework. In this study, with appropriate training, most students were able to notice the AWE feedback and tried to improve their use of lexical bundles and grammatical categories of verbs to fulfill the genre conventions. Moreover, students tended to improve their abstract structure to incorporate all four moves by adding or revising sentences to express the intended communicative purposes.

These positive results allow for some implications for genre-based AWE system design. First, genre analysis is fundamental for genre-based AWE system development. In the past, teaching materials for genre-specific writing have been developed using specialized corpora (e.g., Chang & Kuo, 2011; Hsieh & Liou, 2008). Similarly, to ensure the relevance of the feedback provided by the genre-specific AWE system, a representative corpus of the target genre was collected (Cotos, 2011; Saricaoglu, 2019). The subsequent linguistic analyses on this specialized corpus and the evaluation of the system suggest that the AWE feedback was helpful to the genre-specific task.

The current study suggests the importance of considering learner characteristics in choosing the targeted linguistic features. Specifically, the target learners being EFL engineering graduate students dictated the selection of the two linguistic features (lexical bundles and grammatical categories of verbs). First, the lack of knowledge on using lexical bundles in abstracts was a difficulty encountered by engineering graduate students in Taiwan based on a needs analysis (Feng, 2013), and this issue was seen in students' first drafts of their abstracts. Providing automated feedback on these features proved beneficial as students substantially increased their use of lexical bundles in their final drafts. Similarly, verb categories in RA abstract writing posed a challenge for the students. Previous studies have investigated the use of verb categories in RA abstracts (Cross & Oppenheim, 2006; Gratez, 1982; Salager-Meyer, 1992; Tseng, 2011). To fulfill genre conventions, it proved useful to explicitly present the use of verb categories to L2 learners whose native language is tenseless, and that is why implementing the automatic detection of this linguistic feature is worthwhile.

Finally, this study presents an interactive AWE system that co-constructs feedback with the students based on their input about the intended moves. Based on the Interaction and Noticing Hypotheses (Gass & Mackey, 2006; Long, 1983; Schmidt, 1990), the co-construction of feedback is able to provide more opportunities for intrapersonal and interpersonal communication than feedback generated solely from computers. As Hudyakov and Chukharev (2004) stated, combining human and computer input may enhance the effectiveness of solving linguistic problems. This interactive AWE system provides students with a new approach to interacting with feedback, and it is hoped that this approach holds potential for enhancing genre-specific learning.

In interpreting the results of this study, readers should be aware of two limitations. First, due to the low number of participants, no control group was included. Further, it is undeniable that, without the workshop, the students would have not been able to learn the concept of moves, and to understand how grammatical categories and lexical bundles are used within moves. However, with appropriate guidance, the implementation of the genre-based AWE system could increase the chance of interaction and further promote learning for genre-specific usage.

Additionally, the limited time frame of students' use of the AWE system was another limitation. In order to provide students with sufficient assistance in practicing the writing of their abstracts, students should be allowed to spend more than six hours on using the system or have access to the system outside of class. The results indicate that, although 10 (76.9%) students improved their move structure, only seven (53.8%) students achieved the mastery of all moves in their abstracts. It is hoped that students could improve their

abstracts even more if they were allowed to use the AWE system as much as they wanted.

Future studies could also integrate other linguistic features in genre-based AWE systems. For L2 learners, providing linguistic support based on their L1 could help them achieve the communicative purposes in the intended genre with concrete guidance. Besides, the interactive approach to co-constructing feedback could be considered for future genre-based AWE system development. The more chances are offered for noticing the language differences and for interacting in the co-construction of feedback, the higher the possibility for learning genre-specific language. Lastly, it would be interesting to investigate how teacher feedback and computer-generated feedback may be used in tandem to increase the efficiency of L2 writing development, which could be the next step for genre-specific writing pedagogy.

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Notes

1. Here we must acknowledge the long-standing theoretical debate about the presence of a "future tense" in modern English. However, for the purposes of the present article, we subscribe to a system that posits the existence of a grammatically expressed future tense in English (i.e., the "will + V" construction), in part because this system is in use in the pedagogical setting that we describe. The reader can treat this choice as purely conventional as our intention is not to make a theoretical argument about the system of English grammar.

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About the Authors

Hui-Hsien Feng is an Assistant Professor in the English Department at National Kaohsiung University of Science and Technology, Taiwan. Her research interests include computer-assisted language learning, second-language writing, automated writing evaluation, and computational linguistics.

E-mail: hxfeng@nkust.edu.tw

Evgeny Chukharev-Hudilainen is an Associate Professor in the Applied Linguistics and Technology program at Iowa State University. His main research focus is on the cognitive processes that underlie language acquisition and language production.

E-mail: evgeny@iastate.edu