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# Role of Discipline-specific Vocabulary in L2 Reading by Chinese Chemistry Major Undergraduates

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## Abstract

This study explored the contribution of second language (L2) discipline-specific vocabulary to Chinese chemistry major undergraduates' reading of textbooks. Participants included 82 second-year undergraduates majoring in chemistry. Their discipline-specific vocabulary knowledge and chemistry textbook reading ability were measured. Their L2 proficiency and chemistry knowledge data were collected. Correlation and multiple regression analyses revealed that discipline-specific vocabulary was highly correlated with L2 proficiency and disciplinary knowledge, and discipline-specific vocabulary contributed the most to textbook reading, bigger than either L2 proficiency or disciplinary knowledge. Implications for discipline-specific vocabulary and English for academic purposes (EAP) reading instructions are discussed.

***Keywords**:* L2 Discipline-specific vocabulary, EAP reading, L2 proficiency, disciplinary knowledge

English for academic purposes (EAP) refers to English language research, instruction, and learning that focuses on the specific communicative needs and practices of particular groups in academic contexts (Flowerdew & Peacock, 2001; Hyland & Hamp-Lyons, 2002). A similar term, Cognitive Academic Language Proficiency (CALP), was designated by Cummins (1991, 2008) to differentiate language skills for academic purposes and those for basic interpersonal communication. In the past two decades, the need for EAP has been deeply felt at Chinese universities. Chinese scholars constitute a major force in scientific publications, second only to the United States (Lei & Liao, 2017; Moiwo & Tao, 2013), and the language used for scientific publications is mainly English (Zhang et al., 2013; Zhou & Leydsdorff, 2006). Most of these scholars learn English in China, although some of them have been educated in western countries. Thus, EAP education in China is a tremendous task for universities. EAP education usually begins with reading textbooks in a given discipline written in English, which is a preparatory stage for journal article reading and writing. The need to develop academic textbook reading ability has been reported by many studies (e.g., Anderson, 2015; Hartshorn et al., 2017; Jackson, 2005; Kaewpet, 2009; Pritchard & Nasr, 2004; Ward, 2001). The difficulties in developing textbook reading ability have also been widely discussed (e.g., Amer, 1994; Ward, 2007, 2009). This situation indicates that further investigation is required. The present study aims to investigate how different factors influence academic textbook reading comprehension.

Possible factors include discipline-specific vocabulary, English proficiency, disciplinary knowledge, features of reading texts, and cognitive and metacognitive strategies. In the present study, we focus on discipline-specific vocabulary because its role in EAP reading has been repeatedly emphasized, but understudied (Chung & Nation, 2003, 2004). Discipline-specific vocabulary refers to words that occur frequently in a specific discipline, but are not so common elsewhere (Chung & Nation, 2004; Ha & Hyland, 2017). The meanings of these words are closely associated with a specific discipline (Mudraya, 2006; Paquot, 2010; Valipouri & Nassaji, 2013). Few studies have been conducted on the role of discipline-specific vocabulary in L2 reading, which is contrary to systematic research on the contribution of general vocabulary to reading comprehension of English as a second or foreign language (ESL or EFL) (e.g., Jeon & Yamashita, 2014; Milton et al., 2010; Zhang, 2012) and academic vocabulary to EAP reading comprehension (Paribakht & Webb, 2016).

We also incorporate English proficiency and disciplinary knowledge in this study for theoretical and methodological considerations. First, we know very little about how discipline-specific vocabulary is related to knowledge. Some researchers claim that discipline-specific vocabulary is part of a system of subject knowledge (Chung & Nation, 2004; Nagy & Townsend, 2012). The claim suggests a strong relationship between them, but few studies have provided empirical evidence linking the two. Second, disciplinary knowledge also influences reading comprehension if the text is highly discipline-specific (Douglas, 2000). Therefore, its role cannot be ignored in EAP reading comprehension. Third, discipline-specific vocabulary is a category of vocabulary, but little research has focused on how it is related to English proficiency in general. Finally, we attempt to employ the multiple regression analysis to explore the influence of discipline-specific vocabulary to English textbook reading comprehension. The magnitude of its influence would be inflated if these two essential independent variables are not incorporated in the multiple regression equation. The following two research questions guided the present study.

1. What is the relationship between discipline-specific vocabulary, L2 proficiency, and disciplinary knowledge?
2. What is the contribution of discipline-specific vocabulary to English textbook reading, and what are the contributions of L2 proficiency and disciplinary knowledge?

## Literature Review

### *Characteristics of discipline-specific vocabulary*

Discipline-specific vocabulary is a category of vocabulary. Some similar terms include technical vocabulary (e.g., Chung & Nation, 2004; Ha & Hyland, 2017; Kwary, 2011; Nation, 2001), subject-related vocabulary (e.g., Ward, 2007), specialized vocabulary (e.g., Gablasova, 2014; Lessard-Clouston, 2006), as well as science vocabulary (e.g., Taboada, 2012). The term "discipline-specific vocabulary" is adopted in the present study because it embraces both the technical sense of natural sciences and the abstractions of social sciences and humanities (Nagy & Townsend, 2012). Nation (2001) categorized vocabulary into four types (i.e., general service words, academic vocabulary, discipline-specific vocabulary, and low frequency words). General service vocabulary consists of approximately 2000 of the most frequently used word families, covering around 80% of the words in academic texts. Academic vocabulary includes 570 words that are commonly used in various kinds of academic texts, which covers 8.51% of the running words. Discipline-specific vocabulary is closely related to a particular subject area, numbering about 1000 words for a specific discipline. It covers about 5% of the words in academic texts, varying from discipline to discipline (Gablasova, 2015; Valipouri & Nassaji, 2013). Low frequency words are rarely encountered in everyday reading, although they are the largest group of words. However, there is no definitive boundary between these four types of vocabulary. One person's technical vocabulary may be another person's low-frequency words (Nation, 2001).

Discipline-specific vocabulary has four prominent features. First, discipline-specific vocabulary is domain-specific (Chung & Nation, 2004; Paquot, 2010). Some discipline-specific words are exclusively used in a particular discipline, while some can be used outside the specific discipline, but interpreted differently from within this discipline (Nation, 2001). Second, being specific is a continuum depending on how restricted a word is to a specific discipline. Some words are most discipline-specific. For example, isotope, aldehyde, and redox rarely appear outside chemistry. Some words are used both inside and outside a specific discipline, but with different meanings, such as complex and lattice. Some words have little specialization of meaning, but students with knowledge in the discipline understand the meaning of the word more deeply. For example, both chemistry and non-chemistry major students recognize oxygen as a type of gas needed by animals and plants to survive, but the former know more details of its physical and chemical properties. Third, discipline-specific vocabulary has salient linguistic features. It usually contains more Latin and Greek words than other types of vocabulary; it has more morphologically complex words with prefixes and suffixes (Chung & Nation, 2003; Fang, 2008; Gablasova, 2014; Nagy & Townsend, 2012). Fourth, discipline-specific vocabulary is part of disciplinary knowledge (Bravo & Cervetti, 2009; Chung & Nation, 2004). Discipline-specific vocabulary is loaded with important concepts of the specific field of study, and it provides access to disciplinary knowledge (Coxhead, 2018). To sum up, discipline-specific vocabulary is domain-specific, along a continuum of specificity, linguistically complex, and closely related to disciplinary knowledge.

### *Identification of discipline-specific vocabulary*

To reliably identify discipline-specific vocabulary is the prerequisite to investigate its function in EAP reading. L2 researchers have developed various measures. Chung and Nation (2004) introduced four approaches: (a) using a discipline dictionary compiled by specialists; (b) using clues provided by actual textbook writers, such as word marking through bolding or italicization, words with explicit definition, words in the textbook glossary; (c) using a rating scale to ask specialists to decide; and (d) using computer-based techniques to compare the frequency of occurrence of words in a particular discipline with their frequency of occurrence in other disciplines.

Based on the study of Chung and Nation (2004), Kwary (2011) proposed a hybrid method for determining discipline-specific vocabulary. The method mixed computer-based keyword analysis and systemic classification. Keyword analysis compares word frequency in the target corpus and a reference corpus in order to identify keywords, words which occur with unusual frequency in a specific text. The systematic classification approach involves classifying a subject into several fields and selecting terms that are only relevant to specific fields. Valipouri and Nassaji (2013) developed a 1400-word Chemistry Academic Word List based on frequency, range, and specialized occurrence. This list contains about 1000 words on the General Service List and Academic Word List. Ha and Hyland (2017) employed the Technicality Analysis Model to classify words along a continuum with five degrees of technicality (i.e., least, slightly, moderately, very, and most technical). They used the word lists of the New General Service List (NGSL), the British National Corpus (BNC), and the Corpus of Contemporary American English (COCA) as reference. A word is least technical if it does not have a specialized sense in a dictionary; a word is slightly technical if it is in either the NGSL or the first and second frequency rank of BNC or COCA and has a specialized meaning; along this continuum, a word is most technical if it is in the $10^{th}$ to $25^{th}$of the frequency rank of BNC or COCA, has a specialized sense, and cannot be understood without relevant disciplinary knowledge.

These methods emphasize different facets of the characteristics of discipline-specific vocabulary. Some focus on the frequency of its occurrence (Kwary, 2011; Valipouri & Nassaji, 2013); some are concerned with its degrees of specificity (Ha & Hyland, 2017); some underscore its domain-specific nature by consulting specialists' judgments (Chung & Nation, 2004; Kwary, 2011). For the present study, we adopted two methods from Chung and Nation (2004), namely, using clues provided by the textbook writer and using a rating scale in which specialists are asked to decide.

### *Empirical studies on the contribution of discipline-specific vocabulary to EAP reading*

Most empirical studies on the contribution of discipline-specific vocabulary to reading ability have focused on first language (L1) students at the K-12 levels in the United States (Nagy & Townsend, 2012, p.98). Several studies have been conducted to investigate ESL secondary students' reading of science textbooks (e.g., Ardasheva et al., 2017; Taboada, 2012). These researchers often use terms such as "science reading" and "science vocabulary." Few studies have examined EFL college students' reading of subject textbooks (e.g., Hsu, 2014; Ward, 2009).

Taboada (2012) examined the contribution of science vocabulary to Grade 5 students' science reading comprehension of three groups of learners, which were native speakers of English, ESL learners (English language learners in the US), and EFL learners (English language learners in a Spanish-speaking country). The results showed that science vocabulary accounted for a significant amount of variance in science reading comprehension over and above the variance accounted for by general vocabulary and language proficiency. Ardasheva et al. (2017) reported the correlation between science vocabulary and science reading. It was found that science vocabulary is closely related ($r$ = .70) to textbook reading comprehension. Roo et al. (2018) investigated the contribution of science vocabulary to science reading. The findings suggested that science vocabulary knowledge was the strongest predictor of science reading comprehension among factors such as academic vocabulary and anxiety. Ardasheva et al. (2019) also revealed a strong predictive power of science vocabulary to science reading comprehension.

Overall, these empirical studies have revealed the important role of discipline-specific vocabulary. They focused exclusively on young ESL learners reading science textbooks. No research, to our knowledge, has addressed the issue of EFL university students, who urgently need improvement on EAP reading (Flowerdew & Peacock, 2001). ESL learners and EFL learners differ greatly in their purposes of reading. As to ESL students, they read science textbooks to simultaneously acquire language skills and subject knowledge (Ardasheva & Tretter, 2017; Paquot, 2010; Woodward-Kron, 2008). EFL adult college students, however, generally read textbooks to integrate their English proficiency and previously learned disciplinary knowledge to prepare themselves for other academic activities. The present study aims to investigate the contribution of discipline-specific vocabulary knowledge to the textbook reading ability of EFL university students, and those of L2 proficiency and disciplinary knowledge. In addition, this study examines the relationship between discipline-specific vocabulary, L2 proficiency, and disciplinary knowledge.

## The present study

### *Context*

The present study was embedded in a course of academic English in chemistry at a key Chinese university for one semester (3 hours per week; 16 weeks in total). This course aimed to facilitate Chinese college students' ability to read chemistry textbooks in English and to familiarize them with the standards of academic writing and publication in English. The course was compulsory for all chemistry major undergraduates. It was taught by a professor in chemistry who had studied in an English-speaking country for five years and obtained her doctoral degree there. The course lecture was delivered in Chinese and English. The two languages were used in a balanced way. The main textbook adopted in the course was *Advanced Chemistry through Diagrams* (Lewis, 2001). The content of the textbook involved basic chemistry knowledge and was familiar to all participants. However, the English expressions of the same knowledge were difficult for them to understand. For example, all participants were familiar with the knowledge of atomic structure and isotopes, but most of them did not understand the English sentence, "Isotopes are atoms with the same atomic number but different mass numbers." A typical activity of the course was that the instructor read an English passage on a topic in the textbook, and she presented PowerPoint slides to help students retrieve their disciplinary knowledge and to understand the corresponding English sentences. Other textbooks were recommended by the course instructor, including *Fundamentals of General, Organic, and Biological Chemistry* (McMurry et al., 2014), *The Extraordinary Chemistry of Ordinary Things* (Snyder, 2003), *Understanding Chemistry* (Lister & Renshaw, 2000), and *Principles of General Chemistry* (Silberberg, 2013).

### *Participants*

The participants of the present study were 82 second-year college students from a key university in China. Among them, 32 were females and 50 males, aged from 18 to 20. Nearly all of them had learned English for eight years, starting from primary school. Besides this academic English course, the students had a 2-hour general English course on a weekly basis. The students had completed courses in organic chemistry, inorganic chemistry, and analytical chemistry in Chinese. They also had courses on laboratory operation. Their chemistry knowledge level was much higher than the knowledge needed in the textbook in English.

### *Procedures*

Data collection took place over three major stages. First, the instruments to measure academic textbook reading ability and discipline-specific vocabulary were designed and piloted at the beginning of the semester. The participants in the pilot study were not included in the main study. Second, English proficiency and disciplinary knowledge data were collected in the middle of the semester. Third, academic textbook reading ability and discipline-specific vocabulary data were collected at the end of the semester.

### *Measures*

*The measure of academic textbook reading ability.* The design of the measure of reading ability was guided by the principle of testing languages for specific purposes (Davies, 2001; Douglas, 2001). Based on the objectives of the course, four types of reading skills were described and were used as the basis for testing item writing:

- To identify and locate specific information in expository and instructive passages
- To understand the information conveyed by graphs and tables
- To understand logical organization of sentences and paragraphs, such as problem-solution, compare-contrast, claim-evidence, question-answer, and argue-counterargue.
- To summarize the central idea of the text

Four passages were selected from the referenced textbooks. They were of 229, 240, 239, and 252 words, respectively, with a total length of 960 words and standard deviation of 9.42. Testing items were written by the authors and two professors in chemistry. Question types include short-answer questions, true or false judgment, translation, and summary. The total score for the test was 100 points, which is a commonly used scoring method in China. The four-passage reading comprehension test was piloted with 15 students who had completed the course. Item analysis was conducted by SPSS to assess the test reliability. Items with low item-total correlations were revised. The final observed Cronbach's alpha reliability was 0.730. Two authors scored the test together. At the initial stage, five test papers were used as a trial for scoring, resulting in agreement on 84% of the items. Disagreements mainly existed in the scoring of short-answer questions and summary regarding to what degree details should be included. Based on discussion, the scoring criterion was set. After that, when disagreement on unusual answers emerged (e.g., extremely short answers with only one or two key words), the two raters negotiated to reach an agreement.

*The measure of discipline-specific vocabulary.* To measure participants' discipline-specific vocabulary requires identifying which words in the textbook are discipline-specific and which are not. This study employed two types of vocabulary identification methods. First, the clues provided by the textbook, namely the glossary in the textbook, were used. The glossary consisted of 1900 entries, with 1314 words (69.16%) (e.g., "lattice," "metallic") and 586 phrases (30.83%) (e.g., "alpha particle," "helium nuclei"). Stratified sampling was used, and words and phrases were proportionally selected, resulting in 120 items (83 words and 37 phrases).

Second, the items were screened by the two professors in chemistry using a four-point rating scale designed to measure the strength of the relationship of a word or a phrase to the field of chemistry (Chung & Nation, 2004). The four-point scale is shown in Table 1. Items that rate 3 and 4 were classified as discipline-specific vocabulary in the field of chemistry and retained in the list. Those rating 1 and 2 were excluded. The screening resulted in 106 items, with an inter-rater agreement of 96%. The remaining 106 items were then piloted among the 15 chemistry major students. After a reliability analysis based on item-to-total correlation via the SPSS software, 100 items (69 words and 31 phrases) remained and were used for the present study. The observed Cronbach's alpha reliability of the final 100 items was 0.922.

A three-step item discrimination analysis with the 82 participants was also conducted to examine the quality of the vocabulary measurement. Discrimination index D was used, which is the difference between the correct answer rates of two extreme groups. First, the 82 participants were ranked according to their vocabulary scores. Second, a best performers' group was established with the top 27% (22 participants). Similarly, a poorest performers' group was built with the bottom 27% (22 participants). Third, discrimination indices were calculated for each item. The result revealed that the average discrimination index was 0.42, with the highest at 0.86, and the lowest at -0.02. These analyses showed that the measurement was appropriate to be used to gauge participants' discipline-specific vocabulary.

**Table 1**

*A Rating Scale for Identifying Discipline-specific Vocabulary in Chemistry*

| Rating | Descriptions |
|---|---|
| 1 | Words or phrases whose meaning is similar in general language and is not particularly related to the field of chemistry, e.g., "use," "position," "calculation," and "level." |
| 2 | Words or phrases whose meaning is minimally related to the field of chemistry in that they describe the knowledge of chemistry that are easily understood and are frequently encountered in general language, e.g., "energy," "temperature," "solid," and "liquid." |
| 3 | Words or phrases whose meaning is closely related to the field of chemistry. They are seldom used in general language, but might be used in other fields of study with similar meaning, e.g., "spectroscopy," "oxidation," "organic acid," and "electron pairs." |
| 4 | Words or phrases whose meaning is specific to the field of chemistry and they are scarcely known and used in other fields of study, e.g., "metallic," "stereoisomer," "electrophiles," and "dipole moment." |

*Measure of English proficiency.* English proficiency of the participants was estimated by their examination scores in the college English course from the previous two semesters. The examination is university-based and is administered to 7,000 or so college students each semester. The purpose was to measure first- and second-year students' development of English proficiency. It was composed of listening, reading, writing, and integrated items. The test underwent item writing, item screening, item analysis, and test piloting before the test administration.

*Measure of disciplinary knowledge.* Chemistry knowledge was indicated by their average scores of two inorganic chemistry courses, one organic course, and one analytical chemistry course. These were the main chemistry courses they took before the present study. These four courses in disciplinary knowledge were instructed in Chinese. The maximum possible score for each of them was 100 points.

## Results

This study intended to examine the relationship between English proficiency, disciplinary knowledge, and discipline-specific vocabulary, as well as the contribution of discipline-specific vocabulary to Chinese chemistry undergraduates' academic textbook reading comprehension.

### *Descriptive statistics of the variables*

The maximum possible score for the four variables was 100 points, respectively, with 60 points as a passing score. Table 2 presents the descriptive statistics of the three independent variables and one dependent variable. It shows that the mean of discipline-specific vocabulary was 34.2 points, far below the passing score of 60 points. Its standard deviation was 18.8, the biggest among all variables. The results indicate that students did not master discipline-specific vocabulary well. Compared with their scores of English and disciplinary knowledge, the mean score of discipline-specific vocabulary was the lowest. The mean scores of English proficiency and disciplinary knowledge were 78.8 and 76.7, respectively, which imply the participants had fairly good mastery of linguistic and disciplinary knowledge. The mean of the dependent variable, EAP textbook reading comprehension, was 72.8. This suggests the participants could read the textbook written in English with adequate comprehension.

**Table 2**

*Descriptives of the Variables and Reliabilities (N = 82)*

| Variable | Min | Max | Mean (Maximum possible score) | SD | Reliability (Cronbach) |
|---|---|---|---|---|---|
| Discipline-specific vocabulary | 13 | 92 | 34.2 (100) | 18.8 | 0.922 |
| English proficiency | 53 | 95 | 78.8 (100) | 8.1 | - |
| Disciplinary knowledge | 44 | 94 | 76.7 (100) | 10.7 | - |
| Reading comprehension | 36 | 90 | 72.8 (100) | 5.2 | 0.73 |

### *Results of correlation analyses*

Correlation analyses show that all three independent variables correlated significantly with the dependent variable. Discipline-specific vocabulary correlated significantly with academic textbook reading comprehension ($r = .511$, $p < .01$) (see Table 3). This indicates that students with larger discipline-specific vocabulary comprehended the textbook significantly better. Textbook comprehension ability is closely related to the students' size of discipline-specific vocabulary. The correlation between English proficiency and reading comprehension was also significant ($r = .442$, $p < .01$), which implies that English proficiency contributed to reading comprehension. Similarly, disciplinary knowledge also correlated significantly with reading comprehension ($r = .408$, $p < .01$), which suggested a strong relationship between them.

**Table 3**

*Correlation Matrix (N = 82)*

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1. Discipline-specific vocabulary | - | | | |
| 2. English proficiency | .467** | - | | |
| 3. Disciplinary knowledge | .550** | .343** | - | |
| 4. textbook reading | .511** | .442** | .408** | - |

*Note.*** Correlation is significant at the 0.01 level (2-tailed).

Among the three independent variables, discipline-specific vocabulary correlated significantly with English proficiency ($r = .467$, $p < .01$) and with disciplinary knowledge ($r = .550$, $p < .01$). These results implied strong relationships between discipline-specific vocabulary and English proficiency and disciplinary knowledge. The correlation between English proficiency and disciplinary knowledge was the smallest ($r = .343$, $p < .01$). It implies that their relationship is not as strong as other pairs.

**Table 4**

*Results of Sequential Multiple Regression Analysis (N = 82)*

| Model | Beta | $R^2$ | $\Delta R^2$ | Sig | Tolerance | VIF |
|---|---|---|---|---|---|---|
| 1 | | 0.27 | 0.27 | 0 | | |
| English proficiency | 0.34 | | | 0 | 0.88 | 1.13 |
| Disciplinary knowledge | 0.29 | | | 0.01 | 0.88 | 1.13 |
| 2 | | 0.33 | 0.06 | 0.01 | | |
| English proficiency | 0.24 | | 2.3 | 0.02 | 0.77 | 1.29 |
| Disciplinary knowledge | 0.15 | | 1.37 | 0.18 | 0.69 | 1.45 |
| Discipline-specific vocabulary | 0.31 | | 2.64 | 0.01 | 0.61 | 1.64 |

*Note.* The cutoff of the *p* value was set at 0.05 (2-tailed).

***Results of multiple regression analyses***

Given that less attention has been given to discipline-specific vocabulary in L2 textbook reading, especially in EAP chemistry, the present study aimed to examine its role in L2 chemistry textbook reading. Sequential multiple regression analyses were employed. The unique variance in L2 reading that was explained by discipline-specific vocabulary was examined by comparing two models. Model 1 with English proficiency and disciplinary knowledge as independent variables, and Model 2 with the addition of discipline-specific vocabulary to the previous two variables. The change in $R^2$ between these two models was the unique variance in L2 reading explained by discipline-specific vocabulary.

Table 4 shows that the overall multiple regression of Model 1 was significant ($R^2 = .27$, $F$ [2,79] = 14.61, $p < .001$). The tolerance values for the two variables were both .88, which was close to 1, and variance inflation factor (VIF) values were 1.13, much smaller than 5. These results implied that significant multicollinearity did not exist between the two variables. Model 2 with discipline-specific vocabulary as an additional independent variable was significant ($R^2 = .33$, $F$ [3,78] = 12.79, $p < .001$). The tolerance values for the three variables were close to 1, and all VIF values were much smaller than 5, which indicated that significant multicollinearity did not exist between the three variables.

The results of Model 1 revealed that the two independent variables (i.e., English proficiency, disciplinary knowledge) accounted for 27% of the variance in academic textbook reading comprehension. The results of Model 2 revealed that the three independent variables (i.e., English proficiency, disciplinary knowledge, and discipline-specific vocabulary) accounted for 33% of the variance in academic textbook reading comprehension. Table 4 also shows that $\Delta R^2$of model 2 was .06 ($p = .010$). This result indicated that discipline-specific vocabulary accounted for an additional 6% variance in L2 reading beyond English proficiency and disciplinary knowledge, and its contribution was significant.

Table 4 also shows that the beta value for discipline-specific vocabulary was .31, which was bigger than English proficiency ($\beta = .24$; $p < .05$) and disciplinary knowledge ($\beta = .15$; $p = .18$). This means that each standard deviation increase in vocabulary can lead to .313 standard deviation increase in reading comprehension, controlling English proficiency and disciplinary knowledge. Its contribution to L2 reading was the biggest among the three independent variables. English proficiency also contributed significantly to L2 reading. However, the contribution of disciplinary knowledge was not significant.

## Discussion

The present study investigated the relationships between discipline-specific vocabulary, L2 proficiency, and disciplinary knowledge. It also examined the contribution of discipline-specific vocabulary to textbook reading of 82 EFL chemistry major students, as related to the contributions of English proficiency and disciplinary knowledge. This section discusses the results in response to the two research questions.

### *What is the relationship between discipline-specific vocabulary, English proficiency, and disciplinary knowledge?*

The relationship between discipline-specific vocabulary, L2 proficiency, and disciplinary knowledge was examined in the present study. The results showed that discipline-specific vocabulary was significantly correlated with L2 proficiency, implying that higher L2 proficiency might help with discipline-specific vocabulary acquisition. This result lends support to Ardasheva et al.’s (2017) observation that differences in L2 proficiency influenced science vocabulary learning. Students’ morphological knowledge may help them deconstruct and expand discipline words. General meaning of words may facilitate the learning of additional meanings of the same words. For example, the general senses of “potential,” "noble," and "abundance" are related to their specialized senses in technical phrases in "potential energy," "noble metals," and "isotope abundances."

A strong correlation between discipline-specific vocabulary and disciplinary knowledge suggested that learners with higher disciplinary knowledge are more likely to have better mastery of discipline-specific vocabulary. Collectively, the findings provided further evidence to support researchers' claim that discipline-specific vocabulary, a category of L2 vocabulary, is also a part of domain knowledge (Bravo & Cervetti, 2009; Nagy, 2005; Woodward–Kron, 2008). This nature of duality renders discipline-specific vocabulary different from other types of vocabulary, such as high-frequency vocabulary and academic vocabulary.

***What is the contribution of discipline-specific vocabulary to textbook reading, as related to the contributions of English proficiency and disciplinary knowledge?***

This study revealed the unique contribution of discipline-specific vocabulary to textbook reading based on correlation and sequential multiple regression analyses. Firstly, the results of the correlation analysis showed that discipline-specific vocabulary and textbook reading comprehension are closely related. The revealed correlation is consistent with the result of Roo et al.'s study (2018), which was conducted among ESL secondary school learners. The similar results suggest that for both ESL and EFL learners, discipline-specific vocabulary is significantly related to L2 textbook reading comprehension. The correlation revealed by the current study, however, is smaller than those reported by Taboada (2012) and Ardasheva et al. (2017). The divergence might be attributed to different learner groups involved. ESL secondary students usually have little disciplinary knowledge when they learn related words, but EFL college students in general possessed basic disciplinary knowledge when they begin to read discipline textbooks written in English.

A further examination with the sequential multiple regression analyses revealed a significant role of discipline-specific vocabulary in L2 textbook reading ability. Discipline-specific vocabulary makes unique contributions to L2 textbook reading beyond English proficiency and disciplinary knowledge. It has also emerged as the strongest predictor of textbook reading ability. Even if disciplinary knowledge was familiar to students, which has been learned through L1, it cannot play a role in textbook reading if they do not understand English language mappings of the knowledge. Only after they are familiar with related discipline-specific vocabulary, can they activate disciplinary knowledge and make use of syntactic knowledge learned in general English courses. This result suggests that discipline-specific vocabulary contributes more than L2 proficiency and disciplinary knowledge when it comes to understanding L2 subject textbooks. The findings of the current study corroborated the results of some other studies (e.g., Roo et al., 2018; Ardasheva et al., 2017). These studies provided empirical evidence for the essential role of discipline-specific vocabulary in textbook reading comprehension, as highlighted by some researchers (e.g., Gablasova, 2015; Ward, 2007).

Despite the strong contribution of discipline-specific vocabulary to L2 textbook reading comprehension, the learners in the present study did not have adequate mastery of the related words (only 34.2%). It was the lowest level of mastery compared with English proficiency and disciplinary knowledge. This implies that discipline-specific vocabulary poses a severe challenge to Chinese undergraduates. This result agrees with the findings of many other studies. Evans and Morrison's (2011) survey found that understanding discipline-specific vocabulary was one of the most serious problems for first-year college students in Hong Kong. The difficulties of discipline-specific vocabulary acquisition were also reported by Evans and Green (2007). The challenge of discipline-specific vocabulary to college students has been repeatedly reported, but its teaching and learning in the EFL context has scarcely been reported (Woodward-Kron, 2008). The instructor of the course, in which the present study is embedded, spent little time teaching discipline-specific vocabulary.

English proficiency and disciplinary knowledge have also been found to be correlated strongly with EAP textbook reading. The multiple regression analysis further revealed that English proficiency was a significant contributor to textbook reading comprehension. The role of English proficiency in EAP reading found in the present study agrees with the findings in Taboada (2012) and Ardasheva et al. (2017). They found that L2 proficiency was a significant predictor of reading comprehension. High L2 proficiency implies that learners have adequate syntactic knowledge, which plays a key role in reading comprehension, especially when reading passages with long and complex sentences.

The correlation between disciplinary knowledge and textbook reading was significant, being slightly lower than that between L2 proficiency and textbook reading. However, the results of sequential multiple regression analyses revealed that disciplinary knowledge to textbook reading did not contribute significantly to academic textbook reading. Three reasons might account for this surprising result. First, disciplinary knowledge correlated strongly with discipline-specific vocabulary ($r = .550$), and it appears that it has captured much of the same pool of variance in textbook reading comprehension as discipline-specific vocabulary. Second, it is possible that disciplinary knowledge might not contribute directly to EAP reading, but its effects might be mediated by discipline-specific vocabulary. It suggests that even if the person has high disciplinary knowledge, its function can hardly be activated if the person does not know corresponding English vocabulary. Third, in the present study, academic textbook reading only involved basic chemistry knowledge. Participants' chemistry knowledge level was much higher than the knowledge needed in the textbook reading. Thus, it might be that chemistry knowledge had a ceiling effect in the present study. Variance in disciplinary knowledge did not play a role in differentiating textbook reading ability.

## Conclusion and Implications

By examining the nature of discipline-specific vocabulary, the present study has mainly investigated the contribution of discipline-specific vocabulary to EAP textbook reading ability. The study has revealed three major findings. First, it was found that discipline-specific vocabulary contributed the most to textbook reading ability, compared with the contributions of English proficiency and disciplinary knowledge. Second, EFL college students did not have adequate mastery of discipline-specific vocabulary. Its score was far below the commonly used passing score in China, and below their English proficiency and disciplinary knowledge. This obvious deficiency poses a severe challenge to EFL college students. Even so, instructors seldomly design in-class activities to promote the learning of discipline-specific vocabulary. Instead, they mainly focus on how to express students' previously learned disciplinary knowledge in English. Teachers probably assume that memorizing vocabulary is students' own responsibility. Third, discipline-specific vocabulary is significantly correlated with English proficiency and disciplinary knowledge. It suggests that these two skills can promote the learning of discipline-specific vocabulary. The findings of this study have two important implications for discipline-specific vocabulary instructions.

First, discipline-specific vocabulary needs to be explicitly taught in class and learned after class. The present study revealed a significant contribution of discipline-specific vocabulary to EAP textbook reading. Learning the words required for disciplinary reading is a formidable task to EFL college students, which has been repeatedly reported by former research and by the present study. Direct discipline-specific vocabulary-oriented instructive activities would lower the challenge of the task and promote the process of learning discipline-specific words (Gablasova, 2015). Analyses of the characteristics of discipline-specific vocabulary would benefit the design of instructive activities (Fang, 2008; Woodward-Kron, 2008). For example, words in chemistry feature high frequency of prefixes and suffixes. Words with the same prefix or suffix could be taught together (e.g., “propane,” “propyl,” “propene,” “propyne,” “propanol,” “propanalas,” “methane,” “ethane,” “propane,” “butane,” “pentane,” “hexane,” “heptane,” “octane,” “nonane,” and “decane”).

Second, discipline-specific vocabulary acquisition could benefit from activating students’ L2 linguistic and disciplinary knowledge. The present study found that discipline-specific vocabulary was significantly correlated with English proficiency and disciplinary knowledge. The results imply that some vocabulary instructional activities may call up students’ foreign language knowledge. When the specialized sense of some discipline-specific words is related to the general sense of the words, explaining the shared connotations of the words used inside and outside the discipline would facilitate students’ learning of the words (Ha & Hyland, 2017). Similarly, students’ disciplinary knowledge can also be activated in the vocabulary instruction. For example, chemistry major students’ disciplinary knowledge is typically stored in the way of networks linked by related concepts. These concepts usually appear in clusters, not individual concepts in isolation (Nagy & Townsend, 2012). Therefore, some vocabulary instructional activities could focus on teaching a cluster of conceptually related words, such as, “covalent bonding,” “ionic bonding,” and “metallic bonding.”

The present study appeared to reveal the significant role of discipline-specific vocabulary to Chinese EFL chemistry major undergraduates’ EAP textbook reading comprehension. However, the findings of the present show that discipline-specific vocabulary, together with English proficiency and disciplinary knowledge, only accounts for 33% of the variance in academic textbook reading. Future research may incorporate other factors that may influence textbook reading comprehension. Another worthwhile investigation relates to the nature of context. Since discipline-specific vocabulary is context-sensitive, the present study has only explored one group of college students from one discipline. Future research should include academic readers from diverse disciplines and academic backgrounds.

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