The Contribution of General High-Frequency, Core-Academic, and Academic-Technical Words to ESP Reading Comprehension

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Abstract

Reading is recognized as being the most important skill needed by ESP learners in their field of study, and vocabulary knowledge is the most widely discussed component of effective ESP reading per se. However, research on how much the different types of words exert substantial influences over ESP reading comprehension remains scanty. To address this lacuna in the existing literature, the present study aimed to examine the degree of contribution made by general high-frequency, core-academic, and technical-academic words to 127 Iranian learners studying psychology at three state universities in Tehran, Iran. Three researcher-made and validated tests were utilized to measure the three aforementioned types of vocabulary knowledge accompanied by an ESP reading test. Data analysis drawing on multiple regression revealed that the core-academic words and technical-academic words significantly contributed to the ESP reading comprehension, explaining about 92% of the variance in reading scores, but knowledge of general high-frequency words was not a significant contributor. Moreover, teaching core-academic and technical-academic words did not have a significant effect on ESP reading comprehension in the short term, yet a low significant difference was observed for technical academic words in the long term. Findings of this study imply that direct teaching of the core-academic and technical-academic words can help ESP learners improve their reading over time. The article ends with pedagogical implications and suggestions for future research.

Keywords: ESP reading; general high-frequency words; core-academic words; technical-academic words

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INTRODUCTION

Reading is the most frequently used skill among the ESP and EAP students, and there is a consensus over the centrality of reading in virtually all ESP/EAP courses among the experts in this domain (Bravo & Cervetti, 2009; Flowerdew & Peacock, 2001; Grabe & Stoller, 2014). There is also a growing body of scholarship substantiating the significance of academic vocabulary and academic language proficiency (Bailey & Heritage, 2008; Honig, 2010; Snow & Kim, 2007; Snow & Uccelli, 2009). Regarding the eminent role of vocabulary in ESP and EAP courses, Hyland (2016), for example, accentuates that ESP and EAP can be defined mostly as the special vocabulary which characterizes the specific field of study and a good command over the technical words. So, it has been widely acknowledged that vocabulary knowledge exerts the most crucial influence over reading (Durrant, 2014, 2016; Gardner & Davies, 2014, 2016; Hyland & Tse, 2007; Laufer & Ravenhorst-Kalovski, 2010; Liu & Han, 2015; Nation, 2016; Paltridge & Starfield, 2013; Watson-Todd, 2017). The majority of these studies have heightened the pivotal role of the technical word knowledge (Coxhead, 2018; Martinez, Beck & Panza, 2009; Schmitt, Jiang & Grabe, 2011; van Zeeland & Schmitt, 2013) in developing reading comprehension in English for special academic purposes (ESAP) and in English for general academic purposes (EGAP) as well. Furthermore, the academic vocabulary, consisting of general academic words and discipline-specific vocabulary (Hiebert & Lubliner, 2008), has been identified as an indispensable constituent of academic language, the lack of which has continuously been recognized as a hurdle to students' achievements and success (Nagy & Townsend, 2012; Schmitt et al., 2011); however, the use of technical knowledge is dependent on mastery of the general high-frequency words as well as the core-academic words. Meanwhile, research has documented that effective reading of ESP texts is the joint outcome of the simultaneous operation of general high-frequency, core-academic, and academic-technical words without which reading is undermined (Gardner & Davies, 2014).

Laufer and Ravenhorst-Kalovski (2010), for example, have pointed out that at least mastery of a sizeable general high-frequency and core-academic words sounds mandatory for the technical academic jargons to operate and trigger the ESAP reading process. Dang, Coxhead, and Webb (2017), moreover, contend that a general academic wordlist or a discipline-specific wordlist seems more germane depending on the teaching and learning context. That is, a general academic wordlist is more pertinent to English for general academic purposes (EGAP), while a discipline-academic wordlist is more appropriate for English for specific academic purposes (ESAP); however, the contributions and effects of teaching general high-frequency, core-academic, and academic-technical words on ESP reading comprehension seem underexplored (Flowerdew & Peacock, 2001).

As aforementioned, many studies have examined the role of vocabulary in ESP reading and have sought new ways of teaching specialized vocabulary to ESP/EAP learners to enhance their reading; to date, however, no research, to the best of our knowledge, has been undertaken to determine the contributions and effects of teaching general high-frequency, core-academic, and academic-technical words on ESP reading comprehension. Consequently, the present research was launched to address these issues and fill the lacuna in the existing literature. The findings of the current study will be of interest not only to vocabulary researchers but also to subject specialists involved in teaching content knowledge.

LITERATURE REVIEW

Academic language, specialized language both oral and written, is used to convey academic, abstract, and technical ideas and phenomena which per se could augment academic thinking and cognitive processing of disciplinary conceptualizations and postulations (Nagy &Townsend, 2012). As far as the written form of academic language is concerned, the focus of the present study, reading skill has been generally acknowledged as the most

indispensable skill to facilitate the comprehension of ESP/EAP texts (e.g. Bernhardt, 2005; Hyland & Tse, 2007; Jackson, Meyer & Parkinson, 2006). The importance of reading skill in ESP/EAP is so unquestionable that some scholars have characterized it as the main goal of any ESP/EAP program (Dudley-Evans & Maggie-Jo, 1998; Fang, 2006, 2008; Flowerdew & Peacock, 2001; Grabe & Stoller, 2014; Paltridge & Starfield, 2013). This centrality has its roots in the input receiving nature of reading skill and the goal of using English in a content subject, i.e. seeking intended information mostly for transactional purposes.

There is a vast amount of literature about the nature of ESP reading and influential factors that play a crucial part in ESP reading comprehension. Comprehending an ESP text requires different types of linguistic, cognitive, metacognitive knowledge, and background knowledge (Laufer & Ravenhorst-Kalovski, 2010; Paltridge & Starfield, 2013). Many studies and corpus-based analyses corroborate that to comprehend ESP/EAP texts appropriately and with an agency, vocabulary seems to be the most salient linguistic factor (e.g. Cobb, 2007; Coxhead & Demecheleer, 2018; Dang, 2018; Ward, 2009). According to Coxhead (2018), the lexicon is an integral linguistic and cognitive type of related knowledge in the process of ESP reading comprehension for some reasons. First, lexical knowledge of general concepts and entities is required to use the background knowledge needed to understand an L2. Second, some words are about academic meanings that need to be mastered in advance, and third, a group of words has their technical meanings or has been coined to express a special concept. Fang (2006, 2008) has also labeled the role of technical and academic words as unfathomably crucial for success in content reading by L2 students both as the secondary and higher education curricula.

Accordingly, the ESP reader should possess a large and deeply-ingrained repertoire of different types of L2 vocabulary to read fluently and comprehend accurately. These are some arguments in favor of the leading role of vocabulary and the principal contributions of different types of vocabulary to ESP reading. The ESP reader's vocabulary knowledge can be

classified into three separate categories as general high-frequency, core-academic, and technical-academic words, outlined by Gardner and Davies (2014). The general high-frequency words have been defined as "those that appear with roughly equal and high frequency across all major registers of the larger corpus, including the academic register" (p. 8). Nouns such as *way* and *part* and verbs like *take* and *know* are some examples of these words. They further characterized academic core words (or core-academic words in easier terminology) as the lexical content words that are encountered in a wide range of different academic majors. Based on Gardner and Davies's (2014) academic vocabulary list (AVL), for example, *study*, *group*, *system*, *social*, and *provide* are the first five frequent words. However, academic-technical words of those that appear in "a narrower range of academic disciplines" (p. 8). *Counseling, rapport, client, affection, therapy, emotional, and empathy* are examples of this class of words for the psychology discipline. Nonetheless, developing knowledge of these words should coincide with the improvement in the overall register of the discipline. That is, constructing knowledge of domain-specific vocabulary does not seem to legitimize access to disciplinary texts. Instead, studying disciplinary texts with proper scaffolding will assist learners in appreciating discipline-specific words (Nagy & Townsend, 2012).

As argued by Scarcella (2003), acquiring the core and discipline-specific words poses particular serious challenges for majority of L2 learners due to the multifaceted and often abstract nature of these words that, in turn, impedes ESAP reading comprehension. This difficulty and challenging academic reading hindrance have been directly attributed to L2 learners' feeble and shallow lexical knowledge regarding the frequent academic and technical words as asserted by Grabe and Stoller (2014); however, to date comparatively little empirical research has been conducted to explore the extent, involved dimensions, and depth of such deficiency among the learners.

A walk-through of the previous interventions on the general and discipline-specific academic vocabulary development explicates the efficacy

of vocabulary teaching approaches and the academic demands of different disciplines. In an intervention study on discipline-specific academic words, Vaughn et al. (2009) investigated 7th graders' (n = 888) vocabulary knowledge and comprehension in social sciences, through the strategic use of video clips to build concepts and promote discussion, explicit vocabulary instruction, collaborative tasks, and graphic organizers. Findings demonstrated significant differences in favor of the treatment group on researcher-developed vocabulary and comprehension measures for both experimental studies.

In another study on general academic words, Lesaux et al. (2010) investigated the effects of Academic Language Instruction for All Students (ALIAS) on 476 six graders' vocabulary knowledge and reading comprehension during an eight-week intervention period. The students were given multiple exposures and opportunities to practice learning 8 or 9 general academic words extracted from Coxhead's (2000) Academic Word List. Of five vocabulary assessments administered, three of them yielded significant gains, including the researcher-made multiple-choice test on the target words (d = .39), a researcher-designed test measuring students' knowledge of the target-word meanings in context (d = .2), and a morphological decomposition test (d = .22). However, results on an experimenter-designed test to measure the depth of knowledge of target words as well as a standardized reading vocabulary test did not show any significance. Of marginal significance was the standardized measure of reading comprehension (d = .15).

PURPOSE OF THE STUDY

The aforementioned studies have generally investigated the effects of discipline-specific academic words and general academic words, and to the best of our knowledge, a few previous studies have attempted to cross-compare the effect of different types of vocabulary knowledge including core-academic, technical-academic, and general high-frequency words on ESP reading comprehension. Accordingly, the present intervention was

conducted to measure the degree of contribution made by each type of the aforementioned types of vocabulary knowledge and to explore if teaching these words would have any significant impact on ESP reading comprehension in two-phase mixed-method research. The following research questions were specifically formulated in the present research attempt:

1. To what extent can the three variables of general high-frequency, core-academic, and academic-technical words contribute to Iranian ESP students' reading comprehension? Which one is a better contributor to ESP reading comprehension?
2. Does teaching core-academic and academic-technical words significantly contribute to Iranian ESP students' reading comprehension in different ways?

METHOD

The present study has used an explanatory mixed-method design to examine the degree of contribution for academic core words, general high-frequency words, and academic-technical words on Iranian ESP learners' reading comprehension. Accordingly, data were collected through two subsequent phases; a larger ex post facto phase followed by a smaller experimental phase. The descriptions of these stages, the participants, the data collection instruments and procedures are outlined in this section.

Participants

A total of 127 (Female: 85, Male: 42) Iranian ESP learners, whose age ranged from 20 to 26 ($M = 23.2, SD = 2.2$), participated in the current study. These participants were selected from among 220 senior and junior BA students majoring in the field of Psychology from different high-ranking universities in Tehran including Allameh Tabataba'i University (ATU), University of Tehran (UT), and Shahid Beheshti University (SBU). The

study sample was selected after conducting a Michigan Test. Those students whose scores were one standard deviation above and below the mean were selected for the purposes of the present research. Their mother tongue was mostly Persian; however, some learners had Turkish, Kurdish, and Arabic mother tongues. Concerning the year of study, the participants consisted of juniors (55%) and seniors (45%). They had passed their general English courses, and they were about to take their ESP course.

Instrumentation

Five data collection instruments were utilized in this study, the characteristics of which will be briefly presented in the following sections.

The Michigan Test of English Language Proficiency

To select a homogeneous sample, the 2008 version of the Michigan Test of English Language Proficiency including 100 multiple-choice items was administered to 220 Iranian ESP students whose study major was Psychology. This test was made up of 40 grammar, 40 vocabulary, and 20 reading items. However, due to the logistical and managerial considerations, the writing section was not given to the students. The allocated time based on test manual was 75 minutes. The reliability and validity of the test have been proved during the past two decades in a myriad of studies (e.g. Brown & Abeywickrama, 2010; Shohamy, Iair & May, 2017); however, in our study, the reliability index was .78.

Test of Core Academic Words

A measure for gauging participants' knowledge of academic core words was developed based on Gardner and Davies's (2014) new academic vocabulary list (AVL). Gardner and Davies' AVL was derived from the 120-million academic words subcorpus of the Corpus of Contemporary American English (COCA). They searched the 425-million-word COCA and located the academic word subcorpus based on the frequency of word lemmas, not the single words. This 120-million academic-word subcorpus of COCA

included these fields: education, humanities, history, social science, philosophy, religion, psychology, science and technology, law and political science, medicine and health, and business and finance. The content of the main academic high-ranking journals for each of the aforementioned majors was the ingredients of the academic subcorpus of the COCA. The AVL developers used four criteria for distinguishing the academic core words from general high-frequency and academic-technical words. First, the ratio of the word (lemma) frequency selected as academic core word was at least 50% higher than the other two classes of words in the selected subcorpus. Second, the corpus included a vast range of academic majors. Third, .8 level of dispersion was required for the word to indicate a balanced coverage among the referred majors, and finally, the discipline measure was relied upon to exclude those academic words which were considered as the jargon for a special major or too technical. By administering the academic subcorpus of the COCA, Gardner and Davies (2014) provided the 3000 frequent word lemmas and their families (the list can be freely accessed at www.academicwords.info). The AVL developers also launched two studies and confirmed the superiority of their list compared with their predecessors' lists such as AWL and GSL with regards to coverage, representativeness, and discrimination power. They also reported the high coverage of their AVL through cross-testing with the academic subcorpus of British National Corpus (BNC) that included 33 million+ words. The case studies, for example, disclosed that these words had also 85% coverage with high-frequency words in Academic Word List (AWL) developed and updated by Coxhead (2000, 2011).

This second instrument used for data collection in the present study was a multiple-choice test including 40 items that was developed, piloted, and validated from the 2000 frequent lemmas and their related families based on Gardner and Davies's (2014) academic vocabulary list (AVL) as briefly depicted above. The test showed a reliability index of .81 in a pilot study conducted among 30 ESP students of Psychology at Allameh Tabataba'i University (ATU) in 2014. These students were used to validate

the three developed measures in the present study; however, they did not participate in the main study since they graduated a semester before the main study during the 2015-2016 interval. The required modifications were made based on the results of the pilot study to enhance the reliability and validity of the test.

Test of General High-Frequency Words

In order to provide new, valid, and corpus-based measure of general high-frequency words, one of the latest frameworks was employed. A test included 40 multiple-choice items developed from among the 2000 general high-frequency words determined as a byproduct in Gardner and Davies's (2014) corpus-based study to find the new academic vocabulary (AVL) list. The 40 correct choices for the 40 items and other 120 distractors were all randomly selected from these determined 2000 general high-frequency words. The test was validated in the pilot study with the reliability index of .79 as determined by Cronbach' alpha. All the needed modifications were added after item analysis considering factors such as item discrimination (ID), item facility (IF), item reliability, and choice distribution.

Test of Academic-Technical Words for Psychology Major

This third instrument was also a multiple-choice test including 40 items that was developed, piloted, and validated on the basis of the 2000 frequent academic-technical word lemmas and their related families for the field of psychology as the byproduct of Gardner and Davies's (2014) study. The study just determined the lemmas; therefore, the researchers developed the list for the family of these words through searching renounced online and offline dictionaries and technical dictionaries for the terminology and jargon of the psychology field.

ESP Reading Tests for Psychology Major

Three reading comprehension tests, each including 40 multiple-choice items about psychology topics were utilized in the present study. The first one was

given to the participants as the last used instrument during the first phase of the study to determine their ESP reading ability. The other two equivalent tests were administered at the end of the two educational semesters, i.e. the experimental phase of the study. Each test included 5 passages with the upper-intermediate (3 texts) and advanced (2 texts) difficulty level based on the readability calculations above 15.5 for all the passages. These indexes were provided using Online Coleman-Liau. The indexes showed that the passages were suitable for the level of the study participants. The tests (R1, R2, and R3) indicated reliability indices of .83, .79, and .82, respectively, in the pilot study.

Data Collection Procedure

To examine the extent of the contributions made by knowledge of general high-frequency, core-academic, and technical-academic vocabulary to the reading comprehension among ESP students, an initial sample of 220 Iranian BA level university students majoring in psychology from three state universities in Tehran, Iran was selected. Then, 127 learners whose scores were one standard deviation above and below the mean were chosen. Afterwards, in the first phase of the study 4 tests were administered. First, a validated researcher-made test targeting the general high-frequency words was given to the participants. Then, the next week, learners received a valid test of core-academic words, and finally, in the third week, a test of academic-technical words for the field of psychology was given to the students.

Fifty-four students who studied at Allameh Tabataba'i University were chosen as two experimental groups for the second phase of the study. During this second phase, i.e. the experimental phase, the 500 frequent core-academic words were taught to students in the first experimental group (Group 1 henceforth) and the 500 frequent technical academic words were taught to the other experimental group (Group 2). No experimental group was assigned for teaching general high-frequency words due to the fact that they were almost known by learners based on their performance on the

related test given in the first phase of the study.

A blended flipped method was utilized for vocabulary learning and teaching during the two semesters. Students practiced the target words through reading passages, flashcards, and power-point slides including at least 3 example sentences for each word. This treatment was given for two subsequent semesters each including 14 sessions lasting one and a half hour. Thirty to 40 words were intensively studied in each session. The students engaged in the learning of the words both inside and outside the classroom and using both paper-and-pencil and the e-flash cards, power-point slides, and massive open online courses (MOOCs) created for the psychology discipline. At the end of each semester, an ESP reading test including 40 items and six passages was conducted.

Data Analysis

This study was conducted in two subsequent phases. First, a larger ex post facto study was completed using 127 ESP students from three state universities taking three corpus-driven measures of vocabulary knowledge. The second phase was a smaller experiment using 54 students in two experimental groups at one of the universities. Accordingly, it used a confirmatory mixed-method design in which the second smaller phase wanted to further confirm the results of the first larger phase based on the characteristics mentioned for such as design as claimed by Creswell (2011) and Maxwell (2016).

Both descriptive and inferential statistics utilizing SPSS were employed for data analysis. Descriptive statistics including mean, standard deviation, standard error of the mean, skewness, and kurtosis were calculated for the used measures during the two phases of the study. Normality tests were also conducted to check the assumptions needed for running inferential statistical tests. Multiple regression was employed for answering research question one and the one-way multivariate analysis of the covariance (one-way MANCOVA) was applied to compare the two experimental groups' performances on the two reading tests given at the end

of two succeeding semesters by controlling for their initial performance on
the first ESP reading test that was treated as a covariate.

RESULTS
Research Question One

The first question aimed at examining the contributions made by general
high-frequency, core-academic, and technical-academic words to
psychology major ESP reading comprehension. The descriptive statistics
related to the obtained scores on the used instruments appear below in Table
1.

Table 1: Descriptive statistics of the scores on the four used measures

Measures	N	Minimum	Maximum	Mean	Std. Deviation
General High-Frequency	127	24	40	32.69	4.36
Core-Academic	127	15	35	23.10	4.61
Technical-Academic	127	13	33	21.62	4.50
Reading	127	19	39	27.00	4.49

The highest mean score was achieved on the test of general high-
frequency words ($M = 32.69$, $SD = 4.36$), whereas the mean scores for the
core-academic ($M = 23.10$, $SD = 4.61$) and technical-academic ($M = 26.10$,
$SD = 4.50$) tests were much lower. The mean score and the standard
deviation for the ESP first reading test were 27 and 4.49, respectively.

Since the main assumptions including normality of distributions,
multicollinearity, the presence of outliers, normality, linearity,
homoscedasticity, and the independence of residuals were kept, multiple
regression was run. Participants' scores on the three measures of general
high-frequency, core-academic, and technical-academic words as the
independent or predictor variables and learners' scores on the ESP reading
comprehension test as the dependent or predicted variable were fed into the
SPSS in the constructed model using Enter Method. R came out to be 0.966
and R^2 was 0.932, indicating that the model (including three types of

vocabulary) could explain 93.2 percent of the variance in ESP reading comprehension which is a high percentage. Table 2 reports the results of ANOVA [F (3, 126) = 565.985, p = 0.000], the results of which were considered significant. This means that the model can significantly predict EFL learners' reading comprehension.

Table 2: ANOVA for the relationship among technical-academic, general high-frequency, core-academic words, and ESP reading

	SS	df	MS	F	p
Regression	2372.161	3	790.720	565.985	.000
Residual	171.839	123	1.397		
Total	2544.000	126			

Table 3 demonstrates the standardized beta coefficients that signify the degree to which each predictor variable contributes to the prediction of the predicted variable.

Table 3: Coefficients the relationship among technical-academic, general high-frequency, core-academic words, and ESP reading

Predictor Variable	β	t	p
General High-Frequency	.015	.617	.539
Core-Academic	.562	9.363	.000
Technical-Academic	.427	7.021	.000

The comparison of β values revealed that core-academic vocabulary has the largest β coefficient (β = .562, t = 9.363, $p < .05$). This means that core-academic vocabulary makes the strongest statistically significant unique contribution to explaining ESP reading comprehension. Therefore, it was concluded that core-academic vocabulary could predict more significantly the ESP reading comprehension scores of the psychology major students. Moreover, technical-academic vocabulary was ranked as the

second predictor of ESP reading comprehension (β = .427, t = 7.021, $p <$ .05). However, general high-frequency vocabulary was not a significant contributor to ESP reading comprehension (β = .015, t = .617, $p >$ .05).

Research Question Two

The second research question examined the effect of teaching the 1000 frequent core-academic to one group and technical-academic words to the other group of participants in two subsequent semesters. The first and second experimental groups included 28 and 26 learners, respectively. The assignment of the groups was done randomly. The performance of these two groups of learners on the first ESP reading test which was given at the end of the first phase of the study was considered as a covariate and their scores on the second and third ESP reading tests as an index of their reading scores over a period of one educational year. The participants' scores on the first, second (after treatment in the first semester), and third (after treatment in the second semester) tests are presented in the following table.

Table 4: Descriptive Statistics for the Reading Scores Obtained by the Two Experimental Groups

	Groups: Treatment	*N*	*Min*	*Max*	*Mean*	*Std. Deviation*
Reading 1	1: Core-Academic	28	16	37	26.36	4.612
	2: Technical-Academic	26	23	33	26.81	3.086
Reading 2	1: Core-Academic	28	26	34	29.54	2.575
	2: Technical-Academic	26	25	35	28.85	2.810
Reading 3	1: Core-Academic	28	27	39	32.86	2.704
	2: Technical-Academic	26	25	37	30.19	3.335

The mean scores for the selected learners to attend the experiments were rather the same on the first ESP reading (*M = 26.36 & 26.81*). Since the current reading performance ability of the learners is a decisive factor in their later performances, these before-the-treatment reading scores were

treated as a covariate. However, the experimental group who received direct teaching of the 1000 frequent core-academic words in two succeeding educational semesters (Group 1) outperformed the second experimental group (Group 2) who was taught 1000 frequent technical-academic words for the psychology discipline on the first semester reading test (*M1 = 29.54 & M2 = 28*.85) and on the second semester reading test (*M1 = 32.86 & M2 = 30.19*). Both groups shared reading improvements; however, the mean scores on the two ESP reading tests were greater for the first experimental group.

One-way multivariate analysis of covariance (MANCOVA) was used for checking the improvement of the two groups over time by controlling for the effect of the covariate. The preliminary assumptions including sample size, independence of observations, normality, outliers, linearity, homogeneity of regression, multicollinearity and singularity, and homogeneity of variance-covariance matrix were checked some of which will be reported here (including all the statistics, tables, figures, and their descriptions will be too lengthy and will lengthen the paper to an unacceptable proportion). The multivariate test results have been summarized in the following table to check if the special treatment was effective or not.

Table 5: Multivariate tests for the applied one-way ANCOVA

Effects	*Wilks' Lambda*	*F*	*Hypothesis df*	*Error df*	*p*	*$\eta^2 p$*
Covariate	.350	46.436	2	50	.000	.650
Main Effect	.587	17.591	2	50	.000	.413

There was a statistically significant difference between the two groups on the combined dependent variables (the two ESP reading tests after two stages of treatment) after controlling for the effect of the covariate, i.e. the first ESP reading given at the end of the first correlational phase of the study (F (2, 50) = 17.591, $p < .05$, Wilks' Λ = .587, partial η^2 = .413).

This significance should be further checked for individual dependent test scores by the two groups by refereeing to the between-subjects effects table.

Table 6: Tests of Between-Subjects Effects for the Applied One-Way ANCOVA

Source	ESP Reading	SS	df	MS	F	p	$\eta^2 p$
Covariate	Test 2	137.201	1	137.201	29.259	.000	.365
	Test 3	305.726	1	305.726	91.858	.000	.643
Main Effect	Test 2	10.280	1	10.280	2.192	.145	.041
	Test 3	116.233	1	116.233	34.923	.000	.406
Error	Test 2	239.148	51	4.689			
	Test 3	169.741	51	3.328			

It can be observed in Table 5 that the teaching the first 500 frequent core-academic and technical-academic words had not a statistically significant effect on the second ESP reading (F (1, 51) = 2.192; p = .145 > .05; partial η^2 = .041); whereas the teaching of the second 500 frequent core-academic and technical-academic words had a significant effect on ESP reading among psychology-major students (F (1, 51) = 34.923; $p < .05$; partial η^2 = .406). The covariate (first ESP reading scores) also could significantly affect the learners' performances on the second (F (1, 51) = 29.259; $p < .05$; partial η^2 = .365) and the third ESP reading (F (1, 51) = 91.858; $p < .05$; partial η^2 = .643). The last table provides the results of the pairwise comparisons to locate the exact place of the performance differences among the two experimental groups.

Table 7: Pairwise comparisons for the reading scores obtained by the experimental groups

Dependent Variable	(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	p
ESP Reading Test 2	1	2	.875	.591	.145
	2	1	-.875	.591	.145
ESP Reading	1	2	2.941*	.498	.000

Test 3	2	1	-2.941[*]	.498	.000

The use of post hoc tests (Table 7) revealed that there was no significant difference between the two groups on the second ESP reading test ($p = .145 > .05$); however, those learners in Group 1 who received instruction on the 1000 frequent core-academic words significantly outperformed the participants in Group 2 who were taught the 1000 frequent technical-academic words in the psychology discipline ($p .000 < .05$).

DISCUSSION

The present study sheds light on the contribution of three types of vocabulary knowledge in two ways. First, knowledge of core-academic words made the highest significant contribution to ESP reading comprehension and could explain about 56.2% of the variance in reading scores obtained by students in the field of psychology. The knowledge of technical-academic vocabulary had the second significant contribution, explaining about 42.7% of the ESP reading variance; however, knowledge of general high-frequency words was not a significant contributor and could only account for about 6% of the variance in reading comprehension scores. The second finding suggested that teaching 1000 frequent core-academic words and 1000 technical-academic words have no significant impact on ESP learners' reading comprehension in the short term but showed a significant effect in the long turn in favor of the core-academic words.

As far as the first finding is concerned, it can be argued that general high-frequency words as outlined by Gardner and Davies (2014) are the basic single words the mastery of which needs to happen in the initial stage of learning English; however, they do not assist in understanding advanced level authentic ESP texts. They cannot account for the main concepts and propositional meanings in a specific field of study such as psychology in the present research. Moreover, the knowledge of general high-frequency words is the threshold knowledge that can help beginners to understand general

simple texts, and their use is limited to easy general-purpose readings, and a less proportion of them is encountered when expressing higher thinking and processes. As pointed out by Nagy and Townsend (2012), academic and discipline-related language is highly particular since it should be capable of conveying "abstract, technical, and nuanced ideas and phenomena that are not typically examined in settings that are characterized by social and/or casual conversation" (p. 92); therefore, the general-high-frequency words cannot be that much beneficial though they have been previously mastered to achieve higher language levels. Successful ESP reading comprehension entails the cognitive analysis and semantic reconstruction of technical-specific concepts and processes, which would be either perplexingly strenuous or rather impossible without a good command over the core-academic and disciplinary lexical knowledge.

Another piece of argument for the significant role of teaching core academic words and technical words in ESAP reading comprehension is that lexical knowledge as claimed by Schmidt (2014) can trigger schematic information and background cognitive knowledge all of which more drastically set the stage for comprehending the written text. Such robust cognitive aid provided through the activation of world knowledge and schemas have also been supported by Stahl and Nagy (2006) who stated that successful academic reading is the direct product of lexical knowledge breadth and depth. Fang and Schleppegrell (2008) have also given their support to the incisive contribution of academic vocabulary mastery for reading content texts among L2 learners.

Contrary to the restricted use of this first group of words which were the focus of inquiry in the current study, core-academic words are rather ubiquitous in virtually all academic majors based on their inherent definition and the very nature of their determination in numerous studies including Gardner and Davies (2014) that produced academic vocabulary lists (AVL), Coxhead (2000, 2011) that resulted in academic word list (AWL) and some other less-known lists like Xue and Nation's (1984) university word list (UWL). The technical-academic words as their name implies are the

building blocks and inseparable cornerstones of any specific field of study. Therefore, it seems logical that these two classes of words could explain about 92% of the total variance in ESP reading comprehension. Nagy and Townsend (2012) regarded general academic words, equivalent to the core-academic words as defined in this study, and discipline-specific words (technical-academic words) as paramountly crucial for both spoken and written academic skills, asserting that "academic vocabulary is perhaps the most obvious aspect of academic language, and lack of academic vocabulary knowledge has consistently been identified as an obstacle to student success" (p. 91).

The results of the current study about the significant contributions of core-academic and technical-academic words to ESP reading comprehension are consonant with those of some earlier studies (e.g. Chung & Nation, 2003; Coxhead & Demecheleer, 2018; Durret, 2014, 2016; Martinez et al., 2009; Rolls & Rodgers, 2017). The study conducted by Martinez et al. (2009), for instance, revealed that academic vocabulary related to the field of agriculture determined by a corpus-based investigation was highly correlated with the students' reading scores. Durrant (2014, 2016) has also underscored the positive relationship between domain-specific vocabulary and ESP students' literacy skills including reading and writing. Rolls and Rodgers (2017) investigated the lexical coverage and the frequency of technical-academic word families in a corpus of science fiction-fantasy texts, discovering a high frequency of 50% attributed to related words in the corpus passages on the target discipline. Rolls and Rodgers (2017) highlighted the integral role of such technical word coverage in understanding the science fiction-fantasy texts that puts them at the center of instruction for the ESP courses. A high positive correlation was also reported by Chung and Nation's (2003) study between the knowledge of technical vocabulary and reading specialized text types. By the same token, the results of the present study are in line with Townsend and Collins's (2018) study, indicating the positive effect of the intervention of general academic words and students' depth and gains of knowledge of

the target words. Findings of Vaughn et al.'s (2009) support the results of the present study in that teaching discipline-specific academic words can help students achieve better scores in reading comprehension and vocabulary gains.

Despite a larger number of studies that reported a significant effect for the instruction of core-academic and/or technical academic words on ESP reading comprehension, of course with lists other than the AVL, Lesaux et al. (2010) taught 160 words from Coxhead's (2000) academic word list (AVL) to 470 six graders to examine the effect of these words on various aspects of vocabulary knowledge and their academic reading comprehension. Although the results of this study revealed significant gains in for the used meaning-recall and form-recall vocabulary size measures, only a marginally significant effect was observed on the depth of knowledge of the target words and academic reading comprehension. Two points are worth mentioning here. First, the words were an amalgamation of both the general and technical academic words based on AWL and second, the number of the taught words (160) and the length of the instruction (18 weeks) were limited compared with the number of words and the instruction duration in the current study. Besides, in this study, teaching core-academic and technical-academic words for the first semester (about 4 months) did not show a significant effect on reading comprehension. The significant effect was observed after the second semester of instructional treatment. Another opposing study was reported by Carlo et al. (2004) who did a study involving the effect of a 14-week vocabulary-teaching intervention on both academic vocabulary development and ESP reading comprehension. This study found significant lexical improvement among the participatory ESAP students; nonetheless, the given treatment did not have a significant contribution to learners' reading comprehension.

In the light of the findings of the present study, it can be recapitulated that the control of core-academic words along with technical academic words, or the lack of thereof, can be considered as the single most discriminator and contributor to students' scores and success. In line with

the findings of the present study, as Nagy and Townsend contend (2012), lack of adequate academic vocabulary knowledge leads to less academic achievement and success. Therefore, acknowledgment of such academic words at all levels of education seems to be indispensable, and without exception, practitioners and theoreticians call for more explicit instruction of core-academic words as well as technical-academic words. However, no important previous study was found to compare the role of core-academic and technical-academic words in ESP reading with each other or with general high-frequency words.

CONCLUSION AND IMPLICATIONS

The current study led to the following conclusions. Firstly, knowledge of core-academic and technical-academic words was significant contributors to ESP reading comprehension. Knowledge of core-academic words was a more significant contributor. However, knowledge of general high-frequency words was not a significant predictor of ESP reading comprehension. Secondly, the intentional teaching of the 1000 most frequent core-academic words and the 1000 technical-academic words did not have any significant effect on ESP reading in the short term, but they turned out to significantly influence psychology-major students' reading in the long term. Furthermore, core academic words indicated could significantly affect ESP reading comprehension compared with technical-academic words in the long term.

The findings of this study have some pedagogical implications for ESP learners, teachers, and syllabus designers. Both learners and teachers can focus their practices on core-academic and technical-academic words as determined by AVL to enhance ESP reading comprehension. Syllabus designers and material developers can also integrate these two groups of highly-obligatory words in the design of ESP courses, syllabi, and lessons and focus the learners and teachers' attention to these words and provide adequate contextualized tasks and activities for their acquisition. Teachers

need to bear in mind that vocabulary learning takes place in authentic contexts, and the words need to be contextualized through myriads of opportunities to be learned both receptively and productively, and that their main accountability is to let students know how target words interact and support the meaning of other words. Moreover, attentiveness to academic words seems to be a significant first stage in raising teachers' awareness of the desire to better bolster students' understanding and use of the language of the specific discipline. Bravo and Cervetti (2009) articulate that inasmuch as the fact that technical words intermingle language and subject knowledge, the results of the present study will be of interest both to vocabulary researchers and to subject specialists involved in teaching content through students' L2.

Several potential limitations need to be considered regarding the methodology used in the present study. This research only focused on the knowledge of 2000 general high-frequency, core-academic, and domain-specific words in the first phase of the study and the direct teaching of 1000 of these words during the second experimental phase. Future correlational and experimental studies can target ESP/EAP learners' knowledge of other words frequency levels and can focus on better-designed longitudinal inquiries. Future works can be conducted with more comprehensive and representative measures for estimating the share of different types of vocabulary in ESP/EAP reading comprehension and with larger samples.

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