

The Use of Lexical Verbs in ESL Engineering Student Writing: A Corpus-Based Investigation

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Abstract

Learners' writing in specific fields has not been studied to determine whether engineering writing exhibits distinct academic or non-academic lexical features. This corpus-based study examined the use and distribution of lexical verbs in the academic writing of L2 engineering undergraduates. To compile the Malaysian Mechanical, Electrical and Electronic Engineering Corpus of Student Writing (MECSW), 50 texts consisting of examination scripts, assignments, laboratory reports, project reports, proposals, and final year projects were annotated and analyzed. The MECSW comprises 151,227 tokens and 7,974-word types. The engineering students used all six verb forms totaling 14,629 words, but the past participle verb form was the most frequently used ($n = 5,159$) while the past tense form was the least used ($n = 813$). The top three words used in the past participle form were "used," "shown" and "based," reflecting the expository nature and report-writing style of the texts, and an emphasis on certain discourse segments. The results also showed that the base form (no conjugation) ranked third in frequency ($n = 2,358$) but learners often used the form inaccurately in place of other more "complex" conjugated verb forms. To profile the lexical verbs, the MECSW was compared to the British National Corpus for written texts. The top 50 lexical verbs in the MECSW were found to contain 70% academic vocabulary as listed in the Academic Keyword List. Another 20% of the verbs, which are not in the new-General Service List, can therefore potentially be described as specialized vocabulary, although the majority are non-technical in nature.

The lexical verbs used by the students are largely in line with what is expected in academic writing. The study suggests that academic vocabulary instruction in the ESL classroom should emphasize verbs and verb forms as well as specialized non-technical or semi-technical verbs for new engineering students who are non-native speakers of English.

Keywords: corpus-based study, lexical verbs, academic vocabulary, specialized vocabulary

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Introduction

Corpus-based language research has shown that the nature of learner language differs from professionals in the community of practice in terms of lexico-grammar. For example, Granger and Paquot (2009) found that learners have difficulty mastering academic writing conventions, based on their comparison of the International Corpus of Learner English, the Louvain Corpus of Native English Essays and a corpus of academic expert writing referred to as ACAD. The International Corpus of Learner English contains over three million words of argumentative essay writing by high-intermediate to advanced EFL university students of 16 different native languages. The ACAD is a two-million-word collection of published academic expert writing of books and articles. The Louvain Corpus of Native English Essays contains argumentative essays (150,000 words) written by American university students. Granger and Paquot (2009) found that English as Foreign Language learners tended to use “conversational verbs” (e.g., think, like) rather than “academic verbs” (e.g., include, report, relate) and their range of academic verbs was restricted. The availability of large-sized learner corpora such as the Cambridge Learner Corpus and Trinity Lancaster Spoken Learner Corpus has enabled researchers to examine language elements in a wide range of research contexts, and to produce findings with better representation than previous second language acquisition studies.

A learner corpus is a compilation of authentic electronic texts in a foreign or second language arranged based on “explicit design criteria for a particular second language acquisition or foreign language teaching purpose” (Granger, 2002, p. 7). Because of the variability of learner language in different sociocultural contexts, Malaysian researchers have developed learner corpora involving academic discourse of school and university students. English of Malaysian School Students, the Malaysian Corpus of Learner English, and the Corpus Archive of Learner English Sabah-Sarawak are some of the earlier developed corpora that served as representative sources for examining aspects of learner language including language development, strategies and errors (Abdul Samad, 2004; Ang et al., 2011; Botley & Dillah, 2007).

Alongside learner corpora, the use of corpus-derived word and phrase lists has been prevalent in English for Academic Purposes and English for Specific Purposes, mainly to facilitate students’ acquisition of core academic vocabulary and specialized vocabulary.

Academic vocabulary is defined as “a set of options to refer to those activities that characterize academic work, organize scientific discourse and build the rhetoric of academic texts” (Paquot, 2010, p. 28). Nation (2001) asserted that academic vocabulary is a very significant learning goal for learners pursuing academic study in English, considering how rich vocabulary can positively affect writing ability. Reference books and textbooks are common sources for field-specific academic corpora and word list creation, including for engineering. An example core academic wordlist is Coxhead’s (2000) Academic Word List. Paquot (2010) produced the Academic Keyword List to address the limited coverage of words in the Academic Word List, and incorporated high frequency words such as “argue,” “compare,” and “explain.” Using the keyness criterion, amongst others, Paquot (2010) found that 930 lexical items were identified as characteristic of academic prose because they appeared to be more prominent in the academic corpus as compared to the fiction corpus.

With the ever-increasing interest in science, technology, engineering, and mathematics disciplines, where English often functions as the main language of instruction, more word lists have been created to support learning in specific fields such as medicine and chemistry (Lei & Liu, 2016; Valipouri & Nassaji, 2013). Examples of word lists for engineering include Ward’s (2009) Basic Engineering List and Hsu’s (2014) Engineering English Word List. Word lists are typically derived from specific corpora of academic engineering writing such as the Student Engineering English Corpus (Mudraya, 2006) and the Engineering English Corpus (Todd, 2017). For instance, the Reference Books Corpus compiled by Khamis and Abdullah (2013) comprised 34 texts from two main engineering textbooks used by a Malaysian technical university. They found that keyword lists are more useful than frequency lists because keyword lists provide information on what a text or a corpus is about (aboutness). Ng et al. (2013) highlighted frequently used engineering academic vocabulary in the Engineering Technology Word List derived from the vocational program engineering corpus using locally written Malaysian engineering technology textbooks for the upper secondary level. Ng et al.’s (2013) corpora covered 80% of the words in the General Service List (West, 1953) and 10% of the words in the Academic Word List. Todd’s (2017) analysis of the Engineering English Corpus showed that opaque words (requiring teacher’s elucidation) were mostly high-frequency general or discipline-specific words. The Engineering English Corpus comprises engineering textbooks from all compulsory courses taken by students in English-medium undergraduate

programs at a Thai university. In recent years, engineering lecture discourse has also been compiled for corpus investigation (Kunioshi et al., 2019; Shamsudin et al., 2012).

Corpus research on lexico-grammar in English for Academic Purposes and English for Specific Purposes has generally focused on verbs, rather than other parts of speech because of their central role in language construction (e.g., Mohamad Deli et al., 2019). The verb carries the main responsibility of expressing messages to suit a specific audience and purpose. The reporting verb, for instance, is important for citing other researchers' work in research articles (e.g., Manan & Mohd Noor, 2014). In academic writing, modal verbs are among the most problematic grammatical items in the teaching and learning of ESL (Khojasteh & Reinders, 2013). Inadequate knowledge of lexical verbs can become a serious disadvantage for learners because it hampers the expression of thoughts in all their nuances and their presentation in the expected style (Granger & Paquot, 2009). Moreover, corpus studies have shown that verb forms (i.e., verb tense) can represent style (the author's technique) in academic writing that differs across scientific disciplines (Clippinger et al., 2019). How verb forms are used in writing is also a differentiating feature between discourse segments such as hypotheses, results, and methods, amongst others in scientific writing (e.g., Burrough-Boenisch, 2003). Mohamad Nusri (2018) found that in the discussion section of a Master's dissertation, the most common verb type employed is activity verbs, followed by mental-emotive, report, logical semantic and linking verbs. Abdullah and Noor (2013) found nouns and verbs to be the dominant lexical items used in learners' written texts in the Louvain Corpus of Native English Essays, and the Written English Corpus of Malay ESL learners. Their comparison of the word frequency profiles of these two learner corpora showed that there was an overuse of the infinitive verb form by both groups in the argumentative genre. Furthermore, English as a Second Language learners overused certain verb forms. In addition, Kanestion et al. (2016) reported that students who obtained Malaysian University English Test Bands 5 and 3 frequently used four verb forms (the past tense, - "ing" form, past participle, and - "s" form), but underused the past tense and the base form of verbs. These findings suggest that learners are unable to recognize and use the distinctive conventions of academic writing. Thus, the corpus of verbs and verb forms could be an essential aspect of understanding writing in a particular discipline.

Thus far, learner language corpus-based analyses in Malaysia have largely involved students' writing in proficiency-oriented classrooms or in language assessments rather than those in field-specific classrooms such as engineering courses. This leaves open the question of whether learners' writing in specific fields such as engineering exhibits distinct lexical features compared to writing in general proficiency classes.

This study investigated the use and distribution of lexical verbs in the academic writings of L2 engineering undergraduates. For this purpose, the Malaysian Mechanical, Electrical and Electronic Engineering Corpus of Student Writing (MECSW) was compiled for analysis. The specific objectives of the study were to:

- (1) identify frequently used lexical verb forms,
- (2) identify the top 10 verbs based on frequency in their individual forms, and
- (3) describe the distribution of verbs between the Academic Keyword List, the new-General Service List and potential specialized vocabulary for academic engineering.

Theoretical Background

Recent years have witnessed a significant growth in corpus-based research using computational analysis to examine academic, learner and professional language. This comes as more people take advantage of the availability and accessibility of large text datasets that facilitate language analysis. Within the scopes of English for Academic Purposes and English for Specific Purposes, corpus-based analysis of texts typically involves the investigation of special terminology, keywords, collocations and formulaic language among others with the aim of creating word lists that are often pedagogically-motivated.

To generate discipline-specific academic word lists, some studies have identified lexical items based on frequency, and have excluded technical terms and words found in a corpus of general English such as the General Service List (West, 1953). Wang et al. (2008) reported the compilation of a medicine-specific academic word list based on research articles, while Yang (2015) produced an academic word list for nursing. Others have adopted a statistical approach to the identification of discipline-specific core vocabulary by focusing on keywords that do not occur in externally established word lists. Chiba et al. (2010), for instance, identified the top 1,000 "off-list words" which mainly constitute technical and semi-technical

terms for the sub-discipline of midwifery. Gilmore and Millar (2018) similarly used keyword analysis to identify words associated with civil engineering research articles and of potential pedagogic value from the Specialized Corpus of Civil Engineering Research Articles. Comparisons were then made with established word lists (the new-General Service List and the New Academic Word List) in order to categorize keywords into those: (1) commonly occurring in general English; (2) commonly occurring in academic English, and (3) not occurring in either the new-General Service List or new Academic Word List. Keywords in the 11 sub-disciplines of civil engineering were found to show considerable variation in the off-list keywords between sub-disciplines, with only 35.9% of word families reoccurring in two or more areas, hence raising questions about exactly how specialized a corpus needs to be in order to be of pedagogic value.

The data-driven approach in corpus-based research has allowed researchers to take a more “holistic” approach to analyzing aspects of writing in English for academic and professional purposes. Conrad (2017), for example, compared word-level, sentence-level, and organizational differences in writing by practitioners and students derived from a corpus of student and workplace texts in civil engineering. Specifically, the study utilized lexical and rhetorical move analyses and supplemented these with interviews of practitioners and students. Results showed that student writing contained more complicated sentence structures, less accurate word choice, more errors in punctuation and grammar, and less linear organization, which resulted in reduced effectiveness in areas that practitioners considered important. The study showed that student writing problems were due to lack of awareness of genre expectations and poor language proficiency, suggesting that these are areas to address in writing courses for engineering students.

Methodology

The Malaysian Mechanical, Electrical and Electronic Engineering Corpus of Student Writing (MECSW) corpus was built for the purpose of this study. A total of 50 scripts of written work by engineering undergraduates in the mechanical, electrical and electronic programs of a Malaysian public university were compiled. They comprised student laboratory reports, project reports, examination scripts, and proposals with marks of 70% and above. The students were second language speakers of English. Numbers, complex formulae and short phrases typically displayed in tables were removed as these were not considered as complete sentences. The UCREL single-user licensed Constituent Likelihood Automatic Word-tagging System (CLAWS4) software, a pos-tagger software package, was used to annotate the data. Only linguistic constituent tags for lexical verbs were analyzed in this study. Table 1 shows the coding of the inflection of lexical verbs into six forms. It is necessary to analyze the six forms of lexical verbs because past research in Malaysia shows that English as a Second Language learners overuse certain verb forms such as the past tense, - “ing” form, past participle, and - “s” form (Kanestion et al., 2016) and the infinitive form (Abdullah & Noor, 2013).

Table 1

Codes for the Inflexion of Lexical Verbs into Six Forms

| No | Coding | Example |
|----|--------|--|
| 1 | VV0 | (base form, e.g., work) |
| 2 | VVD | (past tense, e.g., worked) |
| 3 | VVG | (-ing participle, e.g., working) |
| 4 | VVI | (infinitive, e.g., to work) |
| 5 | VVN | (past participle, e.g., has/have worked) |
| 6 | VVZ | (-s form, e.g., works). |

The corpus was tagged horizontally (C7 tagset) as shown in Figure 1. Each word form was displayed followed by its POS tag to facilitate calculation of the frequencies of lexical verbs using the AntConc 3.5.9 (Anthony, 2020) concordance software. Using the Cluster/N-gram tool, lists of all verb forms in the corpora were generated in frequency order. To reassert the “academic quality” of the lexical verbs used by the engineering students, a keyword list was produced using the *KeyWords* tool. Keywords which were unusually frequent were

identified by comparing the target corpus (MECSW) to the British National Corpus word list for the written component (word token = 85,887,272) accessible via the webpage of AntConc's developer Laurence Anthony (<https://www.laurenceanthony.net/software/antconc/>). The British National Corpus acts as the reference corpus representing general English, as it comprises written works in a variety of genres. The keyness value of the keywords shows how significantly and unusually frequent words are in the target corpus as compared to a larger reference corpus. For this study, 50 lexical verbs from a 1,000-word keyword list with keyness log-likelihood values of 6.63 or higher ($p < 0.01$) were selected for analysis. The keyword comparison allows distinctive words to be identified in the corpus, indicative of genre differences between corpora. However, it must be noted that the keyword tool does not differentiate between word classes automatically, so the lexical verb identification and extraction were done manually. In some cases where potential verbs can serve as both a noun and a verb (e.g., *cause*), they will only be selected if they make up over 70% of a word's total frequency. The selected verbs were then manually categorized into academic vocabulary based on the Academic Keyword List, general vocabulary based on the new-General Service List (Brezina & Gablasova, 2015), and specialized words. Although the Academic Keyword List is dated, it was preferred because it "makes no a priori exclusion of General Service List words" (Granger & Larsson, 2021, p. 2) unlike other word lists (e.g., Academic Word List, New Academic Word List) and therefore includes high frequency words with high academic potential. This means that the overlapping of some high frequency words between the Academic Keyword List and the General Service List was expected and did not become the basis for disqualifying words. The new-General Service List was selected for the present study because it is one of the most recent general word lists that reflects language used at present. It comprises 2,494 lemmas of general core vocabulary that resulted from a robust comparison of four language corpora representative of general English with a total size of over 12 billion running words. Subsequently, the *Concord* tool that produces concordances and identifies collocates of the search word was used to analyze the frequent verbs.

Figure 1*CLAWS Horizontal Output (word form POS)*

Temperature_NN1 can_VM be_VBI measured_VVN via_II a_AT1 diverse_JJ
array_NN1 of_IO sensors_NN2 ,_, either_RR analog_JJ or_CC digital_JJ ._.

In this study, verb form analysis was conducted instead of verb lemma analysis because the former takes into account various verb forms such as the infinitive and the past participle of a stem verb, and identifies and calculates it as a word on its own. The verb lemma analysis, on the other hand, only considers stem verbs and disregards other forms of the stem, and thus would result in the loss of important information because each word form has its own phraseological patterning (Sinclair, as cited in Khamis & Abdullah, 2015).

In the reporting of results, sentence examples have been anonymized using labels such as “NN1,” “VBI,” “AT1” and “JJ” to protect the anonymity of the original studies and their authors.

Results and Discussion

The MECSW corpus comprises 151,227 tokens and 7,974-word types. Altogether, lexical verbs in their respective forms make up 14,629 words in the corpus.

Frequently Used Lexical Verb Forms

Table 2 shows the frequency of lexical verb forms used in the MECSW corpus. The student engineers used all six verb forms but the past participle verb form was the most frequently used ($n = 5,159$ or 35.27%) and the past tense form was the least used ($n = 813$ or 5.54%).

Table 2*Frequency of Lexical Verb Forms Used in the MECSW Corpus*

| Verb Initials | Type of verb form | Frequency | Percentage |
|---------------|--|-----------|------------|
| VVN | Past participle of lexical verb (e.g., has/have written) | 5,159 | 35.27 |
| VVI | Infinitive form of lexical verb (e.g., to write) | 3,085 | 21.09 |
| VV0 | Base form of lexical verb (e.g., write) | 2,358 | 16.12 |
| VVG | -ing form of lexical verb (e.g., writing) | 1,805 | 12.34 |
| VVZ | -s singular form of lexical verb (e.g., writes) | 1,409 | 9.63 |
| VVD | Past tense of lexical verb (e.g., wrote) | 813 | 5.54 |
| Total | | 14,629 | 100 |

The prevalence of the past participle (VVN) in the passive form was expected since a majority of the student writing comprised laboratory or project reports in which it was more important for the students to draw attention to the task at hand rather than to the doer of the task. The passive voice allows the experiment or specific procedure to be highlighted in the subject position (Walker, 1999). In the British Academic Written English corpus, student laboratory reports are also the most common type of written academic genre for science and engineering students (Gardner & Nesi, as cited in Parkinson, 2017). The past participle is also frequently used in the discussion section of Master's dissertations (Mohamad Nusri, 2018) because the conventionalized use of passive voice achieves academic detachment and objectivity. However, in non-discipline specific argumentative writing, the past participle is underused. while the base form of lexical verbs is overused (Guo, as cited in Kanestion et al., 2016). The underuse of the past participle may be linked to low proficiency because competent ESL writers frequently used it to show attitude and voice when making arguments (Kanestion et al., 2016).

The infinitive form "to + verb" (VVI) constitutes the second most frequently used verb form (see also Mohamad Nusri, 2018). In the present study, this form was mainly used to explain the procedure or reasons for conducting research in the Methodology section.

The base form (VV0) came third with 2,358 occurrences. The base form was commonly used for lexical verbs in the methodology section. A closer analysis of the collocations revealed that learners often erroneously used the form in place of other more “complex” forms such as the “-ing” and singular “-s” forms, possibly due to first language (i.e., mother tongue) influence (Guo, as cited in Kanestion et al., 2016). The engineering students in this study were from Malay, Chinese or Sarawak indigenous language backgrounds, and all of these languages typically have non-conjugated verbs. This means that the verbs of these languages do not change form to communicate aspects such as tense, person or number. This is why the frequency of “-ing” participle (VVG) use was less (1,805 occurrences). A study involving Malaysian ESL learners at a tertiary institution reported that omission verb-form errors were most frequent in the learners’ writing, which included the omission of the third person singular (-s/-es/-ies) and “-ing” forms (Wee et al., 2010). However, a conjugated verb with “-ing” that did appear in the writing is “using” which was typically presented in a clausal manner, for example, “The experiment was conducted using the X machine.” Other forms such as the singular “-s” (VVZ) and past tense (VVD) had even lower frequencies (1,409 and 813 occurrences respectively).

It was expected that past tense (VVD) would be the least used lexical verb form because laboratory reports contain past actions that are mainly only found in the Methodology section. Instead, the base forms (VVO) were more commonly used, and this may be reflective of interference from the speakers’ first language. The ESL learners in Mohamad Nusri’s (2018) study also preferred to use present tense in the discussion section of their theses but in her context, the use of present tense was acceptable because the results were discussed in relation to the literature. “Research is not referred to in a specific time-continuum but rather seen as a continuing process that is neither in the past nor in the future” (Mohamad Nusri, 2018, p. 71).

In sum, all six verb forms were used, with the past participle being most frequently used while the past tense form was the least used, reflective of the expository nature and report-writing style of the students’ writing. The results also showed that the base form (no conjugation) ranked third in frequency. Interestingly, the concordance analysis for this verb form revealed inaccurate usage by the learners in place of other more “complex” conjugated verb forms which may be due to first language interference.

This is an important finding as insufficient knowledge of verb forms may hinder students from effectively conveying ideas in the expected form and style.

Top 10 Verbs Based on Frequency in Their Individual Forms

Table 3 shows the top 10 lexical verbs based on frequency in their individual forms, as used in the MECSW corpus comprising mainly expository student texts. The top 10 analysis alongside a concordance analysis is important because it provides more detailed verbal and content-related information across the texts within different sections or discourse segments (e.g., result, method, etc.). Crucially, these may be distinct to learners' writing in engineering as opposed to other intra-disciplinary writings such as professional engineering writing, for which word-level comparisons have shown differences (Conrad, 2017), as well as to other inter-disciplinary texts (e.g., learners' writing in the arts and humanities).

The top 10 words used in the past participle verb form (VVN) include the verbs “used,” “shown” and “based.” The top ranked lexical verbs in the present study are linked to the expository nature and laboratory report-writing style of the texts. These three verbs were also in the top 15 verb forms in the ACAD, comprising expository texts (Granger & Paquot, 2009). Khamis and Abdullah (2015) also found that the two verbs “used” and “shown” frequently appear in engineering reference books and articles. The use of the 10 top ranked lexical verbs will be illustrated using excerpts in the rest of this section.

Firstly, the results for the top-ranked verb “use” are described. It is important to note that the lemma “use” is among the 50 most overused verbs in the International Corpus of Learner English when compared to the ACAD (Granger & Paquot, 2009). Table 3 shows that “use” figured more prominently in its past participle form ($n = 381$) and present participle “-ing” form ($n = 309$) than in its past tense form ($n = 48$) and singular third person simple present form ($n = 38$). In the collocations shown in Excerpt 1, it is evident that the past participle form is used to form the passive structure typically used in laboratory or project reports.

Excerpt 1

Collocation lines for “used” in the past participle form

- 1 devices_NN2 that_CST will_VM be_VBI **used_VVN** in_II this_DD1
experiment_NN1 ._.
- 2 other_JJ constructions_NN2 are_VBR also_RR **used_VVN** ._. PT100_FO
resistance_NN1
- 3 temperature_NN1 relationship_NN1 which_DDQ is_VBZ **used_VVN** to_TO
provide_VVI
- 4 sensors_NN2 and_CC thermometers_NN2 are_VBR **used_VVN** in_II the_AT stated_JJ

Another important form for the verb “use” is the continuous “-ing” form. Excerpt 2 shows some collocation lines for “using” which reveal that it often came after the preposition “by” or main verbs of methods in a clausal manner. This suggests the use of the passive voice structure. The continuous form was hardly used in the active voice, such as “is using,” “are using” or “were using” because laboratory or project reports describe completed past actions rather than on-going present or past actions. The occurrence of “use” in passive sentences is expected because scientific reports are typically on “the phenomenon being studied in the lab, not on the person performing the experiments or analyses” (Martin, as cited in Walker, 1999, p. 14).

Excerpt 2

Collocation lines for “use” in the “-ing” participle form

- 1 Water_NN1 was_VBDZ boiled_VVN by_II **using_VVG** water_NN1 heater_NN1
- 2 experiment_NN1 is_VBZ carried_VVN out_RP **using_VVG** three_MC types_NN2
of_IO temperature_
- 3 is_VBZ taken_VVN and_CC measured_VVN **using_VVG** stainless_JJ steel_NN1
ruler_NN1
- 4 of_IO table_NN1 and_CC analysed_VVD **using_VVG** graph_NN1 ._. b_ZZ1)_) 5
is_VBZ taken_VVN and_CC measured_VVN **using_VVG** stainless_JJ steel_NN1
ruler_NN1

Table 3*Top 10 Verbs Based on Frequency in Their Individual Forms*

| No | VVN | Freq | VVI | Freq | VV0 | Freq | VVG | Freq | VVZ | Freq | VVD | Freq |
|----|-----------|------|-----------|------|-----------|------|------------|------|-----------|------|-----------|------|
| 1 | used | 381 | reduce | 81 | set | 93 | using | 309 | shows | 251 | used | 48 |
| 2 | shown | 288 | determine | 77 | increase | 70 | measuring | 54 | increases | 66 | occurred | 40 |
| 3 | based | 240 | make | 69 | connect | 68 | noting | 46 | consists | 63 | stated | 26 |
| 4 | compared | 130 | produce | 56 | obtain | 62 | increasing | 43 | uses | 38 | started | 22 |
| 5 | obtained | 115 | obtain | 55 | record | 53 | moving | 29 | means | 35 | increased | 21 |
| 6 | connected | 103 | improve | 52 | note | 47 | completing | 18 | includes | 29 | needed | 18 |
| 7 | taken | 87 | cause | 51 | determine | 41 | making | 18 | gives | 28 | happened | 15 |
| 8 | conducted | 80 | avoid | 47 | need | 41 | starting | 18 | acts | 24 | caused | 4 |
| 9 | set | 75 | ensure | 47 | carry | 37 | adding | 17 | requires | 24 | inspected | 13 |
| 10 | recorded | 65 | decrease | 43 | compare | 36 | reducing | 17 | indicates | 23 | recorded | 13 |

Note: All of these verbs in their lemma forms are included in Paquot's (2010) Academic Keyword List except for the lemmas "take," "set," "decrease," "make," "need," "carry," "complete," "move," "add," "start," "mean," "give," "happen," and "inspect"

Secondly, “show” is the second highest in frequency in their individual forms. Table 3 shows that the verb “show” in its past participle form “shown” ($n = 288$) was more frequent than the singular present form “shows” ($n = 251$) in the students’ writing. As seen in Excerpt 3, the verb “shows,” often used in the active voice, was usually followed by either “that” or “the + object.” Similar to its past participle counterpart (Excerpt 4), the singular present form “shows” was also mainly used as a reporting verb to relate the description of results to graphics and tables. It is used sparingly in reporting style to explain one’s own findings (i.e., “This/It shows that...”).

Thus far, researchers concur on the functions of the verb “show.” Williams (1996) stated that it is for reporting and observation categories of lexical verbs in clinical and experimental reports in the medical field. Similarly, Khamis and Abdullah (2013) found a high occurrence of “shows” in engineering textbooks and articles. It is an example of a high frequency verb used to “discuss matters lying at the very heart of the scholarly process” (Meyer, 1997, p. 368).

Excerpt 3

Collocation lines for “show” in single “-s” present form

- 1 thermal_JJ equilibrium_NN1 the_AT fastest_RRT **shows_VVZ** that_CST it_PPH1
- 2 12.4kW_NNU at_II 1800rpm_NNU ._. This_DD1 **shows_VVZ** that_CST at_II
higher_JJR
- 3 The_AT fuel_NN1 consumption_NN1 rate_NN1 **shows_VVZ** an_AT1 increasing_JJ
- 4 _NN1 10_MC increase_VV0 slowly_RR ._. It_PPH1 **shows_VVZ** that_CST the_AT
fuel_NN1 flow_
- 5 1 of_IO this_DD1 laboratory_NN1 manual_NN1 **shows_VVZ** the_AT IC_JJ pin_NN1

Excerpt 4

Collocation lines for “show” in past participle form

- 1 NNU 7_MC ._. The_AT temperature_NN1 reading_NN1 **shown_VVN** by_II PTI_NP1
- 2 needed_VVN ._. The_AT reading_NN1 was_VBDZ **shown_VVN** by_II the_AT
digital_JJ display
- 3 response_NN1 as_II the_AT reading_NN1 **shown_VVN** on_II the_AT display_NN1
- 4 Record_VV0 the_AT temperature_NN1 reading_NN1 **shown_VVN** by_II PT_NN1
- 5 Connect_VV0 the_AT circuit_NN1 as_CSA **shown_VVN** in_II Fig_NN1 2.4_MC ._.

The third highest frequently used verb in the engineering students’ writing is “base.” Table 3 shows that “based” was only used in the past participle form ($n = 240$) and not in other forms. Excerpt 5 shows that “based” is frequently used to relate the discourse to a visual (e.g., Based on graph 1, ...) and to explain methods (e.g., support can be calculated based on the given load).

The verbs ranked fourth to sixth in frequency as shown in Table 3 are “compared,” “obtained” and “connected.” Their collocations in Excerpt 6 indicate the use of “obtained” as a method verb and the use of “compared” and “connected” as relation verbs, as categorized by Williams (1996). To explain results in the Results and Discussion sections, it is necessary to make comparisons. More importantly, the four verbs (“based,” “compared,” “obtained” and “connected”) are commonly used in academic-type explanations. They are deemed as academic vocabulary according to the Academic Keyword List, and are therefore not potentially specialized in nature.

Excerpt 5

Collocation lines for “based” in past participle form

- 1 accuracy_NN1 readings_NN2 ._. DISCUSSION_NN1 :_: **Based_VVN** on_II Graph_NN1
- 2 support_NN1 can_VM be_VBI calculated_VVN **based_VVN** on_II the_AT given_JJ load
- 3 and_CC ammeter_NN1 are_VBR monitored_VVN ._. **Based_VVN** on_II the_AT graph_NN1
- 4 power_NN1 of_IO the_AT engine_NN1 ._. **Based_VVN** on_II the_AT graph_NN1 ,_, the_
- 5 of_IO inertia_NN1 was_VBDZ 0.0872kgm2_FO ._. **Based_VVN** on_II the_AT graph_NN1

Excerpt 6

Collocation lines for “compared,” “connected” and “obtained” in past participle form

Compared

1 run_VVI much_RR wider_JJR as_CSA **compared_VVN** to_II thermocouple_NN1 ._.

2 the_AT beam_NN1 also_RR smaller_JJR **compared_VVN** to_II bigger_JJR

weight_NN1

3 the_AT two_MC values_NN2 are_VBR **compared_VVN** ._. From_II the_AT

experiment_NN1

Connected

1 at_II three_MC points_NN2 are_VBR **connected_VVN** to_II the_AT digital_JJ gauge_

2 two_MC dissimilar_JJ wires_NN2 are_VBR **connected_VVN** or_CC welded_VVD

3 is_REX22 ,_, gate_NN1 G1_FO only_RR **connected_VVN** ._. EX-OR_CC Gate_NN1

Obtained

1 Of_IO the_AT experiment_NN1 is_VBZ **obtained_VVN** ._. Discussion_NN1 :_:

2 the_AT value_NN1 of_IO reading_NN1 **obtained_VVN** by_II channel_NN1 2_MC

3 to_II 1800rpm_NNU ._. Some_DD errors_NN2 **obtained_VVN** in_II this_DD1

experiment_NN1

Although the word “reduce” was the most frequently used verb in the infinitive form ($n = 81$) in engineering students’ writing, it is not included in the Academic Keyword List, although its antonym (“increase”) is. The verb “increase” is in the top 10 verbs for its occurrence in all forms except in the past participle and the infinitive forms (70 base form; 66 singular present tense form; 43 -ing form; 21 past tense form). This is because the verb “reduce” has to compete with semantically predominant verbs in the academic prose mentioned earlier, namely, “based,” “shown,” and “used.” Although “reduce” was only found to be in the top 10 for the infinitive and the -ing form, Excerpt 7 shows that “reduce” was needed to deal with calculations or experiments requiring the use of a representative word to mean something becoming smaller in size or extent. Hence, the verb “reduce” is of relevant academic use in the engineering discipline.

Excerpt 7

Collocation lines for “reduce” in the infinitive form

- 1 way_NN1 to_TO avoid_VVI and_CC **reduce**_VVI the_AT error_NN1 is_VBZ
cautiously_
- 2 be_VBI our_APPGE initiative_NN1 ,_, to_TO **reduce**_VVI the_AT problem_NN1
- 3 products_NN2 from_II rusting_VVG ._. To_TO **reduce**_VVI the_AT friction_NN1
- 4 the_AT bench_NN1 ,_, it_PPH1 will_VM **reduce**_VVI its_APPGE overall_JJ
strength_NN1 .
- 5 the_AT mass_NN1 increased_VVD ._. To_TO **reduce**_VVI these_DD2 errors_NN2

The identification of the top 10 verbs in individual forms revealed that reporting verbs which were frequently observed in dissertation-type reports were lacking in the engineering students' writing. For example, “find,” “suggest” and “claim” did not appear in the top 10 verbs based on frequency in their individual forms. This could be due to the nature of the MECSW corpus which comprised mainly laboratory or project reports, where students focused on reporting experimental work (Parkinson, 2017), evident in the more frequent use of observation and method categories of verbs rather than hedging verbs.

Finally, some lexical verbs which appear to be general are, in fact, important for describing engineering-related activities. General verbs like “set,” “go,” “need,” and “carry” belong to the new-General Service List but are relevant for describing some actions in engineering studies. Furthermore, topic-dependent verbs like “moving,” “starting” and “adding” do not have their lemmas listed in the Academic Keyword List, but are important for describing activities, which is why they are rather frequently used in the engineering project or experiment reports analyzed in the present study. However, the occurrences of these verbs are low in comparison with the more “general” verbs, particularly those in the past participle form.

To sum up, for the 10 top verbs in their individual forms, 44 are academic verbs and 16 are non-academic. The use of these verbs mainly reflects the observation-type laboratory or project reports common to engineering. Additionally, a mixture of verbs that are academic and non-academic in nature was used in specific forms to achieve the intended purpose of writing depending on content and discourse segments (e.g., method, result, etc.). The top three verbs

with the highest frequency in the past participle (as well as when all verb forms are combined) which are “used,” “shown,” and “based,” appear to highlight the prevalence and importance of the Methods and the Results section in the writing of these student engineers. Methods provides the information about materials and procedures that are pertinent to laboratory or experimental work. In the Result section, qualitative and quantitative analyses are conducted to provide answers to stated research problems (Ebrahimi et al., 2015). Both sections represent important scientific steps in relaying facts to the reader. The results from this analysis, therefore, show that information about verbs and verb forms can be a differentiating feature across discourse segments (e.g., Burrough-Boenisch, 2003), and can potentially provide the basis for comparing verbal distribution (alongside verbal function) between learners’ writing and professional writing (e.g., Engineering Journal Articles Corpus) as well as writings found in reference and text books (e.g., Engineering English Corpus, Reference Books Corpus, etc.). Ultimately, these can be used to inform vocabulary and writing instructions in ESL and ESP classes for engineering students.

Distribution of Verbs between the Academic Keyword List, New-General Service List and Potential Specialized Vocabulary for Academic Engineering

Overall, the analysis using the keyword list tool in the concordance software revealed that a majority of the top 1,000 words are nouns, and mostly specialized nouns used in the fields of electrical, electronic and mechanical engineering (e.g., voltage, temperature).

Table 5 shows the top 50 verbs and their distribution between the Academic Keyword List, new-General Service List and potential specialized vocabulary for academic engineering. They are arranged based on descending keyness log-likelihood value (6.63 or higher). About 70% (35) of the verbs have their lemmas listed in both the Academic Keyword List and the new-General Service List. This overlap was expected given the wide coverage of words in the English vocabulary for the latter. However, a majority of the top 50 verbs are not ranked highly in the new-General Service List as opposed to more general and conversational verbs such as “see,” “have,” “give,” “say,” and “think.” This suggests that there is a genre difference between the MECSW and the British National Corpus, with the former being academic in nature (and inclined towards expository texts rather than argumentative texts) and the latter reflecting general English.

Table 5

Top 50 Lexical Verbs Based on Log-likelihood (keyness) and Their Distribution between the Academic Keyword List, New-General Service List and Specialized Vocabulary for Academic Engineering

| No. | Verb forms | Log-likelihood | AKL | New-GSL | Spec. vocab. | No. | Verbs forms | Log-likelihood | AKL | New-GSL | Spec. vocab. |
|-----|------------|----------------|-----|---------|--------------|-----|-------------|----------------|-----|---------|--------------|
| 1 | shows | 918.14 | √ | √ | | 26 | recorded | 175.52 | √ | √ | |
| 2 | shown | 893.68 | √ | √ | | 27 | fabricated | 174.09 | | | √ |
| 3 | using | 731.82 | √ | √ | | 28 | detect | 173.17 | | √ | |
| 4 | used | 718.19 | √ | √ | | 29 | compare | 169.65 | √ | √ | |
| 5 | connected | 481.91 | √ | √ | | 30 | measure | 158.11 | √ | √ | |
| 6 | based | 481.68 | √ | √ | | 31 | reduced | 133.12 | √ | √ | |
| 7 | connect | 463.48 | √ | √ | | 32 | stated | 127.63 | √ | √ | |
| 8 | determine | 457.92 | √ | √ | | 33 | tabulated | 127.42 | | | √ |
| 9 | measured | 457.49 | √ | √ | | 34 | plotted | 120.96 | | | √ |
| 10 | obtain | 415.78 | √ | √ | | 35 | increased | 119.74 | √ | √ | |
| 11 | bonded | 388.29 | | | √ | 36 | calculate | 118.24 | | √ | |

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| | | | | | | | | | |
|----|------------|--------|---|---|----|------------|--------|---|---|
| 12 | obtained | 381.89 | √ | √ | 37 | decreased | 116.88 | | √ |
| 13 | decrease | 378.4 | | | 38 | carry | 116.61 | √ | |
| 14 | compared | 351.94 | √ | √ | 39 | inserted | 115.96 | | √ |
| 15 | conducted | 348.37 | √ | √ | 40 | uses | 102.22 | √ | √ |
| 16 | increase | 344.24 | √ | √ | 41 | produce | 101.07 | √ | √ |
| 17 | reduce | 245.85 | √ | √ | 42 | affect | 100.74 | √ | √ |
| 18 | consists | 219.2 | √ | √ | 43 | enable | 100.47 | √ | √ |
| 19 | calculated | 216.58 | | √ | 44 | cause | 97.97 | √ | √ |
| 20 | noting | 216.35 | √ | √ | 45 | occurred | 96.5 | √ | √ |
| 21 | fabricate | 197.76 | | | 46 | achieved | 95.04 | √ | √ |
| 22 | increases | 187.98 | √ | √ | 47 | stabilize | 93.68 | | √ |
| 23 | switched | 182.34 | | √ | 48 | increasing | 93.45 | √ | √ |
| 24 | analyze | 180.97 | √ | √ | 49 | exposed | 92.59 | √ | √ |
| 25 | diagnose | 178.48 | | | 50 | analyzed | 92.54 | √ | √ |

Notes: AKL = Academic Keyword List, new-GSL = new -General Service List

Khamis and Abdullah (2013) also found verbs such as “shown,” “shows,” “determine,” “connected,” “using,” “obtain” and “consider” to be in their top 100 key-keyword list of the Reference Books Corpus alongside predominant specialized nouns. Their engineering corpus (E²C) was larger, comprising the Reference Books Corpus and the Engineering Journal Articles Corpus. Thirty key-key-verbs were extracted from E²C when compared to the BNC, and 70% of the verbs overlap with those found in the present study (e.g., “shown,” “shows,” “determine”). The Correspondence Analysis was then conducted with these key-key-verbs by computing the frequency values of the verbs generated for each corpus: E²C, Reference Books Corpus, Engineering Journal Articles Corpus and British National Corpus. Results suggest that words such as “analyze” and “decreases” were distinctly used in the specialized corpora (higher coordinate on the X-axis indicative of further distance from the BNC as reference) despite words like “used” (16.3%) followed by shown (15.3%), and determine (10.9%) having higher contribution values in differentiating the corpora overall. This finding suggested that Correspondence Analysis is useful for investigating verbs at the individual level.

The other 20% (or 10) of the lexical verbs in the top 50, including verbs such as “fabricate,” “diagnose,” “plotted,” “tabulated” and “stabilize” are neither listed in the Academic Keyword List nor in the new-General Service List, and can be considered specialized vocabulary in academic engineering, although they may likely also be topic-dependent with the limited number of study samples. Only the verb “fabricate” seems to fit the classification of semi-technical words, which refers to words that have one or more general English language meanings and which take on extended meanings in technical contexts (see Cowan, 1974; Nation, 2001). “*Fabricate*”, however, is not on Ng et al.’s (2017) Engineering Technology Word List of highly technical or semi-technical words, which is hardly surprising given that a majority of them are specialized nouns (e.g., amplifier).

Although the majority of the specialized verbs identified in this study are non-technical in nature, they may be potential candidates for a future word list for English for Specific Purposes based on certain criteria. While most engineering word lists focused on the “technicality” of words, Todd (2017) created a 186-word list based on opacity (polysemous and high frequency) with the aim of facilitating teaching in ESP. Some verbs identified in the top 50 of this study, namely, “determine,” “shown,” “shows,” “used,” “using,” “use,” “obtain,” “measured,” “occurs,” “analyze,” “decreases,” “increases” and “consists” also appeared in Todd’s (2017) opaque list. Therefore, the specialized verbs identified in the present study based on students’ production can be potential candidates for future ESP word lists. Compared to general academic corpora, discipline-specific corpora and word lists can address the specific needs of students more directly (McEnery & Wilson, 2001).

Conclusion

The study showed that the MECSW is a corpus that is academic in nature based on lexical verb analysis. Three insightful results were found. Firstly, in the engineering students’ writing, the top three words in past participle form identified via analysis of individual verb forms are the academic verbs “used,” “shown” and “based.” They reflect the expository nature and report-writing style of the texts as well as provide content-related information. Vocabulary instructions should include exposing students to specialized verbs such as these and should ideally be presented alongside real-world excerpts (e.g., from concordance analysis of texts) to show how the verbs actually function. In this study, the identified verbs include many academic verbs (e.g., based) as well as some non-academic verbs (e.g., set). The predominance of academic verbs as a whole could mean that their effective usage is expected for successful writing, apart from the use of other semi-technical or technical words which are commonly nouns rather than verbs (e.g., Ng et al., 2013). Thus, it might be worthwhile to provide vocabulary instruction for these specific verbs earlier in their university studies, as most Malaysian university students demonstrated a low mastery of receptive academic vocabulary level (Lateh et al., 2018). Using targeted vocabulary may be an ideal way of teaching writing to ESL students with limited vocabulary knowledge.

Secondly, the past participle was the most frequent verb form, while the past tense was the least occurring form because the students' reports had an object-oriented approach suited to the use of passive structures. Interestingly, the results from the verb form analysis also revealed inaccurate usage of the base verb form in place of other conjugated forms, suggesting first language interference. It is crucial to ensure that verb forms are used correctly to communicate the intended message given that the tense and agreement morphology of English are often problematic for Malaysians learning English as a second language (Wee et al., 2010; Wong, 2012). In view of this, academic writing courses at the tertiary level should emphasize verb form learning, particularly in regards to tense and agreement morphology.

Thirdly, the top 50 lexical verbs in the MECSW were found to comprise 70% academic vocabulary as listed in the Academic Keyword List. About 20% of the verbs, which are neither listed under the Academic Keyword List nor the new-General Service List, can therefore be described as specialized vocabulary. The specialized vocabulary which comprises a majority of non-technical vocabulary rather than semi-technical vocabulary can potentially be candidates of knowledge-specific word lists for English for Specific Purposes. Highlighting these specialized non-technical or semi-technical verbs in vocabulary instruction could facilitate vocabulary learning because novel words and words with extended meanings may be especially confusing for new engineering students who are non-native speakers of English. The creation of smaller wordlists that match the proficiency level of a particular group of learners may serve this purpose. Ward's (2009) 299-word wordlist and Todd's (2017) 186-word wordlist are examples of this. The latter allows its target users (low proficiency foundation engineering undergraduates in Thailand) to recognize around 16% of the words in their textbooks. Therefore, identifying and compiling high-frequency verbs (alongside other word classes) in the mere hundreds in the future may be a step in the right direction for facilitating ESL learners in Malaysian undergraduate engineering programs to increase their word repertoire and use this to write more effectively.

The study has identified core verbs and forms, as well as non-technical and semi-technical verbs that can be included in future knowledge-specific word lists for English for Specific Purposes suited to the engineering discipline for users of English as a second language. However,

the present study did not identify the criterion for selection into specific word lists; this is an area for future research. A limitation of the study is that the results are based on the MECSW corpus built from 50 scripts of written work of engineering undergraduates in the mechanical, electrical and electronic programs of a Malaysian public university. The corpus size is moderate. Future studies should incorporate a more substantial amount of student writing to better represent learners' academic writing in the engineering field including sub-disciplines within engineering not covered in the present study, such as chemical engineering. This is because the specialized terminology may be different. Future investigations along these lines will produce insights that facilitate students' acquisition of core academic vocabulary and specialized vocabulary for their engineering studies and future practice as engineers.

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