Short Research Papers,
Vocabulary Learning for Japanese Chemists

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This study explores vocabulary learning in an ESP context. Given the vast amounts of research and knowledge accumulated now in vocabulary learning and teaching, the challenge for educators is often how best to impart this knowledge to learners. This paper, originally presented at the 2019 JALT CUE & BizCom ESP Symposium, offers an overview of vocabulary learning research with a view towards supporting Japanese chemists in their efforts to master their professional language; specifically, those working and engaged in research in their field.

English is now well-established as the lingua-franca across a broad range of professions throughout the world, facilitating information exchange and communication on an unprecedented scale (Crystal, 2003; Kirkpatrick, 2007; Ronen, et al., 2014). One domain where this is immediately apparent is within the physical sciences; for example, the field of chemistry (Bornmann, Schier, Marx, & Daniel, 2012; Flowerdew, 2013). As a point of illustration, Ulrich's Periodicals Directory—accessible online as Ulrichsweb—is a comprehensive global source of bibliographic and journal information that has been indexing academic and other periodicals over a broad range of languages since the 1930s. A search of this resource highlights the utility of English compared to Japanese in the field of chemistry. By performing an advanced search and limiting results as listed below (Table 1), a total of 3,047 publications are returned.

However, the same search using Japanese instead of English returns only 451 (Serial Solutions, 2019). As this search demonstrates, the use of English enables Japanese chemists to access a much larger and far-reaching body of knowledge within their field than is possible in their native language. However, this use of

Table 1
Advanced Search Results from Ulrich's Periodicals Directory

Status:	Active
Serial Type:	Journal
Content Type:	Academic/Scholarly
Subject Area:	Chemistry
Key Feature:	Refereed/Peer-reviewed
Language:	English

English as a professional language presents significant challenges.

Among the various issues Japanese scientists face in using English as a professional language, vocabulary learning plays a perennial role. This paper explores the research on vocabulary learning from an ESP perspective, specifically focusing on four major vocabulary groups: high-frequency words, low-frequency words, technical words, and sub-technical words (Nation, 2013). It begins with an overview of how many words are needed to be an effective communicator in English.

How many words?

Research indicates that native English speakers know around 20,000 words by the time they finish high school (Goulden, Nation, & Read, 1990). That number of words can be daunting for speakers of English as an additional language (herein, EAL users); however, fortunately, other research shows that EAL users can understand fluent English conversation with around 6,000–7,000 words (Nation, 2006). This presents a much more realistic goal for EAL users. In order to ascertain where a learner is in relation to this goal, there is a reliable test freely available online: https://my.vocabularysize.com. The test is based on Paul Nation's Vocabulary Size Test, which is a well-established, reliable measure of vocabulary size (Beglar, 2010; Nation & Beglar, 2007).

By recommending learners to take this test, which is easily accessible and freely available online, it is immediately apparent where they stand in relation

to this initial vocabulary goal of 6,000–7,000 words. But then the question remains: *Which* words do they need to know?

High-Frequency Words

Not all words are equal, and some English words are used much more frequently than others. Corpus research provides us with a list of around 2,800 high-frequency words, called the *New General Service List* (NGSL), which cover around 92% of most general English texts (e.g. newspapers, novels, everyday spoken conversations, etc.; Browne, 2014). Figure 1 illustrates the coverage of the NGSL in a short, general English text.

Generally speaking, Japanese chemists typically have a firm grasp of these high-frequency words, having typically progressed through nine years of formal language learning in secondary school and university, and often with additional graduate studies (Mclean, Hogg, & Rush, 2014) . As such, the NGSL will not present good value for learning time; however, for early-career chemists, it may be worthwhile measuring their vocabulary size to ensure that they have already crossed this threshold.

Low-Frequency Words

If a word is not a high-frequency word, it can be considered a low-frequency word. Although there is an enormous number of low-frequency words—possibly more than 100,000—this group of words covers only a relatively small proportion of English (Goulden, Nation, & Read, 1990). Many of these words, EAL users will never meet or need, and for this reason, low-frequency words are best learnt as they are met in context (i.e., not as a list of words). When an EAL

The NGSL *is the place to start your* English vocabulary *learning*. *It is important to master these words*. *In fact*, *not knowing these words will be a serious* disadvantage *when you need to communicate in* English.

Figure 1. Words highlighted in grey italics are from the New General Service List (NGSL), words in black are not. Total words: 36; NGSL words: 31 (86%).

user starts to notice a low-frequency word, it is likely because that word is now of some importance to them, and therefore a good time to learn it. For this type of learning, best practices include, for example, repeating the word aloud, looking it up in a dictionary, and writing it down on a flashcard for later review (Nation, 2013).

Technical Words

Within the extraordinarily large group of low-frequency words, there is a sub-group of words that will demand more attention; these are the technical words. Technical words are low frequency words in general English but used much more frequently in certain domains. For example, *cation*, *ligand*, and *isomer* are rarely used in general English and most native English speakers will not know what they mean, but in chemistry these words are common (i.e., relatively high frequency) and as such, much more likely to be met and learnt by Japanese chemists. Research indicates that in some fields, technical words can account for more than 30% of the English used (Chung & Nation, 2003). Figure 2 illustrates how heavily technical words feature in chemistry.

Due to the relatively high saliency and frequency of technical words, their integral role within the field, and the prevalence of katakana versions, these words tend to be readily recognized and learnt by Japanese chemists, and as such,

Imidazole is readily converted into *cationic imidazolium* by the *protonation* or *di-substitution* of two *N-positions.* The *1,3-disubstituted imidazolium* ring, a *cationic N-heteroaromatic* ring, is well known as the most popular and investigated class of the *cationic* structure of room temperature *ionic* liquids. The reaction of *1,3-disubstituted imidazolium cations* is restricted due to the chemical stability of the *imidazolium* ring *derived* from the *delocalization* or burying of *cationic charge*, the *aromaticity*, and the low *reduction potential*.

Figure 2. Text highlighting technical words (in grey italics). Total words: 75; technical words: 23 (31%). Reprinted with permission from T. Nakashima, M. Goto, S. Kawai, and T. Kawai.

less of a concern for the language teacher. Moreover, given that the concepts that technical words denote require highly specialised knowledge, this set of words is better left to the content-specialists and Japanese chemists themselves to master. However, given that many katakana versions may differ importantly from their English counterparts, it may be prudent for language teachers to spend time guiding Japanese chemists through pronunciation.

Sub-technical words

Finally, in parallel with the technical words, there is another group of low-frequency words (in general English) that occur more frequently in certain domains, referred to as sub-technical words. Unlike technical words, sub-technical words do not belong specifically to one field; that is, they are used across a range of fields. The *New Academic Word List* (NAWL)—a group of 960 "academic" words derived from large-scale corpus-based research—has been demonstrated to cover around 10% of all academic English, including chemistry (Coxhead, 2000; Brown, 2014). The NAWL in order of frequency, including Japanese translations, is freely available on the internet and can be downloaded from the following link: http://www.newgeneralservicelist.org/nawl-new-academic-word-list/. Figure 3 illustrates its coverage of an excerpt from an academic text.

For many Japanese chemists and language teachers alike, this group of words presents good value for learning or teaching time, as it not only helps scientists

The *unique stability*, reactivity, and biological properties of fluorinated *compounds* *contribute* to their *widespread* use in many *chemical* disciplines. *Compounds* containing a trifluoromethyl group have been studied extensively. *Compounds* containing partially fluorinated alkyl groups, such as a difluoromethyl group, should be *similarly* valuable for medicinal chemistry because such groups could act as lipophilic hydrogen *bond* donors and as bio-isosteres of alcohols and thiols.

Figure 3. Text highlighting the New Academic Word list (NAWL; in grey italics). Total words: 63; NAWL words: 10 (15%). Reprinted with permission from P. Fier and J. Hartwig.

to de-code the academic register typically employed in research writing, but also to express their own research at a higher level of sophistication. Moreover, if Japanese chemists are directly involved in the publication of their work, which many are, a skillful application of sub-technical words may even help them to convince reviewers and editors to accept their work for publication.

Conclusion

Vocabulary learning is an ongoing endeavor for most EAL users, including Japanese chemists. This paper has examined this area of language learning with a view to supporting Japanese chemists in their efforts to master their professional language. Research in vocabulary learning has identified four distinct groups of words; namely, high-frequency words, low-frequency words, technical words, and sub-technical words. For Japanese chemists striving to master English as a professional language, and the language teachers that support them, these groupings provide an insightful view towards sound vocabulary learning targets.

This study has asserted that while technical words are an integral part of Japanese chemists' professional language, they do not necessarily demand priority from language teachers. Much like the group of high-frequency words, the high saliency and frequency of technical words within the Japanese chemists' daily working lives, combined with the prevalence of katakana versions, makes them readily learnable with minimal pedagogical intervention from language teachers. Furthermore, learning the concepts that technical words denote is a defining aspect of being a chemist, and a task that is typically beyond the language teacher. In contrast, sub-technical words, for example the NAWL, present good value for teaching and learning effort, as they are a relatively small group of words that cover a relatively large proportion of the type of English that Japanese chemists are likely to use in their professional lives (e.g., journal articles, conference presentations, etc.).

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