Japanese Industrial Technical Terms: Word Formation, Word Type and Word Education

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Research Article

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Abstract

In Thailand, Japanese learners need to attend training or internships at respectable Japanese companies. Previous research has found problems with comprehension of technical terms, but there are no studies or research on how technical terms can confuse or may be difficult for learners to use. So, this study is aimed at analyzing word formation and word types of Japanese technical terms in the industry, simplifying what makes technical terms difficult for learners in terms of their morphological knowledge, and offers a way to teach technical terms and enhance learners' understanding about Japanese technical terms based upon morphological knowledge. The results have shown that in Japanese technical terms, Sino-Japanese or Kango was found mostly when compared to other word types, hybrids, foreign words, and native words. Regarding word formation, compounding is the most common. The difficulties of technical terms could be divided into four types that are unfamiliar with Kango, changing form into hybrids, the different meaning of loanwords, and lack of knowledge of intra-structure of compounds, affixes, and clippings. The test of morphological knowledge by the University of Washington was adapted into learning drills to enhance the knowledge of word types and word formation.

Introduction

Why study about technical words?

In Thailand, job training or internship at the workplace is one requirement for final-year students. Many students that study Japanese as foreign language learners (JFL learners) decide to take their job training at plants in industrial estates located around Thailand. One problem with language usage is technical terms in the workplace (Munintarawong, 2018; Juntaro & Sontirak, 2020). In general, Japanese education in many educational institutions focuses on general Japanese communication, so the offered vocabularies tend to be general words rather than technical terms. Furthermore, some vocabulary and grammatical patterns found in basic Japanese learning tend to be different from the real-world usage and tend not to be updated because textbooks are published once, a long time is needed for revision (Suzuki, 2010), whereas nowadays vocabularies and grammatical patterns in authentic situations tend to be chosen for responding to learner's needs (Kano, 2000).

Even though there are problems with a lack of knowledge of technical terms used in an authentic situation, such as in the Japanese industry, there are very few previous studies that systematically investigate Japanese technical terms or specialized words. This is also mentioned in Komiya (2014:76) who indicates that there are no dictionaries or books that collect and explain technical terms. There are only collections on the collocation of technical terms relating to Chemistry, Physics, and Economics for high school.

The importance of morphological knowledge

According to studies on vocabulary knowledge that learners should comprehend, morphological knowledge including word formation and word types is one crucial part of vocabulary learning. However,

word formation teaching is often avoided in language course books and there is little research conducted about the pedagogical status of word-building processes (Enesi, 2017). Nevertheless, many pieces of research strongly identify the significance of word-formation knowledge as an integral part of language fluency (Nagy, 1997; Haastrup & Henriksen, 2000; Nassaji, 2004). Linguistic knowledge is one of the learners' pre-existing knowledge bases including syntactic knowledge, lexical knowledge, and knowledge of word schema (Nagy, 1997). The dimensions of vocabulary knowledge are distinguished into the depth and breadth of knowledge (Haastrup & Henriksen, 2000). According to Nassaji (2004), depth of knowledge is not limited to individual meanings for each word. Various kinds of knowledge including pronunciation, spelling, register stylistic, and morphological features are all necessary for learners to know. Qian (2002) indicates that the morphological features relate to word formations such as affixes. Kieffer & Lesaux (2008) offer evidence that morphological awareness might have some influence over reading comprehension among native English speakers, so it becomes significant to examine reading comprehension difficulties. Naga & Anderson (1984, cited in Muse, 2005: 5) estimate that learners can predict 60 percent of new words' meanings by using the basic component morphemes as a clue.

Morphological knowledge, especially in aspects of bases and affixes is a significant part of vocabulary knowledge. When learners encounter new words formed from known word parts, they can comprehend all or some meanings of the words (Li & Kirby, 2015). Ma & Lin (2015) surveyed the relation of four subcomponents of the depth of vocabulary knowledge including morphological knowledge and summarized that morphological knowledge is significantly related to reading comprehension. Nation (2001:264) states about the morphological knowledge that the knowledge of affixes and roots has two advantages for English learners: one is that it helps by learning unfamiliar words by relating them to known prefixes and suffixes, and the other is that the confirmation whether unfamiliar words can be guessed from contexts.

As seen above, the relevance of morphological knowledge on language learning, especially on reading comprehension has been discussed in many studies as mentioned by Kieffer & Lesaux (2008), Li & Kirby (2015), Ma & Lin (2015), and Nagy et al. (2006) whom all reported a reasonable relationship between morphological knowledge and reading comprehension. It is believed that knowledge of morphology can contribute to learners' ability to parse the intra-structure of words and to comprehend words' meanings. The implication of morphological knowledge to technical term analysis could be useful for enhancing technical term learning and also reading comprehension.

How to teach technical words?

Regarding technical term education, Nation (2001: 19) offered two ways for how teachers can teach about specialized vocabulary. Technical terms should be treated as high-frequency vocabulary if technical vocabulary is also high-frequency vocabulary and the connections and the differences between the high-frequency meanings and technical uses. Another is teaching technical vocabulary with specialist knowledge of the field because many technical terms will only make sense in the context of the specialized subject matter. Mori (2014: 417) also offered context-based strategies for learning new words

in a meaningful context that was more effective than learning words in isolation. Furthermore, Quackenbush (1977) remarked that devising more systematic methods was needed to present loanwords to students. Some basic understanding of the nature of borrowing should be given to students and exercises in rewriting English.

This study analyzed the technical terms in the industry based on morphological knowledge including word types and word formations and offered a way to teach them to learners who need to learn them for their job training and future employment. Furthermore, some industrial technical terms in this study can be used as authentic teaching materials to enhance learners' Japanese vocabulary knowledge.

Word Formation

As mentioned in Matthews (1974: 38), the field of morphology is divided basically into two major subfields. One is *inflection* that can be found in English as the English verbal endings *-s* or *-en*.

Another is referred to as the process of *word-formation*. The process of word-formation can also be categorized into two smaller subfields that are *derivation* and *compounding*.

Derivation is the process of word formation in which the existing bases are attached with elements called derivational affixes, either before or after the base (e.g., *un-*, *mis-*, *-ly*, *-ous*, *-ize*), while *compounding* is the process of forming new words by joining two or more other words together.

In Japanese, according to Ootsu et al. (Ed) (2002), the process of word formation is also divided into compounding and derivation. The words that are generated by compounding are called compounds or *fukugōgo*, and the words that are generated by derivation are called derived words or *haseigo*. Besides compounding and derivation in Japanese, clipping is also a key process for forming new words. Clipping is when an existing word that is clipped becomes a new, shorter word. Clipping forms shorter words, typically by discarding some parts of the existing words without losing their meanings. In Japanese, Kubosono (2010) indicates that *clipping* or *truncation* appears in foreign words (*gairaigo*) and compound words (*fukugōgo*). Clipping in compounds tends to have two styles: the latter word is removed such as *keitaidenwa* (mobile phone) that is shortened to *keitai* and the first syllable of each word is preserved such as *Tokyodaigaku* (Tokyo University) is shortened to *Tōdai*.

Borrowing is one of the word-formation processes found in every language. The process of borrowing words from another language has occurred in the past, due to several reasons, such as through invasion or general communication (Kenworthy, 1991: 25). The loanwords or foreign words or *gairaigo* in Japanese are the output of the borrowing process, such as *rokkudaun* (lockdown), *konpyūtā* (computer). There are also Japanized English words that are not, in fact, true loanwords at all but rather are foreign lexemes invented in Japanese (Miller, 2011: 123) such as *sararīman* (salaryman).

Japanese Lexical Categories

In Japanese, there are four sub-groupings of Japanese lexical categories or word types: Yamato (Yamato-kotoba) or the Native Japanese such as Neko (cat), Sino-Japanese or Kango borrowed from Chinese such as Gengo (language), Foreign words or gairaigo or ones usually called loanwords (not including Sino-Japanese) such as shisutemu (system), and hybrid (konshugo) the words that combine more than two types of lexical categories, such as kōhī-mame (Coffee bean). Kango is found mostly in Japanese dictionaries, lexical surveys, and Japanese modern magazines (Nomura, 1999, Yamasaki & Konuma, 2004) and is used more than 70 percent in technical words (Matsushita, 2018).

Kango education including word formations and lexical categories has become more extremely essential because it decreases the lexical gap between school education and authentic situations. According to Kano (2000) teaching a set of two Kanji with its part of speech such as netchū (enthusiasm), is a verb that can occur with the suffix -suru or muchū (enthusiasm) that is an adjective verb which can be a verb in the form of muchū ni naru, or derived words that comprise prefixes and suffixes of Kanji like shin- (new), chō- (ultra), -teki (to make words adjectival) should be taught as a part of word-formation knowledge which is also able to enhance learner's memory on lexical.

Matsushita (2018) indicates the importance of the Sino-Japanese word (Kango) for Japanese learning in the case of a word and an affix. Just being aware of Kanji is not sufficient to overcome Kango. Significant Kanji knowledge must include form, basic meaning, word formation, metaphor, and the relationship between On-yomi and Kun-yomi. With these results, it would be important to create a database that would be extremely useful for Japanese education, especially giving them more experience and knowledge so that they may be able to guess the meaning of Kango which is a key factor for successful word learning.

Yamashita (2004) and Matsushita (2018) also indicate the importance of Kango functioning as an affix. Kango as an affix expresses the concrete meanings as same as the meanings as a word such as suffix -shitsu (room) in kaigishitsu (meeting room) which means *room* like the word shitsu (room). From this point, it could be said that learning affixes can decrease the burden learners have for remembering words. Yamashita offers 6 techniques to teach Kango for lexical knowledge enhancement. One of the techniques that should be taught in the intermediate and advanced levels is word formations of Kango including base, affix, compounds, and reduplication words. The amount of affixes in Japanese has at least 753 affixes in Matsushita (2012: 86) and in Cho (2018) there are 818 affixes which are divided into 238 prefixes and 580 suffixes. Thus, it could be concluded that the total number of affixes in Japanese is between 753-818 affixes. Regarding Kango in a specific field such as in economics, according to Komiya (1995), 799 basic words for the Economic field are found. The proportion of Kango is found 82.4 percent or 658 words for economic technical terms.

As seen above, the morphological knowledge in Japanese including word formations and word types correlates to vocabulary learning. Once learners learn about word formations including affixes or Kanji, they tend to guess the meanings of words from their constituents and tend to be able to successfully use the words in communication.

Objectives

1. To explore word formation and word types of Japanese technical terms in industries.
2. To clarify what makes technical terms difficult for learners in the aspect of morphological knowledge.
3. To offer a way to teach technical terms and enhance learners' understanding of Japanese technical terms based on morphological knowledge.

Research Questions

1. What is the proportion of word formations and Japanese word types between native Japanese words, Sino-Japanese words, foreign words, and combinations of them or hybrids?
2. What makes learning technical terms more difficult for learners?
3. What are the suitable drills of a technical term for the preparation course of internship students?

Methodology

1. Collecting the technical terms from authentic materials received from related industries. All data used in this study were collected from authentic materials from many industrial fields relating to vibrating equipment, parts feeders, controllers, industrial electrical equipment, automotive testing system, clutches and brakes, servo actuators, printer systems, industrial transportation, full-scale production of motorcycles, motorcycle and automotive chains, automotive critical safety parts, and automotive parts. The number of token words for analysis is 4,692 words.
2. Analyzing word types and word-formation by categorizing them into native Japanese, Sino-Japanese, foreign words, hybrids, single words, compound words, derived words, and clippings.

Results And Discussion

To answer the research question, the Figure 1 shows the proportion of word formations and word types between native Japanese words, Sino-Japanese words, foreign words, and hybrids.

As seen in Figure 1, technical terms found from various industries totaled 4692 words as the word tokens. In the case of word formation, compounding is the most frequent at 40.88 percent. The second is simple words at 34.87 percent, the third is derivation at 14.71 percent, and fourth is borrowing at 9.06 percent, and finally, clippings at 0.49 percent. For the aspect of word types, Sino-Japanese or Kango is the most at 69.80, hybrids at 18.24, foreign words at 9.29, and native words or Japanese words at 2.66 percent, respectively.

In this section, to answer the second research question: What makes learning technical terms more difficult for learners? The discussion provided is based on the morphological aspects and the gap

between school education and real-world usage.

1. Unfamiliar with Sino-Japanese words or Kango

The proportion of lexical category is not unusual or different from previous studies (Yamasaki & Konuma, 2004; Matsushita, 2018) which indicated a high frequency in the use of Sino-Japanese or Kango in general and specific Japanese including intermediate and advanced Japanese (Kano, 2000). In this study, Sino-Japanese was the most common and some were rarely found in everyday learning, for example, chinden (precipitation), rōden (electrical fault), and neji (screw).

Most of the words found in the industry are technical terms that learners are unfamiliar with; for example, muda (wasteful), mura (nonuniformity), and muri (impossible). Though learners have the opportunity to learn and use muda for meaning wasteful, and muri for meaning impossible, they have little to no chance to encounter mura in their study. Some words can have more than one meaning; for example, bakaana means *unloaded hole* when the word baka in bakaana does not mean *stupid* or *dull*. Baka in the words bakaana comes from the sentence *ana ga baka ni naru* which workers use daily at work in the shortened form. This case is also found in the word bakaneji with the meaning *stripped screw condition* that comes from the sentence *neji ga baka niru*.

Some Kanji have different pronunciations and different meanings, though they have the same structure, for example, Kanji 切 can be read as (meaning “fate”) or fuchi (meaning “edge”), in general, the collocation en o kiru (“break off the relationship”) or the compound *enkiri* is the word with which learners are acquainted, but in industry, the same collocation has a different pronunciation *fuchi o kiru* or the same compound *fuchigiri* which has a different pronunciation and meaning which is “cutting edge”. Some words are used to refer to concrete objects or machines such as *kata* which means “die” (a tool in metal-making). In basic Japanese, learners learn only the abstract meanings of *kata*, *type*, and *model*. *Kata* is shortened from *kanagata* (die) and has the potential for making new words in the industry such as *anaakegata* (hole piercing die), *uchinukigata* (blanking die), *oshidashikata* (pushing outside die), and *kattoofukata* (cut off-die).

Furthermore, a common word such as *furyō* means bad, inferior, or wicked, can be found in textbooks like *furyōgakusei* (a bad student) also has the potential to create new words in the industry such as *sunpōfuryō* (dimension NG), *seikeifuryō* (injection NG), *sōsafuryō* (control NG), *tosōfuryō* (spray NG). Many words have the same meanings which can increase the burden on learners to remember. For example, the words mating part, counterpart component, and common part refer to the same things which are *aitebuhin*, *kyōtsūbuhin*, *kyōyōbuhin*.

In conclusion, the irregularity of Kanji and words, the variety of word meanings, and the potential of words may attribute to increasing the difficulty for learners to understand.

2. The Changing form in hybrid words

Hybrid words are forms structured with a mixture of Native Japanese, Sino-Japanese and foreign words. The difficulty of hybrid words is that their forms tend to be shorter than the former. Some hybrid words are Japanized words (*waseigo*), especially in the case of the compound form of foreign words with Native Japanese or Sino-Japanese forming. Some examples are given below.

Fukaōbā (overload) is a hybrid of Sino-Japanese: *fuka* and a shortened foreign word: *ōbā* deriving from *ōbārōdo* (overload). This word in Japanese is *kafuka* which has the same meaning, *overload*.

Sukimagēji (feeler gauge), is a hybrid of Sino-Japanese: *sukima* and a foreign word: *geiji* (gauge). This word is a Japanized compound because the original word in English is *feeler gauge*.

Learners who are majoring in technological fields may learn the word *feeler gauge* or *overload* in its original English form, but when it is used in Japanese, it has a transformation of form as Japanized words (*Waseigo*). The amount of Japanized words that are found in hybrid forms between Japanese and foreign words is quite a lot, such as *daburushigoto* (double work), *kūkiponpu* (air pump), *āsu-suru* (or *setchisuru*-earth), *kyūmeibui* (rescue buoy), *kensetsusaito* (construction site), *jokyoburashi* (eliminating brush), *bōjinmasuku* (dust protective mask), and *bakkuappudengen* (back-up power supply).

The shortened forms, Japanese style usage, and Japanized words as seen above are also the obstacles of learning and usage. Many foreign words have morphed into Japanese words such as the word *double work* changing into *daburushigoto*, or *air pump* changing into *kūkiponpu*. This complexity makes technical term comprehension more difficult to remember and increasingly burdensome to use.

3. The different meanings of loanwords used in the industry

Loanwords are words borrowed from English or other languages except for Chinese. Normally they should retain most of their original forms and meanings, even after they have become part of the Japanese lexicon written in the Katakana syllabary. Writing in Katakana syllabary often causes the change of pronunciation and sometimes the change of semantic and grammatical features (Quackenbush, 1977). Takashi (1990) identified five functional types of loanwords: (1) lexical-gap fillers, (2) technical terms, (3) euphemisms, (4) special-effects-givers, and (5) trade names. The reasons for using technical words are usually the shortage of native equivalents, and technical terms are more specialized than lexical-gap fillers.

The difficulty of learning loanwords has been explored in many aspects. Quackenbush (1977) indicated the reason why loanwords are difficult for English-speaking students, non-uniformity of adaptation to Japanese, loanwords of phonological changes, production in deduction form, and recognition from the original English form. Sometimes loanwords' pronunciation is distorted or shortened (Yano, 2001), and they change or lack original meanings (Tanaka & Tanaka, 1995). For example, the words *glass* and *grass* in English can be transliterated into *garasu*, the shortage of transliterated pronunciation of katakana which indicates a low green plant and a drinking vessel (Tsunoda, 1988).

The percentage of loanwords in Japanese depends upon the type of publication. Random checks of Tsunoda (1988) showed that in nationally circulated, news-oriented weeklies, 10 to 25 percent of the words are imported. In professional journals in such fields as medicine and science, it is anywhere from 20 to 75 percent. However, according to Takashi (1990), there is 13.30 percent (737 words) from 5,556 loanwords used as technical terms found in television commercials and printed advertising. Like previous results, this study also found 9.06 percent of loanwords of industrial technical terms.

Loanwords in the field of industry are more difficult than those in other fields because of the unfamiliarity as mentioned in the above section. Most of them in original English forms are not found in daily life lexicon such as The New General Service List (NGSL) (Browne, et al., 2013). There are only 20 words found in NGSL from the overall 436 loanwords based on Figure 1: *alcohol, hook, tank, coin, service, dust, paint, oil, pan, gear, brake, supple, wrap, motor, chip, error, size, budget, gap, and staff*. These words should not create any problems for learners because they are often found in general learning and daily usage, while the remaining (416 loanwords) are not found in NGSL.

Furthermore, there are 21 words categorized as Academic Word Lists or AWL (Coxhead, 1998): *design, conduct, commission, credit, computer, initial, cycle, error, and job. project, capacity, tape, transform, aid, convert, couple, equip, infrastructure, offset, random, and manual*. Some loanwords tend to make problems for learners, for example, the word *capacity* can be translated as *nōryoku*. Then, it confuses learners when the loanword *capacity* needed to be used or when *nōryoku* should be. The remaining 395 words are all technical terms that learners may have never seen before because they are out of NGSL or AWL.

Next, in the industry words can have more than one meaning. This affects learners' understanding though the words have been learned before, for example, *couple*. It means *coupler* or *coupling* (two or a few things that are similar or the same, or two or a few people who are in some way connected). In the field of industry, it is used to indicate equipment like *renketsuki* (coupler). The polysemous words are also problematic; For example, *Earth* which means *setchi* or *ground* in English, and also *ground wire* as a piece of equipment. Therefore, in industry, the word *earth* or Japanese pronunciation *āsu* indicates *earth wire* or *ground wire*. *A belt* means a strip of leather or other material worn around the waist or across the chest, but it has another meaning which is a continuous band of material used in machinery for transferring motion from one wheel to another. The latter is used in the industry, and it is hardly found in daily life. *Coating* means covering up something with a layer of a particular substance which is hardly found as a verb in daily usage.

It could be concluded that, unlike other types of loanwords, the loanwords used with technical terms may have various problems. It is not only pronunciation and uncertain transliteration but also complicated meanings that are found in specific industrial contexts.

4. Lack of knowledges

4.1 The knowledge of the intra-structure of compounds

According to Hisamitsu & Nitta (1996), Japanese compound nouns are especially useful because they convey a lot of information in a compact expression, especially in a newspaper. The number of nouns forming a compound noun often exceeds three and may reach as high as ten (Hisamitsu & Nitta, 1996). The capacity of expressing a lot of information in a compact expression is a ubiquitous characteristic that could be implied to compounds in the industry, too.

Several compound nouns in the industry often form two nouns, for example, *gasuseikei* (gas injection), *kisoboruto* (lockbolt), and *sagyōtejun* (operational procedure). Most of the compound nouns are in NN structure as shown in Figure 2. (The division of 8 groups of compound nouns cited from Kageyama, 2001).

The 1,496 words have the structure of NN compounds. This contributes to 83.02 percent of 1,802 words, especially compound nouns such as two nouns forming together, e.g., *aitebuhin* (mating part, counterpart component) and *gasuseikei* (gas injection). Other groups have much fewer as seen in Figure 2; therefore, discussion about them may not be as necessary. The main difficulty lies in the intra-structures of the compound nouns which have four main types as referred to in Kobayashi et al. (1995).

1. A complement relation: initial nouns act as complements for latter nouns such as *seihintenji* (showing the product). The initial noun is an objective of a latter verbal noun as in the sentence *seihin o tenji suru*.
2. An adverbial relation: initial nouns act as the adverbs for latter nouns such as *rinjihatchū* (urgent/special order). The initial noun is an adverb of a latter verbal noun as in the sentence *rinji ni hatchū suru*.
3. An adjectival relation: initial nouns act as the modifiers for latter nouns such as *seikeijōken* (injection condition). The initial noun is a modifier of a latter noun as in the phrase *seikei no jōken*.
4. A parallel relation: initial nouns and latter nouns are independent of each other. There is no modification relation between constituents. Two constituents can be connected by *to* in Japanese such as *jiyūjizai* (free) that can be inserted by *to* as *jiyū to jizai*. They can stand together equally.

In general, Japanese structures, especially intra-structures of compounds are not deeply taught because of their complexity and are not essential. Therefore, when learners encounter compounds, they tend to guess the meaning of each word without the knowledge of intra-structure relations that affect meaning translation.

4.2 The knowledge of affixes

Affixes are a significant part of derived words. They function to decide the part of speech of words and add meanings to the bases. According to Mori (2014: 420), knowledge of semantic components enables students to make educated guesses when they encounter unfamiliar words. In this section, the types of prefixes and suffixes found in industrial technical terms and their coverage rate found in Japanese textbooks are discussed as *the degree of intimacy (the closeness between learners and affixes)*. All

derived words shown in Figure 1 includes 690 words or 14.71 percent of the target words. There are 37 derived words made up of prefixes and 653 derived words made up of suffixes. Some are shown below.

Prefix: jun-(pure), kei-(light), mi-(no), sō-(total), kō-(high), ta-(much), mu-(nught; nothing), chō-(super), o-(honorific meaning), sho-(various, several)

Some can be discussed as follows: The prefix jun- (pure) is used mostly as meaning *pure* as seen from the derived words junsoneki (net profit or loss), junrieki (net profit), junsonshitsu (net loss), and junseisandaka (net production). All are found in an account and monetary department. Next is the prefix kei- for the meaning of light that is found mostly in a group of words related to accidents and problems occurring daily in workplaces. The third is the prefix mi- (un-) that is found in the derivation words mijūten (unfilled), michakuyō (unworn), and mikakutei (undetermined, unresolved).

There are 571 token words and 455 word types made up of suffixes. Some suffixes are shown below.

-ki (machine), -hi (cost; expense), -sha (person), -sei (character; property; quality; attribute), -butsu (thing; restoration; object), -ki (vessel), -do (degree, frequency), -kin (gold, money), -zai (agent), -sho (report, book)

The suffix -ki (machine) is used mostly as seen from the derived words that are found mostly in all departments of the industry such as kansōki (drier; dryer), kenmaki (polishing machine), joshitsuki (dehumidifier), seikeiki (injection M/C), setsudanki (milling machine). The second is the suffix -hi (cost; expense) that is found in the derived word jinkenhi (labor cost) kōsaihi (social expenses) zairyōhi (material cost). The third is the suffix -sha in the meaning man; saikensha (creditor), nōzeisha (taxpayer). Fourth is the suffix -sei in the meaning character; property; quality; an attribute that is found in the derived words nenhatsusei (flammability) chikusekisei (accumulative) taikyūsei (durability). Fifth is the suffix -butsu in the meaning thing; restoration; object, for example, yūgaibutsu (deleterious material) haikibutsu (waste) nenchakubutsu (adhesive).

As seen above, derived words with suffixes are used more than those with prefixes. The top five suffixes, -ki, -hi, -sha, -sei, and -butsu make up more than 30 derived words, that is, 42 words, 39 words, 37 words, 33 words, and 30 words, respectively.

The degree of intimacy is discussed as follows. Six Japanese textbooks of Minna no Nihongo series are selected as sources for studying the degree of intimacy of affixes. Four upper-beginner levels of Shokyū Minna no Nihongo, one intermediate level, and one upper intermediate level of Chūkyū Minna no Nihongo are probably the most famous series of Japanese language study guides, used widely in universities, language schools, and privately around the world.

The degree of intimacy is shown in the coverage ratio of affixes in textbooks per affixes found in the industry.

The coverage ratio of prefixes in textbooks is 33.33 percent or 8 of 24 prefixes in industrial technical words. It means that learners have the experience to study derived words with only 8 prefixes: fu- (un-,

non-), o- (honorific prefix), mu- (un-, non-), oo- (big), sho- (various, many), sō (total), hi- (mis-), and sai- (re-) even though in reality 24 prefixes are used in the industry.

The coverage ratio of suffixes in textbooks is 45.45 percent or 40 of 88 suffixes. This means that learners only get to experience 40 prefixes for derived words when studying, while in the industry 88 suffixes are used for derived words.

The 40 prefixes are displayed as follows:

-ryō (fare, charge), -hi (cost), -hyō (table), -sha (person), -sho (book), -jō (missive), -sho (spot, place), -jin (man), -ka (person), -sa (-ness), -sei (characteristic, trait), -ryō (amount), -in (member), -teki (used to form adjectives from nouns), -ki (machine), -ritsu (ratio), -tō (counter for electric lights), -ka (action of making something; -ification), -hin (article, good, item), -ken (right), -kai (meeting), -shiki (ceremony), -shitsu (room), -chō (mantle), -dai (charge, fee, price), -bu (section), -shi (man), -kan (house, hall, building), -sha (vehicle), -ten (shop, store), -sho (station house), -en (garden), -chi (ground), -shi (teacher, master), -shō (evidence), -ya (shop, someone who sells), -kan (chef, head), -kei (meter; measuring device), -men (aspect; facet; side), -shō (award, prize)

Some derived words with suffixes are shown below.

jūgyōryō (tuition fee), jinkenhi (labor cost), seikyūsho (bill), ryōshūsho (receipt), shinsaisei (reliability), tetteiteki (thoroughly), sentakuki (washing machine), keikōtō (fluorescent light), denwadai (telephone charges), hakubutsukan (museum), jitensha (bicycle), shōbōsho (fire station), dōbutsuen (zoo), keisatsukan (police)

As seen above, the coverage ratio of affixes in a textbook is not high when compared to what is used in the industry. Certainly, the essential affixes especially suffixes, were not fully covered. Learners had little chance to experience and absorb only some affix knowledge unintentionally. The knowledge gap for affixes is wide, so it could be concluded that learners may not understand the meanings of derived words found in the field of industry.

4.3. The knowledge of clipping

As mentioned above, clipping is the process of word-formation that makes words shorter by discarding some parts of the word but still retaining its meaning. Clipped words such as paasokon (personal computer) and pokemon (pocket monster) are acquainted by learners. In industrial technical terms, only 23 clipped words or 0.49 percent are found. They are found in both single words and compound words. The following examples are taken from industrial technical terms.

Single-words

(1) Terebi clipped from terebishon (television)

Compound words

(2) Haizai clipped form haikizairyō (waste materials)

The clipped words in (1) and (2) exemplify the output of full words found in the industry, while most of the industrial clipped words, 21, are from compounds, for example, chōkai (morning meeting) clipping from asa no kaigi, seikaku (production confirmation) clipping from seisankakunin, and seikei (production plan (PS)) clipping from seisankeikaku.

In industrial clipped words in the form of compounds, the affixes retaining in their outputs are outstanding as seen from (3) to (8).

(3) Chihōkōkyōdant*ai*

The clipped form is chikō*tai* (local public entity, found in HR&GA word list).

(4) Shikyūbu*hin*

The clipped form is shikyū*hin* (supplied part, found in PC word list).

(5) Gaichūbu*hin*

The clipped form is gaichū*hin* (subcontract goods, found in the PC word list).

(6) Genchichōtatsuka

The clipped form is genchi*ka* (increase local procurement, found in PU word list).

(7) Sa*keisan*

The clipped form is sa*kei* (recalculate, found in ACC word list).

(8) Yokoten*kai*

The clipped form is yokoten (horizontal expansion, found in the HR&GA word list).

Suffixes, *-tai*, *-hin*, *-ka*, and prefixes, *sai-*, *yoko-* are part of the words retained for keeping morphemic boundaries as mentioned in Daniel (2018). This type of clipping is hardly found in general Japanese, so being able to guess the meanings becomes more difficult.

It can be said that the difficulty of clipped words is not only the phonological unpredictability of the original forms but also various patterns of clipping including omitting the end of the word (back-clipping), the first part of the word (fore-clipping), the middle part of the word (mid-clipping), and the beginning and the end of the word (edge-clipping). Furthermore, the retention of affixes makes it more difficult for learners who are inexperienced about word clipping.

5. Technical term education

Theoretical Implications.

First, the finding of the present study showed that Sino-Japanese words or Kango accounted for the largest proportion (69.80%) of all word types. Next are hybrid words and loanwords, respectively. As a result, learners need to strive to remember Kango words, hybrids, and loanwords to succeed in comprehending in a technical context.

Among the five subtypes of word formations, compounding was found to have the highest proportion in industrial words. Next are simple words which are not a surprising result because single words are the basic constituents of communication. The third highest proportion is derived words. This re-confirmed that affixes are important parts of words that learners should acquire as asserted by many researchers (Nation, 2001; Li & Kirby, 2015; Ma & Lin, 2015) who indicates that morphological knowledge, especially affixes and their roots, is an important contributor for language comprehension, especially reading comprehension. Furthermore, given the fact that the recognition of how these industrial words is formed, may not always be very easy in a language such as Japanese because, by forming new words, several unknown and unpredictable changes might emerge during or after the new formation, regarding output forms in clipped words, meaning relation in compounds, meaning changes in loanwords, and unacquainted words. All these factors increase the difficulty of comprehension for the learner.

Finally, the results of the current study also shed some light on vocabulary knowledge. It could be said that all types of words: general, academic, and technical words can use the knowledge of morphology as the theory to analyze and imply to class teachings.

Practical Implications.

Some pedagogical implications can also be discussed from the results of the present study in terms of technical terms. As the current study shows, there are gaps between lexical knowledge in school education and real-world usage. The suggestion in this section is to design an overall curriculum based upon technical terms systematically. According to Matthews (1974), the overall curriculum is lacking in vocabulary, and most ESL/EFL textbooks do not systematically deal with vocabulary.

Not only ESL/EFL textbooks, but many textbooks in Japanese education including Minna no Nihongo also ignore vocabulary explanation by the way of morphology or word-formation. No explanation is offered to the learners to clarify for them that shōene (energy saving) found in Minna no Nihongo Chūkyū is formed by clipping the prefix shō, and the noun ene is the clipped form of the full noun enerugii (energy). As a result, learners usually come across all types of words such as derived words: okazu (side dish), okane (money), and jugyōryō (tuition fee), compounds: shigotobeya (workroom) and hanashikakeru (speak to), clipped words: rimokon (remote control) and robokon (robot contest) as single units without explanations or practices to enhance learners' awareness. Most words are derived or composed from words that can be broken down into smaller components that have their own functions and meanings and also the ability to create new words even though they will not appear in a dictionary.

For material design, vocabulary with special word-formation needs to stand out to be seen easily and needs extra explanation about its word formation. If learners do understand well how words are formed by the process of word formation, they should be able to apply it to words they come across. Based on the result, the example of explanation on affixations with productivity found in the industry can be concretely given as follows:

First, we should offer general knowledge of morphology about the target words. Once we give the meaning of prefix, *sō-* (total, whole) and its usage (to combine with noun implying quantity, ratio, and percentage (not space or time)). Then, some combined words between it and nouns are displayed: *sōshūnyū* (total income), and *sōshishutsu* (total spending). If this process is firmly established, the unfamiliar word that has *sō-* as a prefix could be guessed. This method is also offered by Nation (2001).

In the case of compounding that produces compounds, NN, a high-frequently found structure, is strongly recommended to make a clear explanation on intra-structure relations to clarify its meanings. It is highly unlikely that NN compounds can be found in an ordinary dictionary. The reason why compound nouns are the most frequently found maybe because they convey a lot of information in a compact form. According to Kudo (2007), Japanese compounds, although there are some exceptions, follow the Right Head Rule of Williams (1981). As a result, the meaning translation of compounds can start from the rightmost constituent to the left one. As mentioned above, NN compounds have four main intra-structure relations. Their meanings can be translated from the right following the intra-structure relations: a complement relation, an adverbial relation, an adjectival relation, and a parallel relation.

For the application of NN compound knowledge to teaching, the Right Head Rule or the translation from the rightmost one and NN intra-structure relations are contributors for grasping the meanings of NN compound knowledge. The explanation should conduct with NN compound examples from industrial word lists to make a solid understanding of the intra-structure of NN compounds used in industrial work.

In the case of clipping that produce clipped words, the output patterns should be taught through the words which learners are acquainted with such as *pasokon* (personal computer); and *rimokon* (remote control) which are the clipped forms of two compound nouns by coining first two moras of each word. To give the output patterns of clipped words by being categorized as single words, compound words, and word types (native Japanese, Sino-Japanese, foreign words, and hybrids) is the way to enhance the knowledge on clipping.

Moreover, the morphological knowledge of each word type should be described with the context. According to Nation (2001) and Mori (2014), context-based strategies, especially the industrial contexts, can further technical word learnings more than learning words in isolation. Therefore, all technical terms found in this study should appear with other words relating to the industry and should be offered repeatedly at least 6 times (Nation, 2001: 81).

Finally, the practices to develop morphological knowledge about technical terms can be applied from the test of morphological knowledge by the University of Washington (1999). First, the derivational suffix

choice test can be adapted to the practice of derived words as follows:

(9) The requirement of production of a derived word to finish a sentence:

The word is *jinkenhi* (labor cost).

Jūgyōin no jinken_____o herashitai.

I would like to decrease the labor cost.

(10) The requirement of selecting the fit one of the sentences. The three or four options of different derivational prefixes or suffixes are offered as parts of sentences.

Three options of words: *hoshōkin* (security money), *hoshōnin* (guarantor), and *hoshōjō* (letter of guarantee) *Hitsuyōshorui o goannai no ue, sumiyakani _____hakkō no tetsuzuki o itashimasu.*

We will give information about the necessary documents and then promptly process the letter of guarantee.

Second, the bee grass test of the University of Washington (1999) is adapted as a practice for enhancing learners' comprehension of infra-structure relation of compounds and the Right Head Rule. Here is an example: *Which is a better name for a bee that lives in the grass? A grass bee or a bee grass?* The adapted example for practicing technical terms, *kōtaikinmu* (shift work), starts with the question, *jikantai wo kugitte, kōtai de kinmusuru toiu kotoba wa dore desuka* (Which is the word meaning to work in shifts by dividing the time zone?) *Kinmukōtai or kōtaikinmu?*

Conclusions

The present study investigated the difficulties of technical terms used in Japanese industries in detail from the viewpoint of morphological knowledge. The most frequently used word type was Kango, hybrid, and foreign words respectively. Compounding was the main process for organizing word forms in Japanese technical terms. Next were derivation, borrowing, and clipping, respectively. The results also showed the gap between school education and real-world usage. The drills modified from the test of morphological knowledge by the University of Washington were proposed to enhance learners' knowledge of technical terms.

Declarations

Availability of data and materials

The datasets generated during and/or analyzed during the current study are not publicly available because they are the technical term lists used in each Japanese industry in Thailand which the

corresponding author collected from but are available from the corresponding author on reasonable request.

Competing interests

There are no relevant financial or non-financial competing interests to report.

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Authors' contributions

This research has only one author. The author has made substantial contributions to the conception and design of the work, analyzed and described all data, and drafted the work or substantively revised it.

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Figures

Figure 1

The Proportion of Word Formations and Word Types

The Proportion of Eight Types of Compound Nouns (N=1802)

Figure 2

The proportion of eight types of compound nouns

Figure 3

Coverage ratio of prefixes

Figure 4