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Explicit Instruction of Memory Vocabulary Learning Strategies in an ESP Context

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Abstract

Recent studies have shown that proficient language learners make substantial use of vocabulary learning strategies (VLS). However, teaching VLS is not emphasized in English education in Japan. This is especially problematic when students are required to learn the technical terms of their field in university since those terms are usually low-frequency words that the students do not encounter when learning academic English. The present study examines the effectiveness of explicit VLS instruction for learning biology terms for Japanese students who major in biology. The study also investigates which VLS are suitable for these students in accordance with their vocabulary size. The instructed VLS in this study were all memory strategies: imagery, association, grouping, and a strategy using affixes. The results revealed that both students with smaller vocabulary sizes and those with larger vocabulary sizes were satisfied with explicit VLS instruction but that lack of vocabulary can hinder the use of some types of memory strategies. The study demonstrates the efficacy of explicit memory VLS instruction in ESP settings, especially the strategy using affixes and roots.

Keywords: vocabulary learning strategies; memory strategies; imagery; association; affix; grouping; ESP; explicit instruction

Introduction

To use English successfully, learners need large vocabularies. In fact, when we ask our Japanese university EFL students what they need more of to increase their proficiency, the majority tell us vocabulary. No matter what the focus of an EFL course or the level of the students, mastery of vocabulary plays a key role. Given that vocabulary learning is a complex, incremental process requiring different approaches at different stages (Schmitt, 2008) and that much of vocabulary learning is done individually (Nyikos & Fan, 2007), it is imperative for instructors to provide learners with effective tools for acquisition and long-term retention. This is especially necessary for English for Specific Purposes (ESP) learners because they need the specialized vocabulary of a discipline to “make meaning and engage with disciplinary knowledge” (Woodward-Kron, 2008, cited in Coxhead, 2013, p. 116).

One learner-centered tool at our disposal that can assist with the development of vocabulary mastery and autonomy for all levels of learners is explicit instruction in vocabulary learning

strategies (VLS) (Chamot, 2005). Research has not only found that integrated VLS instruction is effective and beneficial for less proficient learners but also that when learners are given opportunities to apply and practice the taught strategies in class all proficiency levels benefit (Nyikos & Fan, 2007). As little classroom research on VLS instruction has been done with Japanese university EFL learners, and even less with ESP learners, we are seeking to shed more light on this context. Our previous study focused on Japanese life science majors and found that after VLS instruction they favored "shallower" processing strategies for learning general science vocabulary (Little & Kobayashi, 2015). The present study aims to clarify how Japanese biology majors perceive "deeper" processing strategies after explicit instruction of such strategies when learning biology terms.

Literature Review

ESP Vocabulary

The vocabulary load for ESP learners is particularly high. They not only need to know general service vocabulary and academic vocabulary but they also need to be able to use the specialized vocabulary from their particular field productively. Coxhead (2013) makes two points about the importance of ESP vocabulary. First, drawing on research by Woodward-Kron (2008), she states, "students' knowledge of a discipline is closely tied to the specialized language of that discipline" (p. 116). Second, through understanding and using the discipline's specialized vocabulary, students can show they belong to that community (Coxhead, 2013). The amount of specialized vocabulary varies from field to field, but it can be quite high. Chung and Nation (2003) found, for example, that as much as one-third of the lexis in an anatomy text was technical. Because technical, or specialized, vocabulary occurs frequently in texts within a specialty or discipline, Nation (2001) says it should be treated as high-frequency vocabulary. There are, however, special challenges for learning this vocabulary. First, some of these words may be everyday words that learners already know but which have a particular meaning in their field (Coxhead, 2013). These new meanings can be difficult to learn because the everyday meanings are already established in the learners' lexicon (Coxhead, 2013). In addition, some of the technical words may need specialist knowledge of the field (Nation, 2001). Thus, to cope with these challenges in learning specialized lexis, learners should be trained in VLS (Nation, 2001).

Vocabulary Learning Strategies (VLS)

Rubin defined language learning strategies as "the process by which information is obtained, stored, retrieved, and used" (1987, p. 29). Over the years, various researchers have sought to identify and classify the strategies used by language learners and various taxonomies have resulted (see, for example, Gu & Johnson, 1996; Oxford, 1990; Schmitt, 1997, 2000).

For the purposes of this study, however, Schmitt's vocabulary-specific taxonomy is the most relevant as it is based on strategies Japanese EFL learners use (1997). His taxonomy divides 58 VLS into two broad classes and six strategy types. The first class is discovery strategies, which include determination strategies for discovering a new word's meaning without help from others and social strategies that involve asking teachers/classmates for the meaning or translation. Schmitt's second class is consolidation strategies, which encompass the strategies that are necessary for remembering a word after it has been introduced. These are divided into four strategy types: metacognitive strategies, which involve conscious decision-making about the learning process; social strategies, such as studying and practicing the meaning in a group or interacting with L1 speakers; cognitive strategies, such as verbal and written repetition; and memory strategies, also referred to as mnemonics, which involve connecting the word with previous knowledge using association, grouping, or imagery.

An important difference between cognitive strategies and memory strategies is the depth of processing. In a seminal paper, Craik and Lockhart (1972) posited that "the amount of information that is retained in long-term memory depends on how deeply it is processed during learning" (Baddeley, 1999, p. 176). Cognitive strategies involve shallower processing because the focus tends to be on sight or sound, such as oral and written rehearsal, or more mechanical processes, including labeling, word lists, note-taking and keeping vocabulary notebooks, all of which result in weaker memory traces. Memory strategies, on the other hand, involve deeper, more elaborate processing of the word's meaning, facilitating long-term retention (Schmitt, 2000). Schmitt (1997) categorizes memory strategies into six groups: namely, learning new words with pictures or imagery; linking the word with related words; linking the word with unrelated words; grouping; using the word's orthographical or phonological form (keyword method); and others, such as using affixes and roots and using physical action. Each of these strategies requires the learner to connect the meaning of the new word to knowledge they already have. Because integrating the new word with the learner's existing knowledge requires more manipulation, deeper processing occurs thereby creating a more durable memory trace that leads to better retention than rote memorization (Craik & Lockhart, 1972).

Cognitive Strategies vs. Memory Strategies

Extensive research has been done on both cognitive strategies and memory strategies. Some researchers have found shallower strategies (cognitive strategies) to be effective (Lawson & Hogben, 1996; Nation, 1982), particularly for beginning level students (Schmitt, 1997) who may not have the linguistic resources necessary to employ the more challenging

deeper strategies such as grouping or association. For this reason, Nielsen (2006) suggests that “de-contextualized” vocabulary learning from word lists is more effective for beginning level learners. As Nation (2001) points out, word lists are effective for learning a large number of words quickly. In addition, some types of learners prefer shallower strategies, such as low proficiency learners (Schmitt, 1997) or learners from certain cultural backgrounds, as in the case of Japanese learners (Little & Kobayashi, 2015; Mizumoto, 2010; Schmitt, 1997) and Chinese learners in EFL contexts (Gu & Johnson, 1996) whose L1 education systems traditionally use strategies associated with rote memorization (i.e., written rehearsal). Despite their obvious benefits, shallower strategies have disadvantages as well. For example, words learned using a word list are likely to be rapidly forgotten (Oxford & Scarcella, 1994). Some learners, though acknowledging the effectiveness of rote learning, have negative impressions of it, stating it is “dry” and “boring” (Tanaka, 2009). Moreover, Gu and Johnson (1996) found oral and written rehearsal correlated negatively with both proficiency and vocabulary size. As Nation (2001) points out, “Memorization is only useful if it is one of a wide range of actively used strategies” (2001, p. 227).

Numerous studies have shown that vocabulary learning strategies involving deeper processing (i.e., memory strategies) are more effective than rote repetition, and lead to better short- and long-term retention. For example, many studies have found the keyword method to be effective (e.g., Brown & Perry, 1991; Chen & Hui-Jing, 2010; Hulstijn, 1997); Cohen and Aphek (1980) demonstrated the effectiveness of association strategies; and Atay and Ozbulgan (2007) discovered that grouping and imagery strategies were preferred by their group of ESP learners. Nemati (2009) found using a range of memory strategies resulted in better long-term storage and retrieval. Deeper strategies may also be better for learning certain types of vocabulary. According to Nation (1994) teaching learners strategies for using mnemonics and word parts (affixes/roots) will help them handle low frequency words (cited in Schmitt, 1997, p. 203). Memory strategies, similar to cognitive strategies, have also been found to work better among certain groups of learners. For example, Cohen and Aphek (1981) found association was a more effective strategy for more proficient learners, whereas Brown and Perry (1991) found the keyword method facilitated acquisition among lower proficiency learners. Schmitt (1997) found both strategy use and perceptions changed as learners matured, with adults showing increased use of and preference for memory strategies involving deeper processing, such as imaging, association, and analysis. Based on such findings Schmitt (1997) concluded that deeper (memory) strategies were more appropriate for intermediate to advanced students. However, as with shallower strategies, not all L2 learners favor deeper ones. Practical considerations, such as efficient use of time, may also cause learners to reject more time-consuming complex strategies

even though they may perceive these strategies to be more effective for retention (Cornell, Dean, & Tomas, 2016; Little & Kobayashi, 2015; Mizumoto & Takeuchi, 2009; Schmitt, 1997, 2000). And, some researchers have pointed out the limitations of memory strategies, particularly the keyword method, as not being suitable for abstract words (Ellis, 1997) or as being better suited for certain stages of learning only (e.g., absolute beginners or advanced learners) (Gu, 2003). Others have found that the keyword method is not very effective when the L1 and L2 are unrelated, such as for Chinese and Japanese EFL learners (Fan, 2003; Schmitt, 1997, 2000).

Some Factors Influencing VLS Use

In addition, to the distinction between shallower and deeper VLS as described above, we should keep other, more general findings in mind regarding strategy use. As many researchers have observed, language learners tend to use a combination of VLS, not just one (Cornell et al., 2016; Fan, 2003; Gu, 2003; Gu & Johnson, 1996; Schmitt, 2000). More proficient students use a greater range of VLS and use them more often than less proficient students (Ahmed, 1989; Fan, 2003; Gu & Johnson, 1996). Proficient learners also actively choose, monitor and evaluate their strategy use to achieve their aims, whereas poor learners show little awareness and have no aim (Gu, 2003). Moreover, when learners perceive a strategy to be useful, they use it more often (Chamot, 2005). Among university students, strategy use in general also differs across academic disciplines, with English majors using strategies more often than science students (Bernardo & Gonzales, 2009; Peacock & Ho, 2003). Factors such as age and gender impact strategy use, too, with Japanese female university students using strategies more often than male students (Mochizuki, 1998; Takeuchi, 2003). Researchers have also found a gap between actual use and perceived helpfulness for all age groups and proficiency levels (e.g., Cornell et al., 2016; Little & Kobayashi, 2015; Schmitt, 1997). According to Schmitt (1997), this gap indicates that "learners may be willing to try new strategies if they are introduced and instructed in them" (p. 221).

The Efficacy of Explicit VLS Instruction

In reviewing VLS instruction studies, Nyikos and Fan (2007) concluded it has a positive impact on vocabulary performance and benefits learners of all proficiency levels, especially weaker students. Research has found that explicitly teaching strategies is more effective than simply asking learners to use a strategy (Chamot, 2005). Nyikos and Fan (2007) found that VLS instruction is most effective when it is explicit and integrated into a course. Furthermore, giving the learners ample opportunities to practice and receive feedback in class, and encouraging them to consciously internalize and adopt the strategies can ensure

the VLS instruction is more successful (Nyikos & Fan, 2007). They also found that even if learners only use a strategy because they have to, later they may adopt that strategy if another one proves ineffective. At the very least, VLS instruction can have a long-term positive effect of raising learners' awareness of their own strategy use.

Studies on Instructed VLS in ESP Contexts

Atay and Ozbulgan (2007) investigated the effects of memory strategy instruction in conjunction with contextual learning on retention in a 12-day ESP course for Turkish pilots. They administered a vocabulary test and a memory strategies questionnaire based on Schmitt (2000) at the beginning and end of the study. In addition to five hours of contextualized learning, the treatment group received an hour of explicit instruction each day on all memory strategies in Schmitt's taxonomy (1997, 2000), whereas the control group did more listening and role play activities. The teacher explained and modeled each strategy, provided written explanations, and required students to learn each day's target vocabulary using the strategies they thought most suitable for learning and retaining the words. Results showed the treatment group gained significantly more vocabulary than the control group. The most frequently used strategies were semantic maps and connecting the new word to previous experience. The researchers concluded strategy instruction should be integrated into contextualized vocabulary learning, and that students should be taught a range of memory strategies rather than one or two so they can find the strategies that are most effective for them.

In a 3-day study involving business English majors at a university in Taiwan, Chen and Hui-Jing (2010) compared the effectiveness of keyword strategy training with more traditional methods of learning words (oral rehearsal, translation, and sample sentences). To measure changes in the participants' VLS repertoire, before and after the treatment, they were asked to learn five ESP non-target words and record the VLS they used. Each group spent the first two days learning the 15 target words using their respective treatment methods. The last day, after review and independent study, both groups took an immediate recall post-test for the L1 equivalent. The keyword group recalled significantly more words than the traditional group. Regarding changes to VLS repertoires, both groups' use of segmentation dramatically increased, linking the sound and image increased somewhat, and rote memorization significantly decreased. The keyword group's perceptions of the method were overwhelmingly positive, with learners finding it interesting and efficient, effective for learning pronunciation, and helpful for recall and retention. However, participants also found limitations: it works best when the L1 and L2 words sound similar or the word is concrete, it is better for beginners, is better for word recognition than production, and changing VLS use

is hard.

Brown (2012) developed a 13-week VLS training program and integrated it into a content-based medical English course for first year medical students. Each week 15-20 minutes of class time was spent on VLS instruction and the rest was spent on activities that provided for review of medical terminology and recycling of VLS. The strategies taught were reflection and goal-setting; word parts; keyword technique; guessing from context; combining strategies, including using five senses; and dictionary look-up. Pre- and post-tests indicated gains in the learners' receptive and productive vocabulary use. While their VLS change was not quantified, feedback from student course evaluations indicated that the learners found the VLS instruction useful and it raised their awareness of vocabulary learning.

Little and Kobayashi (2015) explored the VLS preferences of low and high proficiency Japanese life science majors for learning general science vocabulary in English. The participants received explicit supplementary VLS instruction (explanatory handouts and homework tasks for learning target vocabulary) over nine weeks on three cognitive strategies (written rehearsal, vocalization, and word cards), three memory strategies (imagery, association, and mnemonics), and six metacognitive strategies. Mizumoto and Takeuchi's VLS scale (2008) and motivation questionnaire (2009) were administered before and after the treatment to quantify changes in the learners' strategy repertoires and motivation. Qualitative data were also collected. The study found both proficiency levels were most familiar with the cognitive strategies and less familiar with the memory strategies. All students indicated they would use the cognitive strategies again and believed these strategies, especially word cards, were effective for learning science words. Most students felt the deeper memory strategies of imagery and association were too difficult and inefficient to use with science words although some students in both groups saw their value for scientific terminology. Mnemonics was perceived as the least useful by all students. Importantly, explicit instruction appears to have increased learners' use of strategies, with proficient strategy users posting the greatest gains.

To see if giving explicit instruction and hands-on-experience in using memory VLS is beneficial for university students who major in biology we asked the following questions and compared learners with larger vocabulary sizes (LVS) with those with smaller vocabulary sizes (SVS).

Research Questions

1. Which VLS are biology majors already familiar with? Is there any difference between

the LVS and SVS groups?

2. How did the students perceive the usefulness of each memory VLS for learning biology terms? Is there any difference between the LVS and SVS groups?
3. After experiencing memory VLS instruction, which strategy do students prefer? Is there any difference between the LVS and SVS groups?
4. How did the students perceive VLS instruction? Is there any difference between the LVS and SVS groups?

Methodology

Participants

The study participants were 23 male and 45 female second year Japanese university students majoring in biology. The students were all native speakers of Japanese and had had six years of formal English education in Japanese junior high and high school and one year of college English education which focused on academic reading. Their ages were from 19 to 22. Prior to the study, the participants received a consent form explaining the study's purpose and methodology. The form clearly stated the participants could refuse to take part or withdraw without consequences. The form also stated their identity and the university's would remain anonymous. All participants signed the consent form of their own free will. They were divided into two groups according to their vocabulary size based on the Mochizuki Vocabulary Size Test (VST) (1998). The Mochizuki VST, specifically developed for Japanese EFL learners to assess their English vocabulary size, comprises seven levels corresponding to the seven frequency bands of the 1000 most frequent words. Test-takers match English words with their Japanese translations. The VST scores of the 34 students in the higher group averaged 5447 (SD = 176.23), a size considered to be appropriate for a university student, and the scores of the 34 students in the lower group averaged 4792.18 (SD = 344.07), a size considered to be attained upon high school graduation.

The Four Strategies Used in the Study

The students were taught four types of memory strategies: imagery, association, affixes, and grouping (Table 1). This taxonomy is based on a VLS questionnaire developed by Mizumoto and Takeuchi (2009) and Schmitt's VLS taxonomy (1997). The imagery strategies include linking the new vocabulary item with either the students' visual or mental image of the meaning, linking it with the orthographical or phonological form (keyword method), or creating a negative/positive image based on the meaning. This strategy was included because linking the new item with its image can be effective when learning basic biology terms as they include many items with concrete meanings that can be represented by pictures or photos.

The association strategies are strategies that link the new item with related words using a semantic network or sense relationship such as synonymy, antonymy, or hyponymy. This strategy can visually show the learners how the new item can be integrated with their vocabulary knowledge (Oxford & Crookall, 1990). In addition to these two strategies, strategies using affixes and grouping were included. Using the item's affixes (prefixes, suffixes, and roots) is an effective strategy as many science terms can be divided into affix and root. Associating a part of the new item with the learner's background knowledge of word parts requires deep processing (Schmitt, 1997). The students were told to download "Scientific Root Words, Prefixes and Suffixes" from the site Massengale's Biology Junction. The final strategy is grouping strategies: grouping the new items according to their meanings or making a sentence/story using the new item. In the researchers' previous study (Little & Kobayashi, 2015), some higher level students said writing true sentences using the target items is effective for remembering the items.

Table 1: *Memory vocabulary learning strategies and subcategories*

Strategies	Subcategories
Imagery	Drawing a picture
	Using the student's mental image of the meaning
	Associating the meaning with the student's personal experience
	Creating a mental image using the orthographical form
	Keyword method
	Creating a negative/positive image based on the meaning
Association	Associating the item with synonymy, antonymy and hyponymy
	Creating a semantic network
Affix	Dividing the item into prefix, root and suffix
Grouping	Grouping the new items according to their meanings
	Making a sentence/story using the new item(s)

Target Words, Materials and Instruments

The target words were 30 vocabulary items related to biology that were chosen from the *Life Science English-Japanese Japanese-English Dictionary* (Life Science Dictionary Project, 2012) (see Appendix A). The items were pilot-tested with the participants prior to the study to ensure all items were unknown to them. The researchers also confirmed the items could be learned using all four of the strategies taught in class. These 30 items were divided into five vocabulary lists, each containing six items. Four lists were to be learned using the specific

memory strategies taught in class, and the final vocabulary list was to be learned with any strategy of the students' choice towards the end of the study.

Each of the four strategies was taught using a *Strategy Handout* (Appendix B, C, D, E), an instruction handout in Japanese prepared by the researchers for each strategy. It provided a general definition of the strategy, the rationale behind the strategy, an explanation on how to use it, and examples. In addition, each student was given an individual *Study Report* (Appendix F), a sheet which listed the target items with a sample sentence for each in a biology context and provided a space where they were required to write how he/she learned each word using the strategy.

After the students used each strategy to learn the target items, a *Strategy-Specific Survey* to rate their familiarity with the strategy and its usefulness was administered. The survey had three items as follows:

1. Were you already using this strategy before this practice?
2. I think the strategy is useful.
3. Will you use the strategy when you learn a new vocabulary item?

For ease of rating, Items 1 and 3 used Yes/No questions and Item 2 used a five-point Likert scale (1 = I strongly disagree, 2 = I disagree, 3 = Neither agree nor disagree, 4 = I agree, 5 = I strongly disagree).

After experiencing all four strategies, the students were asked to learn the final vocabulary list using the strategy or strategies of their choice. The students were then asked to submit a *Final Study Report* in which they listed all the strategies they used to learn each item. At the end of the study, the students were asked to rate the following two statements given as a *Post-Treatment Survey* using the same five-point Likert scale as on the *Strategy-Specific Survey*.

1. It was good to learn the four vocabulary learning strategies in class.
2. As a result of learning vocabulary strategies in class, I have more choices of strategies when learning a new vocabulary item.

Procedure

The study was conducted during the first 11 weeks of the fall semester in 2016 as a supplementary vocabulary learning activity in an English course that focused on reading science texts in English. In Week 1, the students took the Mochizuki VST and the pilot-test of the target vocabulary items. In Week 2, the students were given explicit instruction on the first memory strategy using the first *Strategy Handout* and *Study Report*. Approximately 10

minutes of class time was spent on an explanation in Japanese of the strategy using the *Strategy Handout*, and the students were given 20 to 30 minutes to learn the items on the first vocabulary list using the strategy. The students used the online version of *Life Science Dictionary* (Life Science Dictionary Project, 2016) to check the meaning and pronunciation of each new item and wrote down how they applied the strategy to learn the items in the *Study Report*. During the course of explicit strategy instruction, the instructor, one of the researchers of the present study, confirmed that all the students understood the correct use of the strategy as well as the significance of using the strategy for better retention of new items. There were a few students who did not complete the *Study Report* in class. These students were asked to complete it by the following week. In Week 3, the students were tested on the first vocabulary list. For this test, the students were asked to write the L2 equivalent of each target item given in L1. This two-week process was repeated four times until the students had been taught all four memory VLS. In Week 10, the students were given the final vocabulary list, and were told to learn the items using any strategy(ies) of their choice including those other than the four memory strategies they were taught in the previous weeks. To report which strategy(ies) they used, the students were asked to complete the *Final Study Report*. In Week 11, the students took the vocabulary test on the final vocabulary list and completed the *Post-Treatment Survey*.

Results

Data Analysis

For the first research question, to identify which of the four memory VLS the students were already familiar with, percentages of the students' responses to Item 1 in the *Strategy-Specific Survey* were obtained for the SVS and LVS groups. Pearson's chi-square tests were conducted to find if there was any difference between the two groups.

The students' responses to Items 2 and 3 in *Strategy-Specific Survey* were used to answer the second research question which asked about the students' perceptions of each of the four strategies. The mean score and the standard deviation of the Likert scale data for Item 2 were obtained for the SVS and LVS groups, respectively. The difference between the two groups was examined using Mann-Whitney U tests. For Item 3, the percentage breakdown of the students' responses was obtained for each group and Pearson's chi-square tests were carried out to identify the difference between the two groups. To see whether the students had the same perceptions of the usefulness and possible future use of the strategy, the correlation coefficients of students' responses to Items 2 and 3 were calculated using Kendall's tau-b.

The third research question asked which strategies the students preferred after receiving the instruction. To answer the question, the number of students in each group who used the same strategy for each vocabulary item was obtained based on the information given in the *Final Study Reports* submitted by the students, and the data were compared for the SVS and LVS groups. No statistical analyses were carried out because the students were allowed to mark all the strategies they used.

The students' perceptions of the VLS instruction were identified using the two items in the *Post-Treatment Survey* by obtaining the average mean score and the standard deviation of the Likert scale data. Mann-Whitney U tests were carried out to detect the differences between the two groups.

Students' Familiarity with the Memory VLS

Table 2 shows the percentages of those who were familiar and unfamiliar with each strategy.

Table 2: *Students' pre-treatment familiarity with memory VLS*

	SVS (N = 34)		LVS (N = 34)	
Strategy	Yes	No	Yes	No
Imagery	8 (24%)	26 (76%)	10 (29%)	24 (71%)
Association	7 (21%)	27 (79%)	4 (12%)	30 (88%)
Affix	12 (35%)	22 (65%)	15 (44%)	19 (56%)
Grouping	4 (12%)	30 (88%)	5 (15%)	29 (85%)

The percentages indicate that more than half of the students in both groups were not familiar with each of the four memory strategies, although the affix strategy was the most familiar among students in both groups (35% in SVS and 44% in LVS). The results of the Pearson's chi-square tests showed that the students' responses were not statistically different for the SVS and LVS groups at .05 level of significance ($X^2(1) = 0.30$, $p = .78$ for imagery $X^2(1) = 0.98$, $p = .51$ for association, $X^2(1) = 0.55$, $p = .62$ for affix, and $X^2(1) = 0.13$, $p = 1.00$ for grouping).

Students' Perceptions of the Memory VLS

Table 3 shows the descriptive statistics of the students' perceptions regarding the usefulness of each strategy in the SVS and LVS groups. The results of the Mann-Whitney U tests indicated that there was no significant difference between the two groups at .05 level of significance ($U = 530$, $p = .53$ for imagery, $U = 565$, $p = .86$ for association, $U = 505$, $p = .34$

for affix, and U = 460, p = .11 for grouping). Table 4 shows the percentage breakdown of the students' responses regarding their willingness to use each strategy again. The results of the Pearson's chi-square tests revealed that the students' responses were not statistically different between the two groups at .05 level of significance ($X^2(1) = 2.13$, p = .22 for imagery, $X^2(1) = 0.24$, p = .81 for association, $X^2(1) = 0.36$, p = .77 for affix, and $X^2(1) = 1.47$, p = .33 for grouping).

Tables 3 and 4 show that there are some characteristics shared by the students in the SVS and LVS groups. Students in both groups gave the highest ratings to the affix strategy. As shown in Table 3, regardless of their vocabulary size, the student ratings on the usefulness were the highest (3.56 for SVS and 3.74 for LVS) for the affix strategy with more than half (53% in SVS and 68% in LVS) agreeing that the strategy is useful. Table 4 shows that more than 75% of the students in both groups (76% in SVS and 82% in LVS) are willing to use the affix strategy again. At the same time, as Table 3 shows, the percentage of students who agreed that the association strategy is useful was the smallest (18% in SVS and 24% in LVS). Table 4 shows that less than half of the SVS students (44%) and the smallest percentage of the LVS students (38%) were willing to use it again.

Table 3: *The usefulness of the strategy – The strategy is useful*

	Strategy	1	2	3	4	5	Mean (SD)
SVS (N = 34)	Imagery	1 (3%)	7 (21%)	15 (44%)	11 (32%)	0 (0%)	3.06 (0.80)
	Association	1 (3%)	9 (26%)	18 (53%)	6 (18%)	0 (0%)	2.85 (0.73)
	Affix	1 (3%)	2 (6%)	13 (38%)	13 (38%)	5 (15%)	3.56 (0.91)
	Grouping	2 (5%)	8 (24%)	16 (47%)	8 (24%)	0 (0%)	2.88 (0.83)
LVS (N = 34)	Imagery	2 (6%)	7 (21%)	10 (29%)	13 (38%)	2 (6%)	3.18 (1.01)
	Association	3 (9%)	9 (26%)	14 (41%)	8 (24%)	0 (0%)	2.79 (0.90)
	Affix	1 (3%)	1 (3%)	9 (26%)	18 (53%)	5 (15%)	3.74 (0.85)
	Grouping	0 (0%)	3 (9%)	21 (62%)	10 (29%)	0 (0%)	3.21 (0.58)

Note. 1 = I strongly disagree, 2 = I disagree, 3 = Neither agree nor disagree, 4 = I agree, 5 = I strongly agree

Table 4: *The students' willingness to use the strategy again: Will you use the strategy again?*

	SVS (N = 34)		LVS (N = 34)	
Strategy	Yes	No	Yes	No
Imagery	13 (38%)	21 (62%)	19 (56%)	15 (44%)
Association	15 (44%)	19 (56%)	13 (38%)	21 (62%)
Affix	26 (76%)	8 (24%)	28 (82%)	6 (18%)
Grouping	14 (41%)	20 (59%)	19 (56%)	15 (44%)

Kendall's tau-b correlations were calculated between the student responses to these questions asking about the usefulness of each strategy and their willingness to use it again (1 was applied to *Yes* and 2 was applied to *No*). Overall, the correlation coefficients were statistically significant between the items in both groups with correlation being significant at the .05 level (for imagery, $\tau_b = -.54$, $p = .001$ for SVS and $\tau_b = -.71$, $p = .000$ for LVS; for association, $\tau_b = -.56$, $p = .001$ for SVS and $\tau_b = -.55$ for $p = .001$ LVS; for affix, $\tau_b = -.44$, $p = .006$ for SVS and $\tau_b = -.44$, $p = .007$ for LVS; for grouping, $\tau_b = -.45$, $p = .006$ for SVS and $\tau_b = -.42$, $p = .014$ for LVS). This suggests that students who believed that a certain strategy is useful will be more likely to use it again.

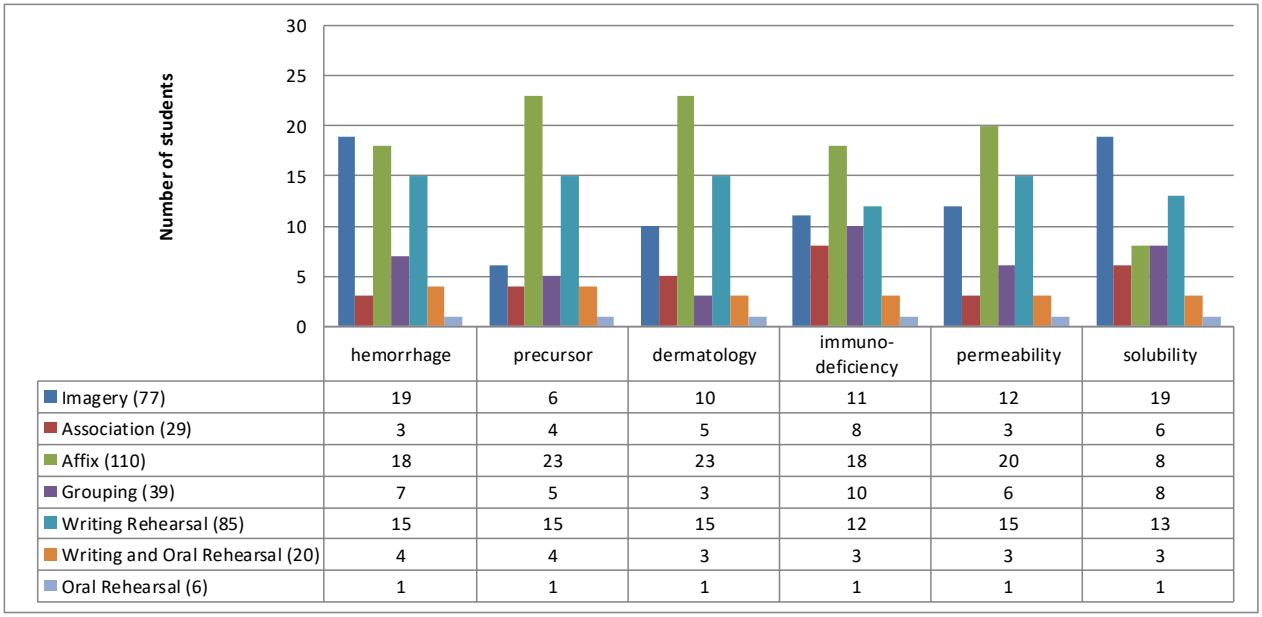
Strategy Preferences of the Students after Treatment

Figures 1 and 2 show which strategies the students used to learn each vocabulary item in the final vocabulary list. For this word list, the students were told to use any strategy they liked including the ones that were not taught in class. They were also told that they could use more than one strategy per item. The two groups have two things in common. First of all, both figures show the overall popularity of the affix strategy over other strategies except for two cases in Figure 1. However, a closer look at each figure shows differences between the two groups. Figure 1 shows that although the students in the SVS group used the affix strategy more often than the other strategies, there were only two cases where the number of students who used this strategy was 23, or almost 70% (for both *precursor* and *dermatology*). On the other hand, Figure 2 shows that the number of students in the LVS group who used the affix strategy was 70% or more for five of the six items (24 for *hemorrhage*, 26 for *precursor*, 27 for *dermatology*, 24 for *immunodeficiency*, and 25 for *permeability*). These show that the students in the LVS group used the strategy more consistently than those in the SVS group. A common characteristic of both groups is that the number of students who used the strategy was the smallest for *solubility*. Secondly, the number of students who used grouping and association was smaller than for the other two strategies for both groups: less than 10 for each word, except for the number of SVS

students who used grouping for *immunodeficiency* which was only 10.

The number of students who used writing rehearsal for each vocabulary item was similar and comparatively higher than for other strategies for both the SVS and LVS groups (12 to 15 for the SVS group and 13 to 17 for the LVS group). In addition, there were eight students (4 each in the SVS and LVS groups) who used the same strategy or the same combination of strategies for all six items. Among them, there were five students who did not change their strategy use after receiving memory strategy instruction. Of these five, three used one strategy they knew before instruction, and two used a combination of previously learned strategies. The other three learned new strategies but used only one of those strategies for all six words.

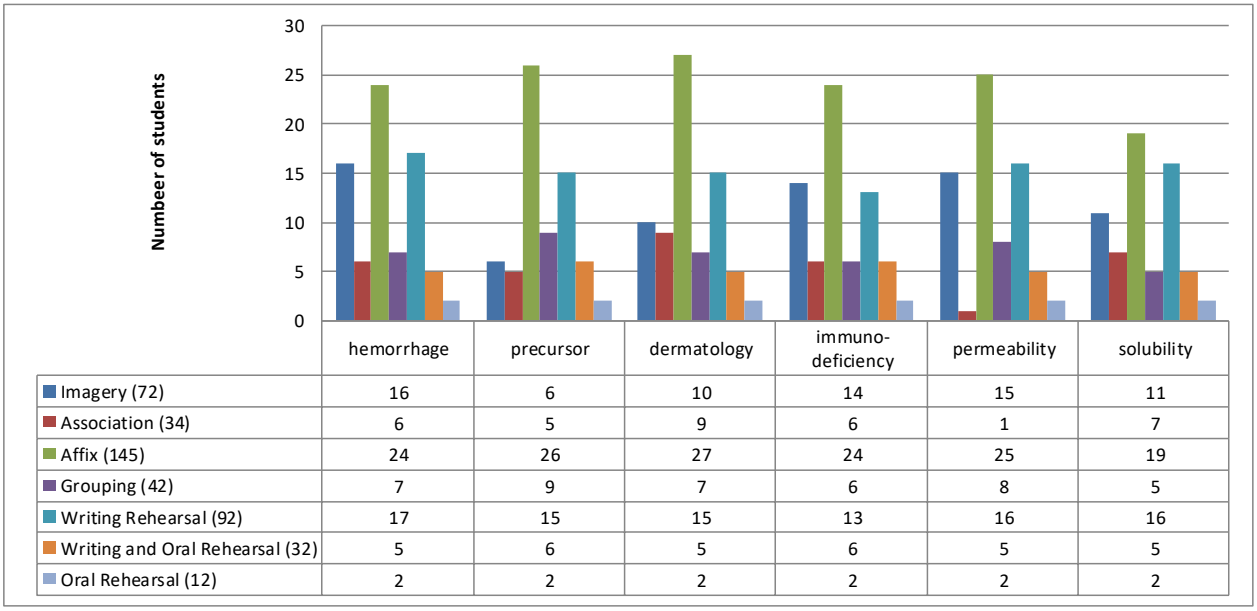
Figure 1: *The students' strategy preferences: SVS Group (N=34)*



	hemorrhage	precursor	dermatology	immuno-deficiency	permeability	solubility
Imagery (77)	19	6	10	11	12	19
Association (29)	3	4	5	8	3	6
Affix (110)	18	23	23	18	20	8
Grouping (39)	7	5	3	10	6	8
Writing Rehearsal (85)	15	15	15	12	15	13
Writing and Oral Rehearsal (20)	4	4	3	3	3	3
Oral Rehearsal (6)	1	1	1	1	1	1

Figure 1. The students' strategy preferences: SVS Group (N = 34). This figure shows the strategy preferences for each vocabulary item on the final vocabulary list for the students in the SVS group. The number in parentheses indicates the total number of students who used the strategy.

Figure 2: *The students' strategy preferences: LVS Group (N=34)*



	hemorrhage	precursor	dermatology	immuno-deficiency	permeability	solubility
Imagery (72)	16	6	10	14	15	11
Association (34)	6	5	9	6	1	7
Affix (145)	24	26	27	24	25	19
Grouping (42)	7	9	7	6	8	5
Writing Rehearsal (92)	17	15	15	13	16	16
Writing and Oral Rehearsal (32)	5	6	5	6	5	5
Oral Rehearsal (12)	2	2	2	2	2	2

Figure 2. The students' strategy preferences: LVS Group (N = 34). This figure shows the strategy preferences for each vocabulary item on the final vocabulary list for the students in the LVS group. The number in parentheses indicates the total number of students who used the strategy.

The Students' Perceptions of Memory VLS Instruction

Table 5 shows the descriptive statistics for the students' responses to the two items in *Post-Treatment Survey*. It shows that the majority of the students in both groups were satisfied with the instruction and think that it expanded their VLS choices. The results of the Mann-Whitney U tests indicated that there was no significant difference between the two groups at .05 level of significance (U = 511, p = .33 for Item 1, and U = 552, p = .69 for Item 2).

Table 5: *The students' perceptions of the memory VLS instruction*

	SVS (N = 34)						LVS (N = 34)					
	1	2	3	4	5	M (SD)	1	2	3	4	5	M (SD)
1. It was good to learn how to use memory strategies in class	0 (0%)	2 (6%)	6 (18%)	24 (70%)	2 (6%)	3.76 (0.64)	0 (0%)	2 (6%)	5 (15%)	21 (62%)	6 (17%)	3.91 (0.74)
2. Now I have more choices of strategies	0 (0%)	0 (0%)	6 (18%)	26 (76%)	2 (6%)	3.88 (0.47)	0 (0%)	0 (0%)	7 (20%)	22 (65%)	5 (15%)	3.94 (0.59)

Note. 1 = I strongly disagree, 2 = I disagree, 3 = Neither agree nor disagree, 4 = I agree, 5 = I strongly agree

Discussion

Vocabulary Size Affects the Perception of Usefulness and Actual Use of Memory Strategies

When asked which strategy was useful and which strategy they would be willing to use again, the students in both groups said they found the affix strategy the most useful and were most willing to use it again. However, when the students were given freedom to choose their strategies, the SVS students used it less consistently. An examination of the vocabulary items to which the students applied the strategy seems to reveal the SVS students lacked knowledge of affixes. The largest number of SVS students (23) used the strategy to learn *precursor* and *dermatology*. Fewer students used it with *permeability* (20), *hemorrhage* (18) and *immunodeficiency* (18). Very few students used the strategy for *solubility*. The reason could be that the students can use the affix strategy when they can divide the item into word parts correctly and have the correct knowledge of the affix and root. Both *precursor* and *dermatology* must have been easy for the students to see the word parts because *pre* is a popular prefix with Japanese speakers as it is used in many commonly used loan words such as *puresêru* (presale), *pure-entori* (pre entry) and *puripeido* (prepaid). In addition, *zenkutai*, the Japanese word for *precursor*, can also be divided into word parts in the same way as *pre-cursor*: *zen-kutai*. The same is true with *dermatology*. For *permeability*, although the SVS students can divide it into its affixes, *per* and *bility*, the root *mea* has no meaning for them. *Solubility* is a more complicated case. The students may be able to divide the word into *solu* and *bility*, but they would apply the incorrect meaning to both parts, thinking of "solution" for *solu*, with the definition as a way of solving the problem and not a liquid with which a solid or gas has been mixed. The suffix *bility* would again be considered as "ability" which would lead them to incorrectly guess the word's meaning as the ability to solve a problem. On the other hand, a larger number of LVS students used the affix strategy for all items. It is assumed, because of their larger vocabulary knowledge, they had enough knowledge of affixes and roots. The smaller number of students who used the affix strategy to learn *solubility* can be attributed to the reason given for the SVS students. Indeed, as Mochizuki and Aizawa (2000) found, English affix knowledge correlates with larger vocabulary size. Moreover, as one participant noted, the affix concept is familiar to Japanese students because they can transfer their knowledge of the composition of Chinese characters to word parts.

With regard to the other three memory strategies, although statistically there were no differences between the two groups, the two groups ranked the strategies quite differently in terms of their perceptions of the usefulness of the strategies and their willingness to use them again. Nonetheless, when it came to choosing the strategies to use with the final

vocabulary list, imagery came second for both groups, with the SVS group using it slightly more, perhaps due to the fact that they only had to link the L1 and L2 meanings and were not required to link the item with other vocabulary knowledge. Another reason may be that linking an image with the L2 word is especially effective for some biology terminology. Overall the LVS group used association and grouping slightly more than the SVS group. However, for both groups, association was not used much when learning the final vocabulary list. This could be because Japanese learners of all levels find association strategies difficult to use with science words (Little & Kobayashi, 2015). For this list, not many students used the grouping strategy, either. A common feature of these two strategies is that, compared with imagery, the students need rather large L2 vocabulary knowledge. When using association, the students should be able to think of words that are related to the target item; when using grouping, they should know both words and grammar to create a new sentence using the target item. The small difference between the SVS and LVS students for association and grouping may be attributed to the LVS group's better vocabulary knowledge. Cornell et al. (2016) found even higher level students had great difficulty writing sentences.

Writing Rehearsal Is Still a Popular Strategy

Interestingly, despite having been instructed in strategies involving deeper processing, when given freedom to decide which strategy or combination of strategies to use in learning the words on the final vocabulary list, almost one-third of the total strategies used were the rote memorization strategies of writing rehearsal and oral rehearsal. As several studies have indicated, Japanese learners tend to rely heavily on rote memorization strategies (Little & Kobayashi, 2015; Mizumoto, 2010; Schmitt, 1997). More mechanical strategies like simple memorization have been found to be effective if students are already in the habit of using them (Schmitt, 2007). Chamot (2005) notes that learners tend to use strategies that they perceive to be useful more often than other strategies. In addition, changing VLS use is hard for some learners (Chen & Hui-Jing, 2010). Although it appears that most students were willing to incorporate new VLS into their strategy repertoires, a few outliers resisted and used writing rehearsal almost exclusively. As Chamot (2005) noted, VLS instruction is only effective for learners who have not already internalized their VLS repertoire.

The Necessity of Memory VLS Instruction

Prior to the study, as Table 2 shows, the majority of the students had little familiarity with the four memory strategies. The students' responses to the *Post-Treatment Survey* revealed that both the SVS and LVS students felt that the strategy instruction was beneficial and that it gave them more choices of strategies (see Table 5). This supports Mizumoto's finding that VLS instruction is imperative to increase the learners' awareness of VLS (2010). In

discussing memory VLS instruction for ESP learners in particular, Atay and Ozbulgan (2007) pointed out that having a broad repertoire of strategies helps learners develop competence and ultimately enables them to become autonomous learners of terminology in their field. Although not every learner incorporates all strategies, presenting students with a range of strategies will help them find the one or two that are the most effective for them (Atay & Ozbulgan, 2007).

Conclusion and Implications

This study investigated the effectiveness of explicit VLS instruction for learning biology terms. Before explicitly teaching the learners how to use the four memory strategies (imagery, association, affixes and grouping), their familiarity with the strategies was examined. After teaching them the strategies, they were asked about their perceptions of the usefulness of each strategy, their willingness to use the strategies again, their strategy preferences, and their perceptions of VLS instruction. The results show that integrated VLS instruction was effective for teaching this group of biology majors new memory strategies and expanding their VLS repertoires. The majority of the participants indicated that they found the instruction useful and would be willing to use the strategies again, particularly the affix strategy. One benefit of teaching a range of strategies is to help learners find the VLS that are most effective for them (Atay & Ozbulgan, 2007), and it appears that explicit VLS instruction achieved this for most learners. Nonetheless, the gap between what the participants said on the Post-Treatment Survey and the strategies they actually employed to learn the final set of vocabulary items seems to indicate that the instruction did not result in the same outcome for all participants. There are several possible reasons for this.

First, learners with larger vocabulary sizes were more able to utilize strategies such as association and grouping than learners with smaller vocabulary sizes. This may have been because effective use of those memory strategies depends upon an ability to link the new item with previous lexical and grammatical knowledge. Learners with smaller vocabulary sizes perhaps had more difficulty doing this. Another possible reason for their inability could be that these learners needed more practice with the strategy than more proficient learners. Second, learners of all vocabulary sizes lack sufficient knowledge of affixes and/or morphology to apply that strategy to more unfamiliar words. Third, as learners in the study by Chen and Hui-Jing (2010) pointed out, changing VLS use is difficult. This may explain why some learners chose to learn the last set of words using rote memorization strategies. Such strategies are easier to understand and use, and as Schmitt and Schmitt (1993) state, some “learners may learn some ‘simpler’ learning strategies initially and never go on to more advanced strategies” (p. 32).

In addition, despite having had memory strategy instruction, the results indicated many learners continued to prefer shallower strategies like written and oral rehearsal when given the option of choosing any strategy. Schmitt notes (2007) these strategies are useful if learners are used to them. Indeed, many learners acquire sizable vocabularies through these strategies, but as Gu and Johnson (1996) point out, focusing solely on these strategies may not lead to increased English proficiency. In addition, learning vocabulary in context correlates with vocabulary size and proficiency (Gu & Johnson, 1996). Consequently, it appears that learners need to be taught the limitations of shallower strategies and the efficacy of deeper memory strategies.

Finally, the results regarding the students' perceptions of VLS instruction indicate explicit teaching of VLS has the potential to lead the students to better vocabulary learning. According to Schmitt (2007), teaching VLS helps learners to learn vocabulary independently. Thus, learners of all vocabulary sizes need to be taught an array of VLS to become more effective learners. As Schmitt (2007) noted, when choosing which VLS to teach, instructors must be mindful of the learning context and the needs of the learners, to which we would add it is also essential to consider their vocabulary sizes. This is particularly important for ESP learners who need to continue mastering specialized vocabulary in their field. As noted earlier, association and grouping strategies were overly challenging for students with small vocabulary sizes. However, from this study, the one memory strategy that was recognized by all of the learners as being especially salient for biology terms was the affix strategy. Teaching ESP learners the most common affixes in their field will enable them to use the strategy easily and increase their autonomy no matter what size their vocabulary is. The study also indicates that learners could benefit from being provided with more in-class opportunities to practice using the more challenging, deeper memory strategies such as association and grouping. As Fan (2003) concludes, the "'secret to vocabulary learning' may include helping students see the relevance of strategy use in L2 vocabulary, introducing them to the strategies used by more proficient learners and, most important, encouraging them to develop their own effective strategies for learning" (p. 235).

Although the findings of the study add to our understanding of explicit VLS instruction for ESP learners, the study had some limitations. First, the Final Study Report after each strategy did not ask why the learners chose or did not choose each strategy. If we had asked for this information, it would have cast greater light on why they liked or disliked each strategy. Second, the number of participants was not large enough to generalize findings to other biology majors. A final limitation was that the instruction lasted only ten weeks, which is

too short to determine if the strategy instruction would have a lasting effect on participants' actual VLS use.

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Appendices

Appendix A

List of Target Vocabulary Items in Alphabetical Order

1 amphibian	9 dissection	17 hydrophobicity	24 oocyte
2 anemia	10 electrolysis	18 immunodeficiency	25 ovulation
3 antigen	11 endoscopy	19 intoxication	26 permeability
4 carcinogen	12 erythrocyte	20 invertebrate	27 precursor
5 carnivore	13 excretion	21 leucocyte	28 proteolysis
6 centrosome	14 gastritis	22 metastasis	29 solubility
7 decomposition	15 germination	23 neonate	30 specimen
8 dermatology	16 hemorrhage		

Appendix B

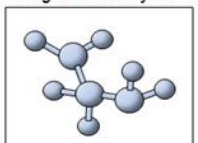
Strategy Handout: Imagery

Imagery Strategy

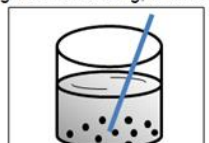
Explanation of the strategy

Research shows that studying words with mental or actual images of their meaning helps learners. This is especially true when learning life-science terms because many of them are names of a part of an organism, or point to a specific phenomenon or a biological or chemical process.

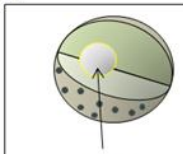
1. Image: It can be your mental image of the meaning, or an actual picture.



molecule

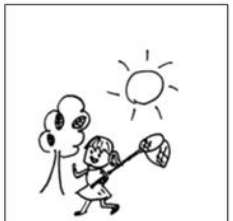


saturation



nucleus

2. Personal Experience: You can also link the new word to your personal experience.



photosynthesis

3. Spelling Image: You can create an image from the spelling of the word.

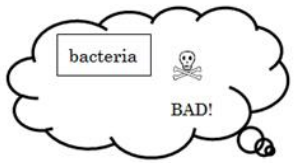
giraffe

4. Keyword Method: After you look up the meaning of an unknown word, think of a word in Japanese (the "keyword") that sounds like the beginning or all of the unknown word. Then, think of a visual image that combines the meaning of the unknown word and the meaning of the Japanese keyword. Actually this is considered one of the most effective strategies.

1.		2.		3.		4.
unknown word	→	Japanese keyword	→	Visual image combining the meaning of the unknown word and the meaning of the key word	→	meaning of the unknown word
word		**word form link**		**meaning link**		**meaning of unknown word**
mathematics		マス		百マス計算		数学

1	2	3	4	5	6	7	8	9	10
4	6	7	8	9					
8	10	11	12						
2	4								
11									

5. Positive/Negative: Finally, it is also effective to imagine whether the meaning of the word is negative or positive.



Putting the strategy into practice

Method

1. Find the meaning of each word on your word list.
2. Choose any of the five methods above and draw an image that can act as a clue for the meaning of the word.
3. Learn the words making use of your drawings.
4. Complete the short survey for this strategy on the site given on the students' portal site.
5. You will be given a quiz on the words in the next class.

Reference

Schmitt, N. (1997). Vocabulary Learning Strategies In N. Schmitt &M. McCarthy (Eds.), Vocabulary: Description, acquisition and pedagogy (pp. 199–227). Cambridge, England: Cambridge University Press.

*In the actual handout, everything except for the figures and references was written in Japanese.

Appendix C

Strategy Handout: Association

Association Strategy

Explanation of the strategy

Research shows that often people remember words better by making associations, or connections, in their minds. One way to do this is to make an **association network** centered on the new word—connect the word to other words that you associate with it and draw a diagram. The figures below should give you some ideas on association. When you use hyponymy, you associate the target word with a more general term or a term of a broader class. The opposite works as well. The network can be large or small, but the important thing is that it is unique because you have thought of the words and made the connections yourself.

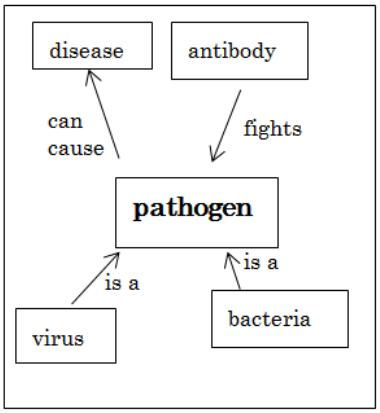


Figure 1: Semantic network

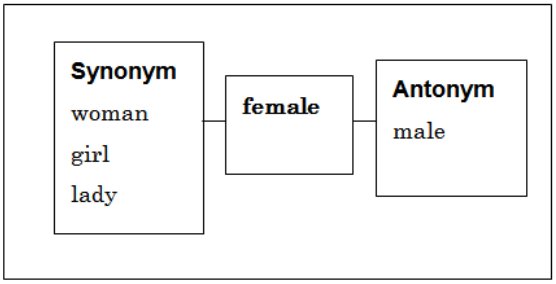


Figure 2: Synonyms and antonyms

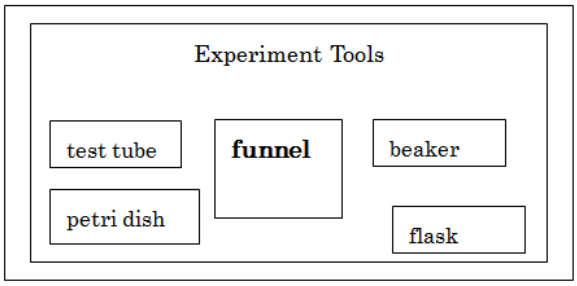


Figure 3: Hyponymy

Putting the strategy into practice

Method

1. Find the meaning of each word on your word list.
2. Draw a diagram that involves some type of sense relationship.
3. Learn the words making use of your diagrams.
4. Complete the short survey for this strategy on the site given on the students' portal site.
5. You will be given a quiz on the words in the next class.

References

Oxford, R. and Crookall, D. (1990). Vocabulary Learning: A Critical Analysis of Techniques. *TESL CANADA Journal, 7 (2).* 9-30

Schmitt, N. (1997). Vocabulary Learning Strategies In N. Schmitt &M. McCarthy (Eds.), Vocabulary: Description, acquisition and pedagogy (pp. 199–227). Cambridge, England: Cambridge University Press.

*In the actual handout, everything except for the figures and references was written in Japanese.

Appendix D

Strategy Handout: Affix

Affixes and Roots

Explanation of the strategy

Studying affixes and roots can help you guess the meaning of a word, or consolidate it. Life-science related terms, like many medical terms, are like an individual *kanji*. You can break the word into their meaningful components. If you learn the meaning of those components, you can use the knowledge when you encounter a new word. Look at the example below.

transplantation

trans (across) + plantation (the noun form of 'to plant')

chlorophyll

chloro (green) + phyll (leaf)

Study the list of scientific root words, prefixes and suffixes on the next page.

Putting the strategy into practice

Method

1. Find the meaning of each word on your word list.
2. Divide the word into meaningful components (affixes/roots).
3. Learn the words making use of the affixes and roots.
4. Complete the short survey for this strategy on the site given on the students' portal site.
5. You will be given a quiz on the words in the next class.

References

Herr, N. (2007). The sourcebook for teaching science. San Francisco, CA: Jossey-Bass. Scientific Root Words, Prefixes, and Suffixes. http://www.biologyjunction.com/prefixes%20and%20suffixes.pdf

Schmitt, N. (1997). Vocabulary Learning Strategies In N. Schmitt &M. McCarthy (Eds.), Vocabulary: Description, acquisition and pedagogy (pp. 199–227). Cambridge, England: Cambridge University Press.

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Appendix E

Strategy Handout: Grouping

Grouping (Using the word in a sentence)

Explanation of the strategy

Sometimes it's easier to learn the words when you put the words belonging to the same meaning category together. Look at the following word list.

apple, monkey, banana, pineapple, elephant, lion

It is easier to learn the words if you rearrange the order of the words like in the following lists.

Fruits	*Animals*
apple, banana, pineapple	monkey, elephant, lion

It is more natural to make a sentence using the target words.

Apples, bananas and pineapples are all fruits.
Monkeys, elephants and lions are animals.

You can even make a story using all the words.

Some animals love fruits. Monkeys and elephants love fruits like apples, bananas and pineapples. On the other hand, there are animals that eat other animals. For example, lions eat elephants.

If you can't group the words by their meanings, you can make a sentence for each word. Look at the following word list.

petroleum, brain, mango, longevity

Petroleum is a necessity in our modern life.
The brain sends messages to the body through the central nervous system.
It's extremely easy to grow a mango tree in a tropical climate.
The family is famous for their longevity.

Putting the strategy into practice

Method

1. Find the meaning of each word on your word list.
2. Make a sentence using each word. Or make a story using some or all of the words in the list.
3. Learn the words making use of the sentence you made.
4. Complete the short survey for this strategy on the site given on the students' portal site.
5. You will be given a quiz on the words in the next class.

Reference

Schmitt, N. (1997). Vocabulary Learning Strategies In N. Schmitt &M. McCarthy (Eds.), Vocabulary: Description, acquisition and pedagogy (pp. 199–227). Cambridge, England: Cambridge University Press.

*In the actual handout, everything except for the figures and references was written in Japanese.

Appendix F

Study Report Example* (Association)

Association Strategy **Student Id:** **Name:**

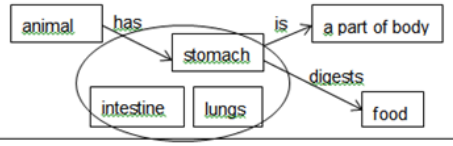
Vocabulary List

	Word	Sample Sentence
1	intoxication	Acute alcohol intoxication is very dangerous and can be fatal.
2	anemia	When your body doesn't produce enough blood cells, you have anemia.
3	centrosome	Centrosomes exist only in animal cells.
4	electrolysis	The students observed the electrolysis of water and confirmed that water can be separated into hydrogen and oxygen using electric current.
5	specimen	There are many specimens of dinosaurs in the museum.
6	hydrophobicity	Greasy substances such as oil and fat are characterized by their hydrophobicity.

List 1

Write down how you learned the word. Make sure you mark the accented syllable and learn the pronunciation.

Example:

stómach 胃	

* In the actual handout, the direction was written in Japanese.