The Evolution of Vocabulary Learning Strategies in a Computer-Mediated Reading Environment

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ABSTRACT
Numerous studies have indicated that the provision of appropriate computer-mediated support to second language (L2) learners results in different vocabulary learning outcomes. However, there is no study available that investigates the transition in their way of learning vocabulary under the influence of technology-based support. This article presents a comparative study that examines the differences between L2 learners’ use of vocabulary strategies with or without such support. Twenty-four ESL students in a Toronto high school were involved. A language learning system was implemented to facilitate a technology-enhanced reading environment. Observations and tape-recorded field notes contribute to the data collection. The results showed that (a) a variety of strategies were employed across cognitive, compensatory, metacognitive and social categories when students learned vocabulary through sustained reading within the computer-mediated environment and that (b) significant variations in the techniques and functionalities of strategies were found between the two reading conditions. Situated within the vocabulary learning strategy framework, the article argues that the technology-enhanced scaffolding can effectively assist students to advance their learning strategies, potentially optimizing their reading-based vocabulary acquisition.

KEYWORDS
Vocabulary Strategies, Reading, Chinese ESL Students, CALL

INTRODUCTION
In the past decade, vocabulary strategy studies as a part of language learning strategies have evolved from identifying the individual strategies that “good learners” use (e.g., Gu, 1994) to discovering reciprocal relationships between vocabulary learning strategies, learning outcomes, and L2 learners’ existing language proficiency (e.g., Bialystok, 1979; Gu & Johnson, 1996; Wu & Wang, 1998; Schmitt, 1997); that is, the proficient use of a variety of vocabulary learning strategies contributes to vocabulary acquisition. L2 learners with a higher level of target language skills are often able to apply more diverse and complex vocabulary strategies, whereas L2 learners with a lower level of target language skills are usually constrained within fewer and more basic learning strategies. Previous studies provide significant insight into variations of strategy use by L2 learners with different L2 proficiency, and vice versa, but no study that has been undertaken, from a dynamic viewpoint, to investigate the changes in strategy use (e.g., vocabulary recognition skills) by a group of L2 learners as their language skills progress into a more advanced level. Although many studies on computer-assisted vocabulary learning have been devoted to understanding the effect of computerized dictionaries (e.g., Knight, 1994; Laufer & Hill, 2000) and multimedia annotations (e.g., Chun & Plass, 1996; Jones, 2004) on vocabulary learning outcome, scant literature is available that examines their impact on L2 learners’ use of vocabulary strategies in terms of how learners internalize the technology enhanced-support that entail and fashion a host of vocabulary.
learning strategies. Within a computer-mediated learning environment facilitated by e-Lecture, a language learning system, designed and developed by Cummins (2003) and Chascas, this article investigates the strategy transformation of a group of Chinese ESL students using the support in the system that instantly increases their word recognition ability. The article aims to answer two research questions: (a) What strategies do the ESL students employ to acquire vocabulary upon receiving the computer-mediated support? and (b) How do these strategies compare with those they employ in learning vocabulary through reading texts at a comparable difficulty level without this support?

Taxonomies of Vocabulary Learning Strategies

A number of attempts have been made to develop a taxonomy of vocabulary learning strategies. One of the earlier, yet more established, categorization systems of L2 vocabulary learning strategies can be found in Oxford’s (1990) strategy taxonomy. Divided into six major categories: memory, cognitive, compensatory, metacognitive, social, and affective, her framework is able to “capture and organize the wide variety of vocabulary learning strategies identified” (Schmitt, 1997, p. 205). Nine of the ten strategies in the four categories of Oxford’s memory strategies specifically refer to consolidation of the connection between word form and meaning. The other major contributions of strategy classification that focus on vocabulary include Stoffer (1995), Gu and Johnson (1996), and Schmitt (1997). Stoffer classified 53 individual strategies into nine categories: strategies involving authentic language use, strategies used for creative activities, strategies used for self-motivation, strategies used to create mental linkages, memory strategies, visual/auditory strategies, strategies involving physical action, strategies used to organize words and strategies used to overcome anxiety. Her vocabulary learning strategy inventory, using factor analysis, showed initial promise in establishing a comprehensive system for describing vocabulary learning strategies. Gu and Johnson’s study of sophomore students at a university in Beijing categorized 91 vocabulary learning behaviors into seven categories: metacognitive regulation, guessing strategies, dictionary strategies, note-taking strategies, rehearsal strategies, encoding strategies, and activation strategies. Gu and Johnson’s study has provided the most complete profile of the vocabulary learning strategies used by Chinese students in the English as a foreign language (EFL) context.

Based on Oxford’s framework and the discovery-and-consolidation distinction suggested by Cook and Mayer (1983) and Nation (1990), Schmitt (1997) developed an inventory of vocabulary learning strategies across two dimensions. With 58 individual strategies in total, the discovery dimension consists of partially social strategies and determination strategies—the category introduced by Schmitt to describe the methods students use for decision making when encountering new words. The consolidation dimension is comprised of five categories from Oxford’s framework: social, memory, cognitive, compensatory, and metacognitive. This taxonomy is regarded as the most extensive in the field and demonstrates considerable potential in establishing a basis to develop a comprehensive framework of vocabulary learning strategy in CALL and multimedia environments (Segler, Pain, & Sorace, 2002).

Perspectives on Vocabulary Learning Strategies

In the past two decades, several trends have emerged from the research literature. First, considerable evidence shows that students do employ strategies to learn vocabulary (Oxford, 1996). High school students who learn English as a second language (ESL) seem to use more strategies for vocabulary learning than for any other aspect of language (Chamot, 1987). This may be ascribed to the discrete nature of vocabulary learning, which makes it possible to ap-
ply strategies effectively (Schmitt, 1997). Second, the basic strategies of vocabulary learning, including repetition and memorization of unknown words and taking notes, were used more frequently than active manipulation of information (Ahmed, 1989; Cohen & Aphek, 1981; Gu & Johnson, 1996; Lawson & Hogben, 1996; O’Malley, Chamot, Stewner-Manzares, Kupper, & Russo, 1985). The studies of Nation (1982) and O’Malley and Chamot (1990) suggest that fundamental vocabulary strategies, such as using word lists and rote repetition, can be effective, and are even more suitable for students with beginner ESL proficiencies.

Third, language proficiency was found to be an essential variable in determining the orientation and effectiveness of vocabulary strategies (Bialystok, 1979; O’Malley et al., 1985). Using a questionnaire to survey students’ reported strategies and perceived effectiveness, Schmitt’s (1997) study compared the vocabulary learning strategies of Japanese students at four different age levels. The study revealed that students’ strategy patterns changed over time as students became more mature and their ESL proficiency increased. That is, their vocabulary learning strategies shifted from form-based memorization toward meaning-based processing as they progressed from the lower grades to higher grades. This suggests that the transition to greater “depth of processing”—“greater degrees of semantic involvement” (Craik & Tulving, 1975, p. 267) promotes long-term retention (Craik & Lockhart, 1972).

Lastly, students’ metacognitive awareness of the nature of learning tasks, appropriate strategies, and their own needs contribute to vocabulary progress. Results from several group comparison studies showed that effective learners were conscious of their learning, actively structured their vocabulary learning, independently engaged in a variety of vocabulary strategies, and demonstrated a higher level of commitment to their learning (Ahmed, 1989; Sanaoui, 1995).

**Computer-Assisted Vocabulary Learning Strategies**

Although there are few studies available that focus on vocabulary strategies in a CALL context, many studies have been conducted to examine how to create an optimal environment to enhance vocabulary acquisition either through explicit vocabulary learning activities or reading. Most studies in the area corresponding to the development of CALL programs can be organized around direct and indirect vocabulary learning approaches. One approach is to present target words (a) in a diversity of electronic texts such as selected authentic texts (e.g., Cummins, 1998a; Ghadirian, 2002), graded texts, and contextual sentences (i.e., Groot, 2000) and (b) in an environment with multimedia features such as with audio, pictorial and video annotations (i.e., Al-Sehghayer, 2001; Chun & Plass, 1996; Jones, 2004; Duquette, Renié, & Laurier, 1998). The other approach is to provide scaffolding to support vocabulary learning activities undertaken on a computer, such as through a variety of electronic dictionaries (i.e., Cummins, 1998b; Horst & Cobb, 2001; Hulstijn, 1993; Knight, 1994; Laufer & Hill, 2000; St-Jacques & Barrière, 2005) and glosses (i.e., Davis, 1989; Hulstijn, Hollander, & Greidanus, 1996; Nagata, 1999). In particular, reading hypertexts with access to electronic dictionaries has demonstrated a great capacity to assist incidental vocabulary learning without interfering with the reading process.

Over the last 10 years, one of the most important research trends in CALL is to study the “dictionary lookup behavior”—an individual vocabulary learning strategy—in terms of L2 learners’ preferences for and techniques in using a variety of computerized dictionaries and their effect on vocabulary acquisition. Laufer and Hill (2000) investigated the relationship between lookup strategies and vocabulary retention. The 32 Israeli students and 40 Hong Kong students in their study demonstrated distinctive lookup strategies toward various types of
dictionaries: L1, L2, L1 + L2, and L1/L2 + other information. Their findings indicated that the access to a variety of electronic dictionaries, catering to the lookup strategy preferences of individuals, was effective in reinforcing retention. Hulstijn’s (1993) study on lookup behavior of 82 Dutch EFL students involved the factors of “relevance” and “inferability.” The results of his study showed that students were able to use electronic bilingual dictionaries strategically to accomplish the reading comprehension task, taking into account a word’s relevance to the reading goal and, to a lesser extent, the inferability of the word’s meaning. Consequently they tended to look up the relevant unknown words they encountered that were unlikely to be inferred from the context, and vice versa.

Variations in using electronic dictionary strategies were found among students with different levels of proficiency. On one hand, electronic reading environments with computer-based bilingual and monolingual dictionaries seem to be particularly compatible with the manner in which vocabulary acquisition occurs in the early stage of second language acquisition, thus effectively supporting students with low ESL proficiency. Knight (1994) found that electronic dictionary access helped the students with low verbal ability the most. On the other hand, undifferentiated consultation of dictionaries was observed and thus took more time. With easy access to dictionaries, students with higher proficiency were reluctant to use other strategies (Knight, 1994); words that could be easily inferred were looked up (Hulstijn, 1993). These studies shed light on vocabulary learning outcomes and lookup strategies resulting from utilizing different computerized dictionaries. However there is a need to study the whole spectrum of strategies that L2 learners use at the time and that may be influenced, modified, activated, or deactivated by the particular technology-enhanced scaffolding.

METHODS

The study reported here was conducted in one of the largest school boards in Canada. Forty-one percent of the students in this school board have a language other than English as their first language. More than 80,000 (30%) of the students were born outside of Canada, and more than 27,000 (10%) of the students had been in Canada for 3 years or less. The largest ESL student group consisted of Chinese students because the Chinese had been the country’s leading immigrant group for the past 10 consecutive years (Citizenship and Immigration Canada, 2008). Many of the recent Chinese immigrant students have faced a great challenge in acquiring academic English and meeting the requirement of The Ontario Curriculum, including the Ontario Secondary School Literacy Test (OSSLT). Policy makers have urged educators to adopt innovative ways to help these students meet the OSSLT standards.

Twenty-four Chinese students from Grades 9 and 10 (except one from Grade 11) with beginning and earlier intermediate levels of ESL proficiency participated in the study. They had formal education in China ranging from 3 to 7 years and had acquired intermediate to advanced Chinese language skills. Students’ knowledge of using the computer varied from two female students at the early beginning levels (who were able to use basic word processing functions and internet search engines) to most male students at intermediate levels (who had knowledge of computer hardware and software installation as well as the more advanced application functions). Except for two students who initially did not have a computer at home, all of the students had access to computers at home and in the school.

e-Lective Tutorial

Prior to the study, the researcher (the author) organized three 35-minute tutorials for the students. The training referenced the instructions included in the User Manual: e-Lective Lan-
guage Learning Program Version 1.0 (Cummins, 2003). Students were first asked to practice using e-Lective in a prescribed sequence; later, they were permitted to choose any of the features they preferred in the program as they read a story.

Consisting of reading, grammar, and writing modes along with practice and test modes, the e-Lective program has a diverse set of functions. Due to the scope of the study, the training focused on the features of the reading mode, in particular, the text to speech module and the built-in dictionaries. The blank words and partial words modules in the practice mode and the parts of speech module in the grammar mode were also demonstrated. The text used in the e-Lective training, “Polio (Poliomyelitis) in Canada,” was adopted from the manuscript of a Chinese-English bilingual story book (Ferguson, in progress). The details of the procedures are presented below along with their corresponding screen captures.

Students were given their own usernames and temporary passwords to log on to e-Lective. When the front page opened, students were asked to choose "Polio (Poliomyelitis) in Canada" from the Selected text window on the right-hand side of the screen. An adapted and expanded version of a monolingual dictionary, the WordNet dictionary developed by Princeton University, was introduced as the first level of support when students encountered words they did not know. This dictionary provided detailed definitions and synonyms for the words (see Figure 1).

Figure 1
WordNet Monolingual Dictionary Feature

Note: Highlighted words are words that have been clicked on.
The second feature shown to students was the monolingual English and English-Chinese bilingual dictionary provided by the embedded Babylon software. The built-in speech module was available in both the Babylon dictionary and e-Lective (see Figure 2).

**Figure 2**
Monolingual/Bilingual Dictionary Feature

![Monolingual/Bilingual Dictionary Feature](image)

The third feature was the unknown words DB (database) which recorded the words that students had looked up. It also tracked their progress in learning these words. This feature helped students to organize and recall what they had learned (see Figure 3).

**Figure 3**
Unknown Words DB Feature

![Unknown Words DB Feature](image)

The fourth feature involved a practice-oriented procedure called Partial Words in the program’s practice mode. Upon completing their reading, students could work on cloze exercises based on the unknown words highlighted on their screen and receive immediate feed-
back on their answers. The level of the exercise can be adjusted with a range from beginning to advanced levels (levels 1-5), and the researcher chose level 3 for the training session (see Figures 4 and 5).

Figure 4
Partial Words Feature

The fifth feature was the Blank Words function, also in the practice mode, which has a structure similar to that of the partial words function. Blank Words, however, requires not only comprehension of the words and knowledge of the spelling, but also memory of the details of the story. In order for students to complete the task and to make the function compatible with their proficiency levels, the researcher suggested that they open the unknown words DB window for clues (see Figure 5).

Figure 5
Blank Words Feature
The last feature included was the parts of speech function in the grammar mode. This function identified the major parts of speech of the whole text individually or collectively by highlighting the parts in a variety of colors (see Figure 6). While reading, students were able to highlight any language units in the text and check all the parts of speech in those units. The purpose of doing so was to provide the students with grammatical indications for inferring the meanings of words.

The researcher conducted the training sessions in Mandarin and referred to the e-Lective terminology in both Mandarin and English.

Figure 6
Parts of Speech Feature

Procedure and Analysis
In consultation with the senior ESL teacher in the school, the researcher identified 10 short fables by Aesop with equivalent levels of difficulty in terms of vocabulary, content, and length. The participants in the project read all 10 texts, five in the e-Lective environment and five in the paper format, over the course of five class sessions. In each session, the students read a text in the e-Lective environment for 15-20 minutes and a second text in the paper format for an additional 15-20 minutes. In the e-Lective environment, the students had access to the tools in the program, principally the monolingual English dictionary and the English-Chinese bilingual dictionary. They also had a printed copy of the text on which they could take notes. In the paper condition, the students had access to a print monolingual English dictionary and/or a hand-held electronic English-Chinese bilingual dictionary. (Fifteen out of 24 students in the study owned one.) All sessions—both the e-Lective and paper conditions—were recorded on audiotape, totalling 7 hours of discussions among the students themselves and the author’s communication with the students describing typical scenarios as the students read the texts.

In order to examine the techniques, sequences, and the dynamics of strategies used in the two reading conditions, conceptual analysis was applied to code for the presence of strat-
egy use in excerpts from the recorded sessions (Carley, 1990; Krippendorf, 1980). Next, a comparative study was conducted using thematic analysis (Bogdan & Biklen, 1992) to identify distinctive patterns of strategy use as students read in the e-Lective and paper conditions.

RESULTS

The results of the study provide a profile for two sets of strategies used by the students in the two reading conditions that varied by nature and technique. Observations revealed that most strategies were based on word-decoding support provided in the two conditions (i.e., the dictionaries). When using e-Lective, students’ engagement with the other parts of the program was rather casual, amounting to informal experimenting, due to their limited English proficiency and time constraints (i.e., 15-20 minutes).

**Strategies in the Paper Condition**

**Using monolingual print dictionaries**

In the paper condition, students with beginning and early intermediate ESL proficiency frequently encountered different kinds of problems in understanding English definitions when using monolingual print dictionaries. These problems included: (a) too many unknown words in definition entries, (b) the complicated sentence structure of definitions, and (c) elaborations involving unfamiliar concepts. The students had to make an extra effort to search for additional bilingual information, which included using hand-held electronic bilingual dictionaries and asking for Chinese definitions from peers and the researcher, as illustrated in the examples below.

Researcher: Okay, *jaws,* where is it? *(It) means upper or lower bone structure in the vertebrates containing the teeth* {reading the definition in the Oxford English Dictionary}. *These are lower and upper bone structures. And you have teeth here* {opening her mouth and using a finger to point to her jaws}. So this is the *shàng* (上颚 upper bone structure containing the teeth) and *xià* (下颚 lower bone structure containing the teeth) of a human.

Jane: Ou (Chinese intonation indicating understanding).

Researcher: Animals have jaws, too, is that right?

Mei: Um {no, shaking her head}.

*Italicics indicates the use of English, nonitalics indicates the use of Chinese.*

*Phrases and local idiomatic expressions often used by students are marked with underlined pinyin—Mandarin phonetic alphabet—and Chinese characters with the meaning given in brackets afterwards.

'TAll names are pseudonyms, but students’ preferences for English versus Chinese names are maintained.

The dictionary gave an accurate, yet complicated, description of “jaws.” Words used in the entry such as “structure,” “vertebrate,” and “contain” caused difficulties for the students. To students with only limited English proficiency the concept appeared rather abstract.

Researcher: *Rather, by preference, more truth, as more likely attractive* {reading the definition from a print dictionary}. *Okay, preference, do you know the word?*

Mei: Um {no, shaking her head}. 
Researcher: Do you know *adv.* {pointing at the print “adv.” in the dictionary}?
Mei: I do not know. I just found it in the dictionary.
Mei: Is this one {writing down “ning” in Chinese}?

Mei was not able to take advantage of the English definition of “rather” because it involved more unknown words and also because she did not have the knowledge of parts of speech, one of the two fundamental clues to infer the meanings of words (Nation & Coady, 1988).

**Delaying reading**

The lack of fundamental vocabulary knowledge hindered not only the students’ comprehension of texts, but also their understanding of English explanations in dictionaries. Some of the students with access only to a monolingual print dictionary showed an apparent tendency to withdraw from reading or to delay reading.

Researcher: How is your progress? Oh, you haven’t checked these ones, not even one {looking at Hao’s notes}.
Hao: (I will) wait until I get home.
Researcher: What kinds of dictionary do you use at home?
Hao: Dictionaries on the computer {laughing}.

Since they were not allowed to take printed copies of the stories home, a few students who did not own hand-held electronic bilingual dictionaries made a list of unknown words and decided to look up their meanings using an online bilingual dictionary that they could access through their computer at home.

Researcher: Why can’t you read?
Su: *Cha ye cha bu dong* (查也查不懂 cannot check to understand – cannot understand word meanings through looking up the dictionary).
Researcher: What do you mean?
Su: I cannot read, understand the English, those [///]a...
Researcher: These in English?
Su: Some English, I don’t understand.
Researcher: What are you saying --b
Su: Some English (words), I don’t understand.
Researcher: So, you are talking about the English words in the definitions.

a Backslashes in square brackets indicate indecipherable utterances.

b A bold double hyphen (--) indicates utterances that were interrupted.

This episode revealed that when Su read in the paper condition, he was reluctant to read the story because he was aware of his difficulty in comprehending English definition entries.

**Extending reading time**

The 15-20 minute reading sessions in the paper condition were often extended to 20-25 minutes at the request of the students.
Researcher: Michelle, I will give you five minutes more. Is it enough?
Michelle: {Nodding her head}.
Researcher: Okay, everybody, where are you now?
Judy: Almost there.
Researcher: Almost finished?
Judy: Almost.
Researcher: How about you, Mei?
Mei: I still have to look up the words, ai {sighing}.
Researcher: How many words do you still have to look up?
Mei: Ai {sighing}.
Researcher: Okay, Jane, I will be right over. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, so Mei you have 21 (unknown) words in "The lion and the mouse" {Jane walking over from another table, asking for help}.
Mei: {Looking at the researcher}.
Judy: Waha.
Jane: Wow, I have 25.

Due to the considerable number of unknown words, Michelle, Judy, and Mei, who used hand-held electronic bilingual dictionaries, and Jane, who used a monolingual print dictionary, were not able to look up the meanings of all the unknown words.

Using hand-held electronic bilingual dictionaries
Hand-held electronic bilingual dictionaries were the major resource that the students used to search for the word meanings in the paper condition. Fifteen out of 24 students in the study owned this kind of dictionary (see Figure 7).

Figure 7
Samples of Hand-Held Electronic Bilingual Dictionaries Used by the Students
Some of the students who did not have an electronic dictionary often borrowed one or asked friends who had one for help. The students mainly looked up Chinese definitions and wrote down one or two basic meanings. Their knowledge of Chinese allowed them to successfully use these dictionaries. “Because of their ease of use and range of the features” (Hartmann, 1992), hand-held electronic bilingual dictionaries have grown in popularity and were perceived by the students as an effective strategy, if not the best strategy, to access the word meanings.

The use of electronic bilingual dictionaries appeared to be a potent strategy (Tang, 1997), enabling students such as Tian who had native proficiency in Chinese but only limited proficiency in English to sustain their reading by finding explicit Chinese equivalents for English words.

**Guessing and inferring**

When reading in the paper condition, guessing and inferring word meanings was commonly found among the beginner students who were reluctant to look up unknown words. Because it is “a lot of trouble” to search words in a dictionary and they “do not understand (the English explanations), it is useless to check it.” Without referencing the basic meanings of the words in a dictionary and looking for contextual clues, their guesses often failed.
This episode shows that without consulting the contextual information, Su and Tian tried to deduce the meaning of “pleased” with a few failed attempts. These attempts at guessing might also be misled by one-word translations in some bilingual dictionaries (Laufer & Hadar, 1997). The students with early intermediate proficiency, who also tended to look up words more frequently, appeared to have a slightly higher inferring ability.

**Taking notes**
Consistent note taking was observed among some of the students. The students often highlighted and looked up unknown words prior to and during reading and shared Chinese definitions with each other. The students copied the word meanings, almost exclusively in Chinese, in notebooks or in the margins or between the lines of the printed version of the texts because they felt that it is “not easy to 

\textit{lijie} (理解 comprehend) in English.” Judy, Jane, and Mei were observed to be constantly taking notes in Chinese while reading in the paper condition throughout the five sessions. The three of them also frequently exchanged information in Chinese. Signs of reduced learning effort was also reflected in the absence of note taking.

Researcher: If you do not take notes, you will forget {talking to Tian}.
Su: {Whispering} Like me {pointing at himself, smiling}.
Tian: If I take notes, I don’t read them. ... 
Researcher: I see. Like who, Su? Do you want any pen and paper?
Su: I have pens. I do not like to write.
Researcher: If you do not like taking notes, what do you do if you don’t remem-

ber later on?
Su: I can remember. I do not need to take notes.
Researcher: Are you sure?
Su: (If) I cannot remember, even I take notes, I still don’t remem-

ber.

Su and Tian did not take any notes when they read in the paper condition, except for occasionally highlighting unknown words in the printed version of the stories.

**Making connections**
Students were able to associate new information with prior knowledge, including words they had learned in other contexts and stories they remembered in Chinese with equivalent thematic connotations.

Researcher: What is this, forest?
Su: In the wild field, some grass, something like ...
Researcher: The place with many trees, what is it?
Su: 

\textit{Jungle}.
Researcher: Umm ...you can say it is a jungle, but..., Tian, do you know what a forest is?
Tian: \textit{Senlin} (森林 forest).
Researcher: Yeah.
Su: \textit{Senlin} is just like a jungle.
Researcher: A jungle is more like \textit{conglin} (丛林 a tropical forest). It is not ex-

actly the same ...
Researcher: Excuse me, Tian. What are you saying?
Tian: Is this the story about a kid who lied to people, Lang laile, Lang laile (狼来了，狼来了 wolves are coming, wolves are coming)?
Researcher: Dui, dui, dui, dui (对, 对, 对 yes, yes, yes, yes).

Su was able to associate the word “forest” with the word “jungle,” which he had learned from a computer game, while the story “The shepherd’s boy” reminded Tian of “Wolves are coming,” similar to a story told in China.

**Strategies Used in the e-Lective Condition**

**Using online dictionaries**

Using online dictionaries, which provided monolingual and bilingual definitions, was the pre-dominant strategy adopted by students at both levels of ESL proficiency in the e-Lective condition. To look up the meaning of an unknown word in the text shown on the screen, the students clicked on the word which opened a window displaying both Chinese and English definitions with no visual shifting required. Free from the difficulty in retaining information gathered from other sources (Ellis, 1995), the students seemed to be better able to concentrate on reading, and their comprehension abilities appeared to increase significantly. Very few students approached the researcher for assistance regarding the text content. Also, in contrast to reading in the paper condition, students often shortened the 15-minute reading session by an average of 5 to 10 minutes.

Researcher: How long did it take you to read the story?
Jane: Very fast.
Researcher: How long did it take exactly?
Jane: Ten minutes.
Mei: Ten minutes.
Jane: Because if there is anything you do not know, you just click. If using that one (print English dictionaries), it is very mafan (麻烦 troublesome) {everybody laughing}.

Researcher: How about you, Judy?
Judy: It appears easier to remember, because I do not really understand (the definitions) if using that one.

Utilizing the online bilingual dictionary relieved the students from the time-consuming lookup activities when using a conventional print dictionary.

**Taking notes**

Note-taking strategies in e-Lective were different from those in the paper condition (see sample student notes in Appendix A). The students often took notes after they had finished reading the stories rather than while they were reading them. Also, the range of their notes extended from lists of unknown words to comprehensive, well organized notes to facilitate memorization and review. For example, Juan copied all the words she looked up because she believed that “it would be easier to remember.” She said, “It is just like after exams I write the Chinese (translations) along the side of the stories, and then I will remember them” (see Figure 8). She made a deliberate effort to take notes and organize them, creating a personal bilingual word-pair vocabulary list (Nation, 1990) which led to effectively retrieving the meanings of words.
After having acquired sufficient comprehension of the text, many students were able to analyze sentences and paragraphs to infer the meaning of unfamiliar words (Nation, 1990). In the e-Lective condition, students used contextual cue-oriented guessing strategies with higher accuracy than in the paper condition. In addition to an easily accessible bilingual dictionary, the e-Lective system integrates the dictionary and text windows on the same screen as mentioned previously. The definition window immediately appears next to the selected word, and the word is highlighted, providing instant, one dimensional visual stimuli to readers. This integration of windows also seemed to contribute to text-based inferences.

**Guessing and inferring**

Su: Does “axe” mean “futou” (斧头 axe)?
Researcher: Yes.
Su: Do both of these words mean revenge {pointing at “vengeance” and “revenge”}? 
Researcher: Yes, one is a noun, and the other is a verb ... If you click on the dictionary, it says there.
Su: Really?
Researcher: Sure, see {clicking on the Babylon bilingual dictionary}.
Su: Do you understand all of these (words) now?
Researcher: Yeah.
The above two episodes demonstrate Su’s and Tian’s successful use of guessing strategies. Su also showed some interest in another aspect of vocabulary knowledge—parts of speech.

**Summarizing and making connections**

With adequate comprehension of the stories, the students in the e-Lective condition were able to engage in the use of higher levels of cognitive strategies that promoted deeper semantic processing and better vocabulary retention, such as summarizing, applying, and manipulating phrases and words.

Researcher: Who said “pi zhe yangpi de lang” (披着羊皮的狼 wolf in sheep’s clothing)?
Jane: This silly guy {jokingly pointing at Su}.
Researcher: *Good. It is “pi zhe yangpi de lang”...* 
Tian: Pi zhe yangpi de Jane (披着羊皮的简)—Jane with a sheep’s skin {Tian started joking using the phrase he just learned}.
Judy: Lang (狼 wolf) in the clothing of sheep {laughing}.

The above example indicates that Tian summarized the significance of the fable, “The wolf in sheep’s clothing” by using “pi zhe yangpi de lang,” an equivalent Chinese idiomatic expression referring to somebody hiding disgraceful purposes behind a friendly face. Tian and Judy elaborated their understanding of the story by applying and paraphrasing the phrase humorously.

**Reading aloud**

The practice of reading aloud may provide aural stimuli that help students recall words and store them in memory (Fay & Culter, 1977). In the e-Lective condition, students used the built-in text-to-speech module to read aloud and practice the pronunciation in words, sentences, and whole texts. They paid attention to syllables and stress patterns in the words. The transcript in Appendix B shows how Su used the text-to-speech module to read a text aloud. He meticulously checked difficult words and tried to repeat them accurately after the computer. The transcript indicates that Su persistently focused on the text while reading aloud.

**Discussing**

By acquiring fundamental comprehension of the texts using the tools in the e-Lective system, the students appeared to be able to actively engage in discussions, one of the most effective ways to learn vocabulary (Stahl & Clark, 1987). In applying this strategy, they used a few techniques reflecting a wide range of cognitive strategies to process the readings and retain vocabulary items. These included repeating, quoting, reciting and referencing the texts; pay-
ing attention to the keywords of the stories; switching languages to make communication as comprehensible as possible; translating to verify the understanding of the texts; and reasoning—a higher level of semantic processing of information.

The excerpt in Appendix C shows that Jane was eager to share her understanding with Su by her detailed elaboration of a story at the beginning of the discussion. During the discussion with Jane on plot development, Su referenced the text content accurately in English, “You can never forget the death of your son,” and to make sure that Jane understood the sentence, he translated the sentence into Mandarin immediately after he stated it in English. An early attempt by Su to conclude his argument was revealed through reasoning statements: “That is why the farmer (was) chasing the snake to cut his tail off;” “That is why the snake wants to revenge” (misusing the preposition “to”). English, Mandarin, and Cantonese were alternatively used throughout the discussion for a variety of purposes, mostly to confirm, clarify, and speed up communication. For instance, to convey her point of view Jane said “cattle” in Mandarin (chusheng 動物) to explain that it was a question of cattle in the story, not the farmer’s son. To point out the deficiencies of Jane’s argument and out of excitement, Su used three languages in one sentence, “Can you say the death mousia?” – Can (in English) you say (in Mandarin) the death (in English) is not dead (in Cantonese)?

**DISCUSSION**

The general findings of the project indicated that students used a variety of strategies when they learned vocabulary through sustained reading in both reading conditions and that the strategy profiles cover the majority of the items in Oxford’s (1990) strategy classification, in particular the categories of cognitive, compensatory, metacognitive, and social strategies. However, significant variations in the techniques and functionalities of strategies were found between the two reading conditions mainly as a consequence of utilizing different types of dictionaries to acquire the meanings of words. These variations are grouped under three themes and are discussed below.

**Variations in Technique and Function of the Use of Strategies**

The students in this study were observed using the cognitive strategy of “taking notes” and two compensatory strategies, “generating connections” and “guessing from context,” in both reading environments. However, because of the different levels of word-recognition support facilitated by different types of dictionaries, the frequency and techniques of the use of these strategies varied by reading condition. Categorized also as a consolidating strategy in Schmitt’s (1997) taxonomy, note-taking schemes offer an effective framework in which students can store and retrieve what they have learned. When reading in e-Lective, students’ note-taking appeared to be consistent, informative, and comprehensive in contrast to the periodic and fragmented note-taking in the paper condition (see student notes in Appendix A). In the former, the students tended to write down unknown words and their definitions in a well organized manner that made them ready for review afterwards; in the latter, the students wrote down only unknown words to remind them of the words they did not know and perhaps to look them up afterwards. This difference seems to be related to differences in the time available during the lookup intervals, as well as the convenience in accessing word meanings in the dictionaries.
Despite their relatively low English proficiency, the students in the study appeared to focus on meaning when acquiring vocabulary items. They persistently attempted to decode the meaning through contextual guessing and making connections with known information in both reading conditions. Nonetheless, as a result of the instant enhancement of word recognition by means of the support provided in e-Lective, students’ inferential ability in this condition was greatly increased. This observation confirmed a significant relationship between vocabulary knowledge and the skill at guessing word meanings from context (see Bensoussan & Laufer, 1984; Daneman & Green, 1986; McKeown, 1985; Shefelbine, 1990). This finding also is in keeping with Liu and Nation’s (1985) study that in order to guess successfully from context learners need to know about 19 out of every 20 words (95%).

Variations in the Use of Levels of Strategies

The results of the study further showed that students in the e-Lective condition used higher levels of cognitive and social strategies (e.g., summarizing and discussing), whereas in the paper condition they used lower levels of social strategies (e.g., consulting with the researcher and peers regarding meanings of words). Although use of the strategy of discussion was observed only occasionally in the e-Lective condition, this pattern of use revealed a hierarchy of strategy utilization. Summarizing and discussing are both highly demanding cognitive strategies, but the latter also requires advanced social skills. Proficient use of these strategies requires certain levels of reading comprehension arising from basic vocabulary knowledge. The frequently used social strategy in the paper condition, consulting with the researcher and peers in Chinese, is an alternative to the low level cognitive strategy of “using resources to find out the meaning of what is heard or read in the new language” (Oxford, 1990, p. 81). This reflects the primary needs of the students to access meanings of words efficiently in order to carry on the reading process, thus achieving greater vocabulary acquisition. As word decoding demands conscious attention, when the students encounter a massive number of unknown words, their “depth of processing” strategy is compromised unless meanings of unknown words are easily accessible to free their working memory while reading. The most plausible explanation is that an overall hierarchical pattern of strategy utilization was likely responsive to variations in word recognition support provided in the two reading conditions. This therefore supports the position presented in studies related to the psycholinguistic model of reading (Coady, 1979; Goodman, 1967) and “depth of processing” theory (Craik & Lockhart, 1972). The former indicates that a higher level of proficiency in L2 contributes to interactive processing in which readers integrate both linguistic and contextual information to deduce meaning from reading (Cziko, 1980; Kern, 1989). The latter emphasizes that optimal semantic processing and elaboration of words leads to good recall (Brown & Perry, 1991; Craik & Tulving, 1975). It can be concluded that students supported by efficient meaning-decoding innovations—in this case, the e-Lective system—engaged in more interactive reading processing using more cognitively challenging strategies such as guessing, inferring, making connections, discussing, and summarizing. It thus assisted in-depth semantic processing of vocabulary related to existing cognitive structures. In this dynamic environment, students’ vocabulary learning is likely to achieve long-term retention as illustrated in Figure 9.
Variations in the Nature of Strategies Used

Some variations in the students’ metacognitive awareness in different reading conditions emerged. Students integrated metacognitive strategy elements into a planned sequence of reading and note taking when reading in the e-Lective condition, but they developed coping strategies of scheduling reading delays and lengthening reading time in the paper condition. Two explanations can be suggested to explain these findings. First, using computerized dictionaries saved the students a considerable amount of time, thus enabling them to complete their reading and systematically take notes as discussed above. Second, enhanced meaning access in e-Lective possibly gave the students more confidence and encouraged them to follow planned reading procedures of first reading and/or reading aloud word by word, then looking up words for meanings and pronunciation, and finally taking notes and reading the whole story. These procedures contributed to their multiple exposure to unknown words that led directly to efficient retention. Although it is not certain that the students intentionally organized the reading process when they read in the e-Lective environment, it is clear that the rapid word decoding enabled the students to read in a well organized fashion with stronger motivation.

The students did not directly employ affective strategies. Nevertheless, utilizing their L1 appeared to lower the students’ level of frustration during the reading sessions. Particularly in e-Lective, easy access to the bilingual dictionary enabled the students to complete the reading tasks quickly. This, however, seems to contradict the findings of Hulstijn (1993) and Knight (1994) that students with higher proficiency take longer to read because they relied exclusively on the easy access to electronic dictionaries and were reluctant to use other strategies to decode the word meanings. This difference may be related to student attitudes
towards the task and different proficiency variations in the studies. In Hulstijn's study, participants were Dutch high school students in Grades 10 and 11 with 4 to 5 years of EFL instruction. They may have had a generally higher English proficiency than the Chinese ESL students in the study presented here. Hulstijn found that the decision to look up word meanings “is only modestly influenced by the reader's vocabulary knowledge, and it is not influenced by the reader's ability to infer word meanings from contextual information”, because “possibly EFL readers with high inferring ability approached their reading task in a truly critical manner, or perhaps too cautiously in case of minus relevant words: they guessed the word meanings and subsequently checked their own inferences by making use of the consultation facility” (1993, p. 146). By contrast, the Chinese students approached the reading task pragmatically. Another explanation may be attributable to the length of the reading. In Hulstijn's study, the text contained 772 words; in the present study the texts averaged 145.7 words.

CONCLUSION

There are several limitations in this exploratory study. Because of a small sample size of the participants, the findings should be treated as tentative. Second, the scope of the study was restricted to online monolingual and bilingual dictionaries and the speech module, meaning that a wide range of options in e-Lective representing greater potential of CALL scaffolding to enhance students’ strategies were not explored. Third, although e-Lective as a research instrument operated effectively, it does not currently have the capability in the practice mode to document the frequency of lookups and specific activities that students were engaged in.

Further research is needed to replicate this study with a greater number of participants. In future studies, it also would be useful to examine the impact of a variety of computer-mediated tools on students’ language strategies, and the degree of their vocabulary learning. For example, it would be interesting to assess the effect of providing controlled dictionary supports—basic and contextually relevant word meanings—to less proficient ESL students because some of them appeared to experience difficulty using the noncontrolled dictionary support due to the multitude of definitions and synonyms in many of the dictionary entries.

Nonetheless, this study contributes to understanding how technology-supported scaffolding interacts with and transforms L2 learners’ strategies to enhance their vocabulary learning. Its results can be described from three points of view.

Theoretically, because the students demonstrated an urgent need for word recognition support, the findings suggest that it is useful to distinguish an instant and delayed strategy classification relevant to vocabulary learning in a CALL environment. The descriptive categories of the functions of strategies should be expanded and diversified to include the time component, that is, to stratify two categories of Schmitt’s (1997) vocabulary strategies into instant and delayed discovery strategies, and instant and delayed consolidation strategies. Given the distinctive nature of CALL programs, this may provide a better way to identify the characteristics of students’ strategies and the support they need in a CALL environment (see also Segler et al., 2002).

Methodologically, an effort was made to avoid overt reliance on introspection and retrospection of data collecting inherent in the field of strategy research caused by exclusively using a self-reported format and forced answer questionnaires (Reid, 1987; Spada, 1984; Tyacke & Mendelsohn, 1986). Different instruments were adopted for data elicitation—direct observations and recorded interactions during the reading sessions. The analysis of a substantial collection of recorded field notes offers strong evidence to support the findings, con-
tributing to a comprehensive description of strategy patterns and dynamics when students learn vocabulary through reading with and without technology-supported scaffolding.

Pedagogically, the study suggests that as the students who have proficient Chinese language skills attempt to use their L1 to make sense of English text, it would be effective to encourage this strategy explicitly and promote a progressive integration of L1 and L2 by using technology-based support. CALL has a great capacity in further defining its techniques to cater to individual students’ needs. In addition, the results show that CALL programs such as e-Lective that are oriented towards facilitating students’ efficient vocabulary learning strategies hold considerable promise to promote students’ vocabulary learning. Since insufficient L2 linguistic knowledge inhibits good reading strategies that are ultimately needed for vocabulary acquisition, CALL features that support students' comprehension can enhance their word recognition ability, thereby freeing up cognitive resources for higher order strategies that are essential to effective vocabulary acquisition. In conclusion, it is clear from the finding in the study presented here that student vocabulary learning progress will likely be enhanced if we build on the strategies they bring to learning by using the support for text processing and text comprehension that are potentially available via computer-based scaffolding.

REFERENCES


APPENDIX A
Sample Student Notes

Michelle’s notes when reading in the e-Lective condition

The Man and the Serpent

A Farmer’s son by accident stepped upon a Serpent’s tail, which turned and bit him; he died. The Father in a rage got his axe, and pursuing the Serpent, cut off part of its body. So the Serpent in revenge began stinging several of the Farmer’s cattle and causing severe loss. Well, the Farmer thought it best to make it up with the Serpent, and take care of the mouth of its lair, and said to it: "Let's forget and forgive. You were right to punish my son, and take vengeance on my cattle, but surely in trying to revenge him; now that we are both satisfied why not be friends again?"

"No, no," said the Serpent. "Take away your gifts; you can never forget the son, nor I the loss of my tail."

Injuries may be forgiven, but not forgotten.

Michelle’s notes when reading in the paper condition

The Lion and the Mouse

Once when a Lion was asleep a little Mouse began running up and down upon him. This soon wakened the Lion, who placed his huge paw upon him, and opened his big jaws to swallow him. "Pardon, O King," cried the little Mouse. "Forgive me this time and I shall never forget it. Perhaps some day I may be able to return the favor and help you. The Lion was so amused at the idea of the Mouse being able to help him that he lifted up his paw and let him go.

Some time later the Lion was caught in a trap. The hunters desired to carry him alive to the King and so they tied him to a tree while they went in search of a wagon on which to carry him. Just then the little Mouse happened to pass by, and seeing the sad plight of the Lion, went up to him and soon gnawed away the ropes that bound the King of the Beasts. "Was I not right?" said the little Mouse.

Little friends may prove great friends.
Jerry's notes when reading in the e-Lective condition

The Fox and the Crow

A Fox once saw a Crow fly off with a piece of cheese in its beak and settle on a branch of a tree. "That's for me, as I am a Fox," he said, and he walked up to the foot of the tree. "Good-day, Mistress Crow," he cried. "How well you are looking today, how glossy your feathers, how bright your eye. I feel sure your voice must surpass that of other birds, just as your figure does, let me hear but one song from you that I may greet you as the Queen of Birds." The Crow lifted up her head and began to caw her best, but the moment she opened her mouth the piece of cheese fell to the ground, only to be snapped up by the Fox. "That will do," said he. "That was all I wanted. In exchange for your cheese I will give you a piece of advice for the future: Do not trust flatterers."

Jerry's notes when reading in the paper condition

The Shepherd's Boy (Crying Wolf)

There was once a young Shepherd Boy who tended his sheep at the foot of a mountain near a dark forest. It was rather lonely for him all day, so he thought up a plan to get a little company and some excitement. He rushed down towards the village calling out "Wolf! Wolf!" The villagers came out to help him, and some of them stayed with him for a considerable time in case the Wolf returned.

This pleased the boy so much that a few days afterwards he tried the same trick, and again the villagers came to his help. But shortly after this a Wolf actually did come out from the forest, and began to hunt the sheep. The boy of course cried out "Wolf! Wolf!" even louder than before. But this time the villagers, who had been fooled twice before, thought the boy was again deceiving them, and nobody came to his help. So the Wolf made a good meal off the boy's flock. When the boy complained to the villagers, a wise man in the village said:

"A liar will not be believed, even when he speaks the truth."
APPENDIX B

Reading Aloud in e-Lective

e-Lective speaker: Perusing, perusing, serpent.
Su: Serpent [///] … {repeating after the speaker in e-Lective}.
e-Lective speaker: Revenge.
Su: Revenge, [///] …
e-Lective speaker: Stinging.
Su: Stinging.
e-Lective speaker: Several.
Su: Several.
e-Lective speaker: Cattle.
Su: Cattle.
e-Lective speaker: Caused.
Su: Caused.
e-Lective speaker: Server.
Su: Severe, server loss.
e-Lective speaker: Loss.
Su: Well, the farmer thought it best to make it up with serpent and …
e-Lective speaker: Brought.
Su: Brought food and ney ("honey" in the original text) to the menth ("mouth" in original text) of its …
e-Lective speaker: Liar.
Su: Lair and said it, said to it, les ("let’s" in the original text) …
e-Lective speaker: Let’s ...
Su: Les ("let’s" in the original text) forgot and forgive.
e-Lective speaker: Perhaps.
Su: Perhaps you were right to punish my son, and take revenge, REVENGE {rising tone} ("vengeance" in the original text), on my …
e-Lective speaker: Cattle.
Su: Cattle, but certainly ("surely" in the original text), I was right in trying to revenge him; now that we are both …
e-Lective speaker: Satisfied, satisfied.
Su: Satisfied why not be friend ("friends" in the original text) again? "No, no," said the serpent. "Taking ("take" in the original text) away your gifts; you can never forget the death of your son".
e-Lective speaker: "Nor [///] …"
Su: "Nor ... nor I the loss of my tail".
e-Lective speaker: Injuries.
Su: Will ("may" in the original text) be forgiven, but not forgotten.
APPENDIX C
Discussion While Reading in e-Lective

Jane: Because the boy’s foot stepped on the snake, his father hated the snake and wanted to take revenge on him. He cut off his tail.

Su: Yes, YES {emphasizing in a joking way}.

Jane: So he wants the snake to forgive him, but cannot forget what ... about the son?

Su: His son was already dead.

Jane: [///]...

Su: His son was already dead.

Jane: [///]...

Su: His son was already dead.

e-Lective speaker: Punish {Su still trying to listen to pronunciation at the early stage of the discussion}.

Jane: No, he wasn’t.

Su: Yes, it seems that he was bitten by the snake and dead at the beginning.

Jane: No, it was the chu-sheng (畜牲 cattle) that was dead. It was the CHUSHENG (畜牲 cattle) that was dead.

Su: His son was dead.

Jane: No.

Su: Yes.

Jane: No.

Su: Yes, have you read here, you can never forget the death of YOUR SON?

Jane: Mou-a (Cantonese: no).

Su: Ha ni-duo gei gang-go si-zuo-la (Cantonese: it said here that he was dead already). That is why the farmer (was) chasing the snake to cut his tail off. That is why the snake wants to revenge (Su misusing the preposition “to”).

Jane: Mou-si-a (Cantonese: not dead).

Su: You-si-a (Cantonese: dead).

Jane: Mou-si-a.

Su: Can ni shuo (你说 you say) the death mou-si-a?

Jane: [///].

Su: You cannot forget. You cannot forget your dead son.

Jane: Hai-a le-gou — (Cantonese: because here)

Su: Hei! (嗨 Mandarin intonation indicates attention is required, equivalent to “look”) {pointing at the sentence to Jane}.

Jane: Ah, here, here.

...
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