Compleat Lexical Tutor (http://www.lextutor.ca), 14 target words were selected from the K-7 word list or above, which were supposed to be unfamiliar to the learners.

With regard to the vocabulary tests, all of the four tests include: (1) a spelling recognition test, (2) a Vocabulary Knowledge Scale (VKS)-based (Wesche & Paribakht, 1996) meaning, use and part of speech (POS) test, and (3) a pronunciation (PRON) test. The main structure of the tests was similar, but the question order was changed to avoid the carryover effect from the previous test (Chen, 2011). The small differences between the tests include: (1) There were 14 extra words at the K-5 level or above included in the pre-test as distractors; (2) There was an extra question asking participants whether they have learnt the word during the two-week interval in the delayed post-test. Besides, two self-report questionnaires were designed to collect self-report data, asking a participant to report whether they looked up the target word and what aspect they focused on. The semi-structured interviews mainly explored the reason why they paid more attention to certain words/aspects.

Data Analysis

Descriptive analysis was applied to analyse the quantitative data in the self-report questionnaires and the scores in the pre- and post-vocabulary tests. Qualitatively, *MAXQDA Plus* was used to analyse all data from the interviews. We used the thematic analysis method for "identifying, analysing and reporting patterns within data" (Braun & Clarke, 2006, p.6). Based on the six stages in the thematic analysis (O'Leary, 2014), the first author checked all the transcripts, coded and separated them into themes by using the open-coding method (Rivas, 2012). The second author reviewed and defined the themes and examined the initial results. Finally, we double checked the integrity and accuracy of the information, themes and results.

FINDINGS

Incidental Vocabulary Learning

Learner's Use of the Mobile Dictionary

Using data from the self-report questionnaires, Table 1 summarises participants' mobile dictionary use in reading. Maggie and Frank looked up almost all target words (13 and 14 words). Both of them preferred to consult word spelling (13) and meaning (11 and 14), and they were keen on looking at just one definition, especially the first definition. Their attention to word meaning in two languages was slightly different: Maggie paid attention to the Chinese translations of six target words and five in both Chinese and English, but Frank only read the Chinese translations. Besides, Frank did not look up and read any other information, while Maggie read eight example sentences, 11 POS, and 12 word pronunciation.

On the contrary, the other two participants — Lucy and Harry — seldom used the mobile dictionary. Lucy did not look up any of the 14 target words, and Harry consulted only two words. Despite a reading comprehension task, Harry did not pay any attention to word meanings and example sentences, which are assumed to be crucial for reading comprehension.

Student name	Look up	Spelling	Meaning									e.g.	POS	PRON	Other aspects
			yes/ no	No. of meaning(s)				first	EN/CN						
				1	2	3	>3		EN	CN	Both				
Maggie	13	13	11	10	1	0	0	10	0	6	5	8	11	12	3
Frank	14	13	14	12	0	0	2	11	0	14	0	1	0	0	0
Harry	2	0	0	0	0	0	0	0	0	0	0	0	1	1	0
Lucy	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 1. Learners' mobile dictionary use in reading

Their responses from the semi-structured interview can be understood to interpret their dictionary use behaviours:

a. Maggie: A mobile dictionary serves as a ***learning*** tool.

Maggie was used to looking up all the unknown words in the dictionary, especially word meanings. In the interview, she explained that her focus was word definition. She prioritised Chinese translations (L1), which were more useful for her quick understanding of the word. Apart from that, she underscored the importance of word spelling, example sentences, POS, and pronunciation, perceiving these aspects were quite beneficial to acquire a word. In other words, she looked up words in the dictionary not just to understand the word meaning in the text but to acquire the word comprehensively.

b. Frank: A mobile dictionary serves as a ***referencing*** tool.

Although Frank looked up all the 14 target words, he paid the most attention to the word spelling and meaning (particularly the first meaning). As he supposed, the first definition is the most commonly used definition of the word and likely to fit the reading context. Regarding Chinese translation, Frank had a reason similar to Maggie's, attributing his preference to his familiarity with Chinese. Looking at the word spelling, as he described, could help him establish an association between the word form and meaning. Because reading everything in the word entry was time-consuming, he usually ignored other information when doing reading comprehension exercises.

c. Harry: A mobile dictionary serves as a ***supplementary*** tool.

Harry preferred to directly guess word meaning from the reading. He talked about his guessing strategy in the interview, perceiving that sometimes it was not necessary to know the exact meaning of the word. Alternatively, getting a general sense of the word from the context was enough to complete the reading comprehension questions. A mobile dictionary was just a supplementary tool for him when he needed extra information.

d. Lucy: A mobile dictionary is an ***interrupter***.

Similar to Harry, Lucy showed a preference for guessing the word meaning from the reading context. She was confident in her guessing ability and complained that looking up words in the dictionary usually interrupted her reading. She elucidated that as reading tasks were usually paper-based, she needed to move her eyes to her mobile phone, type the word, find the suitable word meaning and get back to the reading. She sometimes forgot what she had read after using the mobile dictionary, so she had to reread the previous sentences, which was time-consuming and caused cognitive burdens.

The Effectiveness of the Mobile Dictionary in a Learner's Incidental Vocabulary Learning

a. Short-term vocabulary retention

Table 2 presents four participants' pre- and immediate post-vocabulary test scores as well as their short-term retention. Maggie, who fully used the mobile dictionary when reading, performed the best in the immediate post-test and made great progress in all three aspects (score diff = 60 for spelling, score diff = 72 for meaning and use, score diff = 20 for pronunciation). In comparison, Frank, who focused on the word spelling and (the first) meaning, greatly improved spelling but made small progress in meaning and use (score diff = 49) and pronunciation (score diff = 3). On the contrary, no significant progress could be found in Harry's and Lucy's vocabulary test scores, although Harry made some progress in spelling (score diff = 30) and pronunciation (score diff = 7). Arguably, the results indicate that the active and effective use of a mobile dictionary benefits incidental vocabulary learning in the short term.

Student	Pre-test score				Immediate post-test score				Short-term retention			
	Spelling	Meaning & use	PRON	Overall	Spelling	Meaning & use	PRON	Overall	Spelling	Meaning & use	PRON	Overall
Maggie	24	39	62	125	84	111	82	277	60	72	20	152
Frank	24	21	75	120	84	70	78	232	60	49	3	112
Harry	36	14	63	113	66	15	70	151	30	1	7	38
Lucy	54	17	76	147	54	17	76	147	0	0	0	0

Table 2. Learners' pre- and immediate post-test score and short-term retention

b. Long-term vocabulary retention

Participants were asked to report whether they had learnt the 14 target words before answering the questions in the delayed post-test. The results were refined and presented in Table 3. In general, students' delayed post-test scores are lower than what they achieved in the immediate post-test, demonstrating that their incidental vocabulary retention weakened as time went by. Comparatively, Maggie and Frank still performed better in the delayed post-test than Harry and Lucy, evidencing better long-term retention, especially in spelling as well as meaning and use. Thus, the results may reflect that using mobile dictionary can benefit their long-term vocabulary retention, but the effects also depend on how much and how effectively the learners use the mobile dictionary.

Student name	Pre-test score				Delayed post-test score				Long-term retention			
	Spelling	Meaning & use	PRON	Overall	Spelling	Meaning & use	PRON	Overall	Spelling	Meaning & use	PRON	Overall
Maggie	24	39	62	125	78	87	74	239	54	48	12	114
Frank	24	21	75	120	78	58	76	212	54	37	1	92
Harry	36	14	63	113	48	15	68	131	12	1	5	18
Lucy	54	17	76	147	54	17	76	147	0	0	0	0

Table 3. Learners' pre- and immediate post-test score & long-term retention

Intentional Vocabulary Learning

The everyday self-report questionnaire was used to track participants' intentional vocabulary learning process. Table 4 offers a brief overview of their 14-day intentional vocabulary learning, which reflects that participants were quite active and able to schedule their daily vocabulary learning at their own pace. They preferred to study in the evening and studied an average of 64 minutes to 78 minutes per day.

Name	Study days	Study time			Average study length (per day)
		Morning	Afternoon	Evening	
Maggie	14	3	3	8	68 min

Frank	14	4	2	8	64 min
Harry	14	3	2	9	74 min
Lucy	14	4	3	7	78 min

Table 4. Overview of learner's 14-day intentional learning process

Table 5 shows participants' final test scores after the 14-day intentional self-directed vocabulary learning. Overall, all four learners benefited from this learning process, especially Harry and Lucy (score diff = 131 and 117), who seldom used the mobile dictionary at the incidental learning stage. The score differences between the four participants in the final vocabulary test are subtle, with overall scores of 277, 268, 262, and 264, respectively. Specifically, Harry and Lucy made great progress in the meaning and use test, with scores of 87 and 89, which may corroborate the effectiveness of the two-week intentional learning for acquiring the words receptively and productively. In comparison, Maggie and Frank made less progress, especially in the meaning and use test, seeming to enter a bottleneck period.

Student name	Delayed post-test score				Final test score				Intentional learning progress			
	Spelling	Meaning & use	PRON	Overall	Spelling	Meaning & use	PRON	Overall	Spelling	Meaning & use	PRON	Overall
Maggie	78	87	74	239	84	113	80	277	6	26	6	38
Frank	78	58	76	212	84	106	78	268	6	48	2	56
Harry	48	15	68	131	84	102	76	262	36	87	8	131
Lucy	54	17	76	147	78	106	80	264	24	89	4	117

Table 5. Learners' intentional learning progress

DISCUSSION

Using a Mobile Dictionary is More Effective than Guessing.

The effectiveness of a dictionary (especially a paper dictionary) in incidental vocabulary learning was researched and empirically verified by some scholars, including Luppescu and Day (1993) and Knight (1994). The present study echoes the previous findings that looking up words in a dictionary is beneficial for a learner's vocabulary retention. In addition, we further reported that the two learners who were keen on using the mobile dictionary (Maggie and Frank) outperformed the other two learners who preferred to guess the word meaning (Harry and Lucy). The involvement load hypothesis, proposed by Laufer and Hulstijn (2001), may provide some theoretical underpinnings into this finding. The hypothesis informs some determining factors in incidental vocabulary learning from the motivational dimension to the cognitive dimension. They argued that retention of words when processed and acquired incidentally is conditional, highlighting three factors — *need, search*, and *evaluation* — as main components of involvements. The *need* component, from a motivational perspective, refers to a learner's motivation to achieve. *Search* is an attempt to find the form of the L2 word to represent a concept or find the meaning of the word. *Evaluation* involves a process of making comparisons between words and word meanings to find the most suitable word/word meaning in a specific context.

In practice, Laufer and Hulstijn (2001) verified their assumption that words processed and acquired with higher involvement load could be retained better. According to Laufer and Hulstijn (2001), *need* is moderate when it is imposed by external factors (e.g. teachers and tasks, marked as +). It becomes stronger when learners themselves are willing to use the dictionary (marked as ++). The involvement of *evaluatio*n depends on whether there is a need to compare different meanings of a word (marked as +), and whether there is a productive task (e.g. making sentences, marked as ++). Table 6 summarises the possible involvement index of using dictionary and guessing in this study, indicating higher involvement load in using dictionary. In this study, the cases of Maggie and Frank justified the active use of a mobile dictionary with more cognitive involvement load could contribute to their better word retention.

Strategy	Need	Search	Evaluation	Involvement index
Using dictionary	+ (imposed by the reading task) ++ (imposed by the learners)	+	- (without comparison) + (with comparison but without productive output) ++ (with comparison and productive output)	2-5
Guessing	+ (imposed by the reading task) ++ (imposed by the learners)	-	-	1-2

Table 6. The involvement load index of using dictionary and guessing[3]

Self-Directed Intentional Vocabulary Learning is Beneficial.

Findings in this study show that all our four participants' vocabulary retention was weakened after the two-week interval, indicating that short exposure to the word may result in shallow processing and word retention both in a short and long

[3] In this table, a minus (-) marks an absence of an involvement factor; a plus (+) marks that the factor is present but only in its moderate version; a double plus (++) marks the strong version of an involvement factor (Laufer & Hulstijn, 2001).

term. Many scholars such as Webb (2007) emphasised the importance of repetition, arguing that increasing the number of exposures to target words is beneficial for word retention. Craik and Lockhart (1972), from a cognitive perspective, underscored the importance of in-depth processing. As they proposed, information is mainly processed in three ways at two levels: (1) *structural* processing, to encode the physical qualities of the word at a shallow level; (2) *phonemic* processing, to encode the sound of the word at a shallow level; and (3) *semantic* processing, to encode the word meaning and its associated knowledge (e.g. word use, synonyms) at a deep level. The *semantic* processing, as they proposed, is of great importance in the process of storing vocabulary knowledge in the long-term memory.

With the provision of rich vocabulary knowledge information and learners' active involvement, the effectiveness of the 14-day self-directed intentional vocabulary learning confirmed that vocabulary retention is affected by the quantity of exposure as well as the quality of the learner's attention and use (Laufer & Hulstijn, 2001). The rich and numerous associations with the learner's previous knowledge also benefit his or her acquisition of new knowledge. In this study, results indicate the intentional learning with rich and enormous exposure to the word can stimulate learners' *semantic* processing, which is useful for their vocabulary retention. In the realm of pedagogy, when teachers implement intentional vocabulary teaching, it is recommended that they provide learners with rich, high-quality, constructive vocabulary learning materials and more exposure so learners can become familiar with, understand, and acquire the word.

CONCLUSIONS AND FUTURE RESEARCH

To conclude, this study explored four Chinese EFL learners' vocabulary learning across contexts, aiming to examine learners' use of a mobile dictionary in reading, as well as the effectiveness of a mobile dictionary in both incidental and intentional learning settings. At the incidental learning stage, results show that Maggie and Frank, who preferred to use the mobile dictionary, made more significant progress than the other two participants (Harry and Lucy). In particular, Maggie, who made the most effective use of the dictionary and regarded the dictionary as a learning tool, showed the greatest progress. At the intentional learning stage, all of the learners improved, and the gap between the two who preferred the mobile dictionary (Maggie and Frank) and the two who preferred to use context (Harry and Lucy) was narrowed. This study verified the benefits of a mobile dictionary in a learner's self-directed incidental and intentional vocabulary learning, but the effectiveness may be largely subject to whether and how learners use the dictionary. Theoretically, the results to some extent corroborate involvement load hypothesis (Laufer & Hulstijn, 2001) and depth of processing (Craik & Lockhart, 1972). Nevertheless, as a study with quite a small sample size, this study is just a point of departure for determining the usefulness of a mobile dictionary in L2 vocabulary learning. We call for more research to further explore this topic with a larger group of learners and a longer intentional vocabulary treatment. As it seems that Maggie and Frank entered a bottleneck period at the end of the intentional learning stage, more efforts on how to break through the bottleneck are needed. Pedagogically, teachers are suggested to put more emphasis on how to efficiently and effectively implement incidental and intentional vocabulary learning both inside and outside the classroom. Governments and universities should consider more about how to provide teachers, especially those in less developed areas, with adequate digital multimodal resources and training to help them use technology in different teaching contexts (Zhang, 2019). As self-regulation plays a definitive role in non-formal self-directed L2 vocabulary acquisition, learners should make endeavour to develop their vocabulary learning strategies via technological and pedagogical support for different language learning purposes.

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