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Out-of-the-classroom learning of English vocabulary by EFL learners: investigating the effectiveness of mobile assisted learning with digital flashcards

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Abstract

The importance of vocabulary knowledge as one of the most challenging aspects of foreign language learning has been widely acknowledged. In order to facilitate learning vocabulary items in English by language learners, mobile assisted vocabulary learning attracted considerable attention in recent years. Nevertheless, the application of mobile devices for learning the most frequently used vocabulary items in core vocabulary lists received far less attention. To address this gap, the current study investigated the contribution of a digital flashcard application (i.e. NGSL builder) designed for smartphone devices in out-of-the-classroom learning of essential vocabulary in English among EFL learners. The participants were 86 university students in experimental and control groups. In addition to formal language education during a semester, the experimental group used the mobile application for studying vocabulary items outside the classroom, while the control group used traditional materials (i.e. word list) to study the same content. The participants' vocabulary knowledge was measured in three times (pre, post, and delayed posttest), and the results revealed that the use of mobile applications contributed significantly to vocabulary knowledge development, and those in the experimental group outperformed their counterparts in the control group. The findings also provided empirical evidence for the long-term impacts of mobile-assisted vocabulary learning. The study highlights the significance of mobile technologies in helping L2 learners to acquire essential vocabulary in English and discusses the pedagogical implications of these findings.

Keywords: Mobile assisted vocabulary learning, Vocabulary, Mobile applications, Autonomous vocabulary development, EFL, MALL

Introduction

In recent years, the phenomenal growth in digital and communication technologies have transformed the language of education landscape by expanding the scope, nature, and opportunities available for out-of-the-classroom learning (García Botero et al., 2021; Nunan & Richards, 2015). Relatedly, the addition of new communication and connectivity options to smartphones, alongside other features provided in these devices (such as

listening to music, watching videos, GPS, high quality cameras, note taking, etc.) have turned them into life partners for many people (Godwin-Jones, 2017). These developments have resulted in an increased interest among researchers and educators to exploit such features for mobile assisted language learning (MALL) (Alamer & Al Khateeb, 2021; Demouy & Kukulska-Hulme, 2010; Kukulska-Hulme, 2009; Lai, 2016; Wrigglesworth & Harvor, 2018). Defined very broadly, mobile learning is one of the most recent developments in the application of educational technology that emphasizes the affordances, experiences, and opportunities provided by the evolution of portable devices for learning at any time and any place (McQuiggan et al., 2015). Such learning extends beyond the physical devices themselves, and a wide range of technologies including tablet PCs, smartphones, laptops, and personal media players can support MALL.

It has been argued that the rise of touchscreen smartphone devices started a new era in educational technology development which has a potential to “fundamentally disrupting teaching and learning, including L1 and L2 literacies and learning” (Godwin-Jones, 2017, p. 3). Additionally, Kukulska-Hulme (2009) maintained that MALL provides learners with portable, authentic, social, and contextual environments that promote language learning. Over the past decades, a number of studies investigated the impacts of mobile devices on language learning and teaching, and their results collectively indicated that the use of mobile devices significantly contributed to language development in different contexts and for different age groups (e.g., AbuSa’aleek, 2014; Burston, 2013, 2014; Chwo et al., 2018; Godwin-Jones, 2011; Golonka et al., 2014; Stockwell, 2013; Wong & Looi, 2011). Furthermore, the use of mobile devices produced a moderate mean effect size for students’ achievement, and initiated more diverse and innovative learning and teaching activities, scenarios, and situations (Sung et al., 2015).

Within this growing body of research, a considerable number of studies employed mobile devices for teaching English vocabulary, and their findings underscore the affordances of mobile technologies for vocabulary learning (Mahdi, 2017; Xodabande et al., 2022; Xodabande & Atai, 2020). Nevertheless, against the backdrop of these developments, the majority of MALL studies conducted so far have been criticized for being conventionally teacher directed and scheduled, and also for failing to take advantage of anywhere, anytime learning affordances provided by mobile technologies (Lin & Lin, 2019). Moreover, due to the various constraints of formal instructional contexts, classrooms remained resistant to exploiting educational technologies, and it has been argued that the true potential of these technologies (such as mobile devices) for language learning may be realized best outside the classroom (Lai & Gu, 2011). Moving along these lines, the current study investigated the impacts of using mobile applications for out-the-classroom learning of English vocabulary by university students. The next section provides theoretical and empirical backgrounds for the study and highlights the gaps in the literature that this research aimed to address.

Literature review

Essential (core) vocabulary in English

Acquiring foreign language vocabulary either incidentally from prolonged exposure to the comprehensible input, or through deliberate learning and teaching remained among the most challenging aspects of language learning for many learners around the world

(Nation, 2001, 2013; Webb & Nation, 2017). According to Webb and Nation (2017), the frequency with which a given word occurs in a language determines its relative value for the learners. Research in this area also indicated that in the long-term process of learning new languages, words tend to be learned according to their frequency in the input received by learners (Schmitt et al., 2001). In this regard, in order to make the selection and teaching vocabulary more systematic, the English lexicon has been classified into four main categories that include high frequency, academic, technical and low frequency words (Coxhead & Nation, 2001). Almost 80% of the words used in different text types in English belong to the high frequency category (Nation, 2001, 2013). Given high coverage and hence importance of these words, it has been argued that beginner English language learners should focus on the first 2000 most frequently occurring word families in English (Nation & Waring, 1997), for which the General Service List (GSL) (West, 1953) is a widely employed resource. However, the GSL has been criticized on various grounds including its age, size, and the use of word family as a defining unit for vocabulary items (Browne et al., 2013; Gardner & Davies, 2014). To address the shortcomings associated with the GSL and building on an updated and much larger corpus (i.e. 273 million-word subsection of the two billion word Cambridge English Corpus (CEC)), a new general service list (NGSL) has been developed (Browne et al., 2013). The NGSL contains 2800 words, accounts for around 92.34% of the CEC, and provides considerable improvement over the old GSL (West, 1953) which covers about 84.24% of the same corpus. From a pedagogical point of view, this core vocabulary should be prioritized in a well-balanced language learning course (Nation, 2013; Webb & Nation, 2017). In this regard, learning the NGSL should be considered as a major milestone in language development for English as a foreign language (EFL) learners. More specifically, knowledge of this core vocabulary is important for EFL learners, as they need this vocabulary to understand most conversations and texts in English.

Moreover, previous research indicated that in most EFL contexts, vocabulary instruction is neither effective nor efficient, and many learners fail to learn the 2000 most frequent word families (Webb & Chang, 2012; Webb & Nation, 2017). As vocabulary demand of daily conversations, television programs, and films in English goes even beyond this threshold to about 3000 word families (Nation, 2006, 2013; Rodgers & Webb, 2011; van Zeeland & Schmitt, 2012; Webb & Rodgers, 2009a, 2009b), there is a need for finding more effective strategies for bridging this vocabulary knowledge gap for EFL learners. Relatedly, due to time constraints in the language classrooms which limits systematic focus on vocabulary learning by teachers (Webb & Nation, 2017), there is a growing need to ensure that language learners can successfully learn important vocabulary outside the classroom. Recent developments in mobile assisted language learning provided new opportunities in this respect.

Mobile assisted vocabulary learning

Significant improvements in the functionality of modern mobile/tablet devices alongside increased access to such platforms among the students resulted in an ongoing interest among the researchers and educators to improve language education through mobile assisted learning (Burston & Giannakou, 2021; Hou & Aryadoust, 2021; Nazari & Xodabande, 2020, 2021). Consequently, since a wide spectrum of lexical tools and

applications are currently available for learning vocabulary, a large proportion of the existing literature in MALL has focused on using mobile devices for vocabulary developments (Burston, 2013). The related studies in this line of research investigated using a range of technologies including text and multimedia messages, context-aware, gamification, and locally developed mobile applications (Lin & Lin, 2019; Mahdi, 2017). Based on a recent systematic review, previous studies in this area either viewed mobile devices as being much beneficial for second language vocabulary learning, or regarded them somehow disadvantageous, or not making any significant difference (Lin & Lin, 2019). Accordingly, such observations underscore the need for more research to better understand the impacts of mobile devices on vocabulary learning across different contexts.

Moreover, although mobile assisted vocabulary learning has been widely investigated in the literature, the use of mobile platforms for teaching essential vocabulary lists that contain a relatively large number of words remained less explored. In a series of studies focusing on mobile assisted learning of a large number of words, Wu (2014, 2015a, 2015b) studied the effectiveness of applications designed for smartphones for learning English vocabulary among Chinese EFL learners. In the first study, Wu (2014) divided 50 students equally into experimental and control groups. The participants in the experimental group used the mobile application designed by the researcher to learn 852 English words over a semester. The findings revealed that participants in experimental group outperformed those in control group who used traditional materials for learning the same vocabulary items. In a follow up study, Wu (2015a) investigated the use of a similar mobile application for learning 1274 English words. The participants included 70 fourth year college students in experimental and control groups. Using a pre and post-test design, this study reported similar finding for using smartphone applications in learning English vocabulary, and concluded that the use of the mobile application contributed significantly to vocabulary gains attained by participants in the experimental group. In the last study, Wu (2015b) designed a smartphone application containing 3402 English words, with each word containing spelling, pronunciation, and Chinese definitions features. The participants included around 200 Chinese university students in three experimental and three control groups. The study sought to help students in learning English vocabulary on their own, and compared the performance of experimental group who used the application with control group who used traditional learning materials. The results of the pre and the post-test revealed that the participants using the mobile application outperformed those in control group, and scored on average 8.49% higher in the post-test. Collectively, the findings from these studies provided empirical evidence for the effectiveness of self-directed and out-of-the-classroom learning of a large number of English words in mobile assisted vocabulary by EFL students.

Besides being an effective medium for presenting target vocabulary items for EFL learners, mobile devices have been also employed as more attractive alternatives for vocabulary learning strategies. Among the various strategies proposed for fast and effective vocabulary learning, the use of flashcards attracted considerable attention (Nakata, 2011; Nation, 2013; Webb & Nation, 2017). In this vocabulary learning strategy, the learner writes a target word on one side of a small card, and uses the other side for the definition or translation of that word. Flashcards are especially helpful in learning form-meaning connection, and learners can use them in different places because of their small

size and portability. With the advancement of computer technologies, many flashcard programs are currently available for personal computers and mobile/tablet devices. Nakata (2011) conducted a comprehensive investigation of flashcard software available for learning foreign/second language vocabulary, and concluded that most programs maximize vocabulary learning. Recently, a growing number of studies investigated the use of digital flashcards (DFs) on mobile devices, and the overall findings pointed to their effectiveness for learning English vocabulary (Fathi et al., 2018; Lin & Lin, 2019; Sage et al., 2019; Yüksel et al., 2020). Given that DFs applications significantly facilitate learning form meaning connection of words with spaced repetition and multimedia features, using them for out-of-the-classroom learning of core vocabulary in English seems much promising.

Some studies in the literature compared the relative effectiveness of traditional paper-based flashcards with DFs. For example, Fathi et al. (2018) studied the effects of using a mobile application (Memrise) for English vocabulary learning and self-regulatory capacity in vocabulary acquisition among 59 Iranian EFL learners. The participants were randomly assigned into an experimental ($N = 33$) and a control group ($N = 26$), and during a period of 13 weeks, those in the experimental group used Memrise application for learning new vocabulary items, and the participants in the control group learned the same content via traditional materials. The findings indicated that the use of mobile application helped students in the experimental group in improving their vocabulary knowledge and self-regulating capacity more than the participants in the control group. In another study, Seibert Hanson and Brown (2020) investigated the effectiveness of a flashcard application with spaced-repetition technology (i.e. Anki) on improving 62 university students vocabulary learning in a semester-long Spanish course. The mobile assisted vocabulary learning was implemented as a class requirement. With controlling for baseline abilities and for motivation, self-efficacy, and beliefs, the results pointed to a positive relationship between the number of days that students studied with Anki and their end of the semester Spanish performance. Moreover, although the participants were motivated and professed more effort-based or incremental beliefs about learning at the end of the semester, they were reluctant to use the application for vocabulary learning and reported low enjoyment. In a study with different findings, Sage et al. (2020) compared 150 undergraduate students' vocabulary learning from flashcards on paper, laptop, and smartphone. The participants were randomly assigned to one the platforms for reviewing vocabulary flashcards, and afterwards were asked to complete a memory quiz. This was followed by asking the participants some questions regarding their perceptions related to selected technologies for vocabulary learning. The findings indicated that although the learning outcomes, cognitive load, and satisfaction were equivalent across paper, laptop, and smartphones flashcards, the students spent more time on paper-based materials. Obtained data also indicated that the participants regarded laptops as more valuable resources for learning vocabulary compared to smartphone devices.

The present study

Review of the related literature on mobile assisted vocabulary learning indicates that the use of different mobile applications generally resulted in improvements in ESL/EFL learners' vocabulary knowledge development. The results obtained in the

previous studies also justify the use of mobile applications in out-of-the-classroom learning of English vocabulary for EFL learners. Nonetheless, there are some gaps in the existing literature that demand further attention and more empirical research. First, the majority of studies were conducted in a very short or relatively short time periods, which makes it difficult to better acknowledge and fully understand the impacts of mobile assisted vocabulary learning interventions (Chwo et al., 2018). Second, some studies did not include any control groups in their treatments, and the common design employed in most studies was pre- and post-test measurement of vocabulary learning outcomes. As a result, the long-term effects of different treatments has not received sufficient attention. Additionally, focus of the majority of studies following this line of research have been on teaching a limited number of words in short-term interventions, without giving much attention to the potential of new technologies for facilitating learning large number of vocabulary items that foreign language learners need to master for successful use of their developing language knowledge. Finally, as highlighted by Lin and Lin (2019), different measurement scales were employed to gauge the achievements, and only a few studies used standardized tests. In this respect, the current study aimed to address the above mentioned gaps in the literature. To this end, using a repeated measures design over a 6-month period, the current study investigated the contribution of a mobile application (i.e. NGSL builder) for learning the NGSL items among university students. The following research questions were addressed:

- 1- Does using mobile application for out-of-the-classroom vocabulary learning result in improved knowledge of core vocabulary in English among EFL learners?
- 2- Does using mobile application for vocabulary learning result in long-term vocabulary gains among EFL learners?

Method

Participants

The participants of this study were 86 first- and second-year university students (51 males, and 35 females) in Iran. The mean age of the participants was 21, and they were selected due to their availability in the context of the study. In order to investigate the impacts of mobile assisted vocabulary learning, the participants were assigned to an experimental (N=58) and a control (N=25) group. Regarding their previous English language education, the participants had studied English as a compulsory subject in their Junior High School and High School, nevertheless, their general proficiency in this language was B1 and B2 levels (pre-intermediate and intermediate) as assessed by Cambridge online placement test (Test Your English, 2022). All participants in the experimental group had smartphone devices (51 Androids, and 7 iPhones operating system) which supported installing and using the mobile application intended to use for vocabulary learning in the current study. The study adhered to ethical considerations in educational research by obtaining

informed consents from the participants and by ensuring them regarding the confidentiality of collected data.

Materials and instruments

The study used the New General Service List (NGSL) (Browne et al., 2013) as a source for high frequency vocabulary in English, and the study was implemented as a supplement for the participants’ formal English language education in the university. In order to learn vocabulary items in the list by EFL university students, those in the experimental group installed NGSL Builder Multilingual (English version) which is a free vocabulary learning flashcard application developed by EFL technologies (*EFL Technologies*, n.d.). The application contains simple tools for learning NGSL vocabulary items. As represented in Fig. 1, after the installation process, the application asks the learners to choose vocabulary items for their study. In choosing the vocabulary items, learners have the option to study all words (beginner level), or start from intermediate, high intermediate, or advanced levels. The application also provides learners with affordances to use the flashcards for developing receptive (seeing the target words first) and productive (seeing the definitions first) vocabulary knowledge development. Furthermore, the flashcards in the application provide part of speech and pronunciation information for target words (Fig. 2). The correct definition of the words are provided at the other side of the digital flashcards, where the learners are required to evaluate their response by selecting ‘wrong’ or ‘right’ options.

The participants in the control group were given a list of the same vocabulary items with simple definitions as used in NGSL builder application. Considering the proficiency level of the participants and also based on initial assessment of their vocabulary knowledge (see the results for pre-test in the next section), around 50% of NGSL words were skipped for both groups, and the participants started from high intermediate level. Moreover, in order to measure the participants’ vocabulary development, the current study used the New General Service List Test (NGLST) (Stoekel & Bennett, n.d.), which is a test of written receptive knowledge of the New General Service List (NGSL) (Browne et al., 2013). The NGLST contains 100 items, which are grouped in five levels, each with 20 multiple response questions types. According to

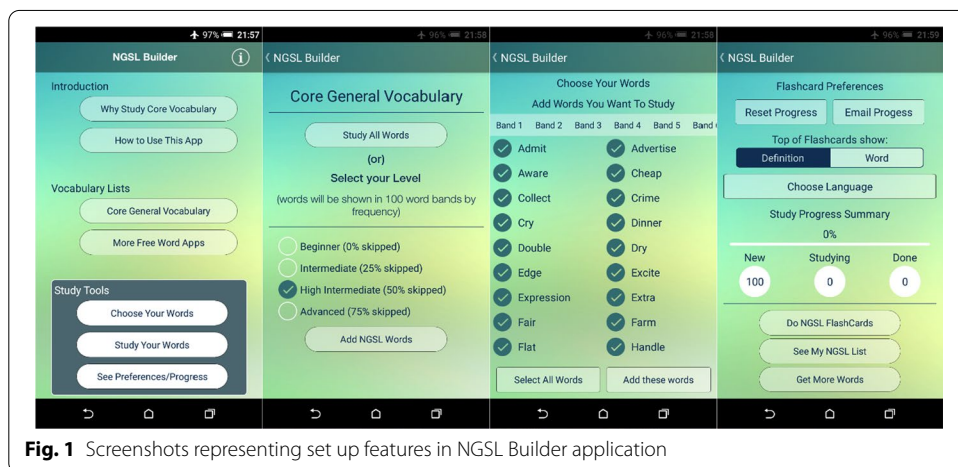
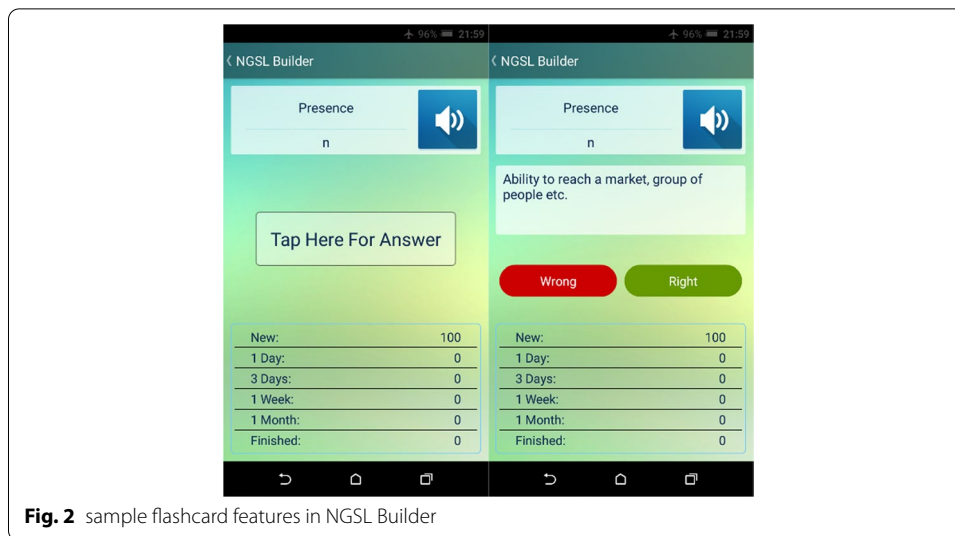


Fig. 1 Screenshots representing set up features in NGSL Builder application



test developers, the test is a reliable measure of NGSL and shows very high reliability (over 0.90), and every level represents approximately 560-word bands from the NGSL.

Procedures

Before starting the treatment and assigning the participants to experimental and control groups, the NGSLT was administered to 108 first and second year university students in the research context. After analyzing the results and in order to ensure homogeneity, 92 participants were selected, and 16 participants who scored more than 10 points higher or lower than the mean score of all participants on NGSLT were excluded from data analysis. This step was taken to control for the small variation in the participants proficiency level. It should be noted that all participants installed the app or received similar materials printed on paper, nonetheless, data obtained from 16 individuals were excluded from final analysis. Moreover, as the propose of this study was to track the contribution of a mobile applications on vocabulary development over a relatively long period of 6 months, the study also excluded data obtained from 6 participants in the final analysis, as these individuals failed to take the delayed post-test. Overall, data obtained from 86 individuals who completed pre, post and delayed tests were taken into account.

After the administration of the pre-test, all participants in the study received one hour training on vocabulary learning strategies with a focus on using wordlists and flashcards. Those participants in the experimental group also received relevant instructions on installing the NGSL Builder app from Google play store (or iPhone app store), selecting level appropriate vocabulary items for their study, and changing app preferences to show the word or definitions first. Moreover, they were provided with researcher's contact information for further questions and possible problems in using the app. As the focus of the study was on out-of-the-classroom vocabulary development, the participants studied target vocabulary items in self-directed learning mode on a weekly basis. To this end, all participants were asked to spend 10 min every day over 5 days of the week to study target vocabulary items. However, the participants were reminded that although their vocabulary knowledge will be tested at the end of the semester,

out-of-the-classroom vocabulary learning program is optional and they have the option to focus on their regular and formal language education only. Both groups are regularly encouraged to improve their vocabulary knowledge through working with the assigned materials, and they received pertinent information regarding the crucial role of core vocabulary (such as NGSL) in their language development. During the treatment period, the level of the engagement among the participants in the experimental group was checked monthly using a built-in feature in the NGSL builder application, and those in the control group answered short survey questions regarding their vocabulary learning and progress. At the end of the academic semester (fourth month), both experimental and control groups completed the post-test, and a follow up delayed post-test was administered after 2 months. This study used the intervals of 4 months from pre-test to post-test, and 2 months from post-test to delayed post-test to minimize the effects of memory and learning from completing the test items.

Data analysis

Obtained data from the 86 participants in the three stages (pre, post, and delayed post-test) were analyzed using the SPSS software version 25, and both descriptive and inferential statistics techniques were employed. To this end, the participants' performances on pre- and post-tests were compared using independent samples t-tests, and one-way repeated measure of ANOVA was conducted to compare the scores obtained by the experimental group at different times.

Results

Table 1 provides descriptive statistics for participants' performances in three times on NGSLT scale. As it is shown in the table, the mean score of participants in experimental and controls groups before receiving the treatment were 47.64 ($SD = 2.936$), and 47.04 ($SD = 2.574$) respectively. This means that participants of this study had a receptive knowledge of about 50% of NGSL items. However, after using the NGSL builder app for 4 months, mean score of participants in the experimental group increased to 70.33 ($SD = 3.137$), indicating a considerable improvement in their vocabulary knowledge, compared to participants in the control group ($M = 47.68$, $SD = 2.839$). Moreover, the results of delayed post-test (NGSLT3) which was administrated 2 months later indicated that mean score for participants' vocabulary knowledge in the experimental

Table 1 Descriptive statistics

GROUP	N	Minimum	Maximum	Mean	Std. deviation
<i>Experimental</i>					
NGSL1	58	43	52	47.64	2.936
NGSL2	58	65	76	70.33	3.137
NGSL3	58	61	72	66.67	3.295
<i>Control</i>					
NGSL1	25	43	51	47.04	2.574
NGSL2	25	44	53	47.68	2.839
GSL3	25	44	54	48.60	3.136

group decreased to 66.67 ($SD = 3.295$), nonetheless, this value is still considerably larger than the mean score obtained on pre-test (NGSLT1). The obtained results by participants in control group remained to a large extent similar to their earlier performances, and indicated little improvement in their receptive vocabulary knowledge of NGSL ($M = 48.60$, $SD = 3.136$). These results in general indicated that the use of mobile application (i.e. NGSL builder) contributed to improvement in receptive vocabulary knowledge among the participants in the experimental group.

The following figure (Fig. 3) is a visual representation of participants' performances over time, which gives a general overview of changes in scores on pre, post and delayed tests. As it is represented below, the mean score obtained on three different times indicate different patterns for results obtained by experimental and control groups. In this regard, while the participants in the control group had negligible improvement from pre-test to post and delayed tests (the red line), the mean score for participants in experimental group (blue line) indicates a sharp increase from pretest to post-test, and a slight decrease from post-test to delayed test.

In order to see if the observed differences were statistically significant, independent samples t-tests were conducted to compare the NGSLT scores (pre- and post-test) for participants in the experimental and control groups. The results indicated that there was no significant difference in NGSLT scores for the control ($M = 47.04$, $SD = 2.574$) and the experimental ($M = 47.64$, $SD = 2.936$; $t(81) = 0.882$, $p = 0.38$, two-tailed) groups on pre-test. However, the observed differences for the control ($M = 47.68$, $SD = 2.839$) and the experimental ($M = 70.33$, $SD = 3.137$) groups on post-test (NGSLT2) were significant ($t(81) = 31.021$, $p = 0.000$, two-tailed). The magnitude of the differences in the means (mean difference = 22.648, 95% CI: 21.195–24.100) was very large (eta squared = 0.922) based on criteria proposed by Cohen (1988) (Table 2).

Furthermore, in order to investigate the differences in obtained scores on NGSLT in pre, post, and delayed tests, a one-way repeated measures ANOVA was conducted to compare scores at Time 1 (prior to the treatment), Time 2 (4 month following the treatment) and Time 3 (2-month follow-up). The results (Table 3) indicated a significant effect of time for the experimental group (Wilks' Lambda = 0.028, $F(2,$

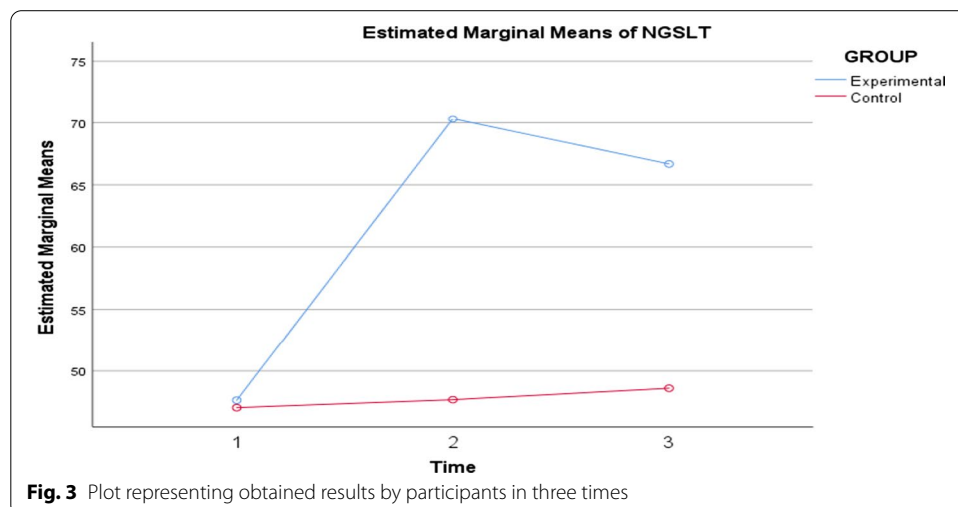


Table 2 Independent samples T-tests

	Levene's test for equality of variances				t-test for equality of means				
	F	Sig	t	df	Sig. (2-tailed)	Mean difference	Std. error difference	95% confidence interval of the difference	
								Lower	Upper
NGSL1	.803	.373	.882	81	.380	.598	.678	-.751	1.947
NGSL2	.266	.607	31.02	81	.000	22.648	.730	21.195	24.100

Table 3 Multivariate tests (Wilks' lambda)

GROUP	Value	F	Hypothesis df	Error df	Sig	Partial eta squared
Experimental	.028	974.241	2.000	56.000	.000	.972
Control	.838	2.228	2.000	23.000	.131	.162

Table 4 Pairwise comparisons

Measure: NGSLT

GROUP	(I) Time	(J) Time	Mean difference (I - J)	Std. error	Sig. ^{ab}	95% confidence interval for difference ^{ab}	
						Lower bound	Upper bound
Experimental	1	2	- 22.690*	.586	.000	- 24.135	- 21.245
		3	- 19.034*	.529	.000	- 20.338	- 17.730
	2	1	22.690*	.586	.000	21.245	24.135
		3	3.655*	.606	.000	2.161	5.149
	3	1	19.034*	.529	.000	17.730	20.338
		2	- 3.655*	.606	.000	- 5.149	- 2.161

Based on estimated marginal means

*The mean difference is significant at the .05 level

^a Adjustment for multiple comparisons: Bonferroni

56) = 974.241, $p < 0.000$, multivariate partial eta squared = 0.972), but no significant effect for the control group (Wilks' Lambda = 0.838, $F(2, 23) = 2.228$, $p = 0.131$).

Finally, pairwise comparisons of obtained scores by participants in the experimental group were conducted and the results are provided in Table 4. The data presented in the table indicate that the differences in participants' performances in both post, and delayed tests are statistically significant ($p < 0.000$) from the results obtained on pre-test (mean differences, 22.69, and 19.03 respectively). Moreover, the results of pairwise comparisons also revealed that the decrease in participants score from post-test to delayed post-test is also statistically significant (mean differences = 3.66, $p < 0.000$).

Discussion

The first research question was concerned with the contribution of a DFs mobile application (i.e. NGSL Builder) on improving participant's receptive vocabulary knowledge. The results of the post-test indicated that the participants in the experimental group outperformed those in the control group significantly and demonstrated increased knowledge of New General Service List (NGSL) (Browne et al., 2013). This means that the use of mobile flashcard applications for English vocabulary learning can benefit EFL learners to master essential vocabulary in English. The findings are in line with previous studies which also reported positive impacts for using mobile applications for learning English vocabulary (2015a; Fathi et al., 2018; Sage et al., 2020; Seibert Hanson & Brown, 2020; Wu, 2014, 2015b). The participants in the experimental group learned approximately 22.7% of vocabulary items from NGSL over the 4 months (Table 4), which is a significant achievement. In fact, given that in most EFL contexts, many learners fail to acquire essential vocabulary (Webb & Chang, 2012; Webb & Nation, 2017), this additional knowledge helps students and facilitates their understanding of daily conversations, television programs, and films in English. The results obtained by the control group indicated a very limited and negligible development in their vocabulary knowledge. There might be a number of reasons contributing to the different learning outcomes among the groups. First, as the participants in the experimental group were given ready-made digital flashcards, they naturally regarded learning materials easy to use and more convenient. On the other hand the participants in the control group had to create their own flashcards or study the vocabulary items from the word list which requires more effort and naturally is less motivating. Second, according to Stockwell (2013) there are some inherent motivational effects in using new technologies for language learning that result in enhanced motivation among language learners. In this regard, the integration of mobile devices into vocabulary learning resulted in increased motivation and hence improved learning outcomes for the experimental group. Additionally, as the out-of-the-classroom vocabulary learning was voluntary and the number of target vocabulary items was considerably large, those participants in the control group were less motivated to invest time and effort in learning the NGSL items.

The second research question sought to investigate the long-term effects of using mobile devices and applications for vocabulary learning. In this regard, the findings indicated that the scores obtained by participants in the experimental group in both post and delayed tests were higher than the scores obtained on the pre-test. Since the differences were statistically significant, the findings pointed to a long-term effect for using mobile applications in learning foreign language vocabulary. It seems that the NGSL builder application with built-in spaced repetition feature provided the learners with a platform to learn core vocabulary items systematically and effectively. However, it should be also highlighted that the differences in scores between post-test and delayed post-test was also statistically significant. In the other words, although the participants learned about 22.7% of the items in NGSL from pre-test to post-test during the four months, the results indicated a 3.66% decrease in scores from post-test to delayed test which was administrated two months later. In this respect, even though still there is a significant amount of around 19% improvement in participants' vocabulary knowledge after six months, it seems that there is a declining trend for scores which might have several

reasons. First, as highlighted by Webb and Nation (2017), certain conditions are needed for vocabulary learning to take place, which include meaningful repetition and significant encounters with the target words. Since after the treatment period the students stopped reviewing vocabulary items using mobile applications, this resulted in forgetting some previously-learned vocabulary items. Second, despite the motivating impacts of integrating mobile devices in vocabulary learning, it seems that the motivational dimension of new technologies and language learning applications fade gradually as learners lose their initial enthusiasm in long-term interventions. Finally, there is a more important factor that impacted the long-term retention of vocabulary items for the participants of the current study, which is related to the learning context. Since the learners had no (or very little at best) exposures to English language in the context of study (an EFL context), they were unable to use the vocabulary items they learned in the course of mobile assisted vocabulary study in new situations, and this impacted their long-term retention of learned items.

The current study has some implications for teaching vocabulary to EFL learners. First, it has been argued that learning foreign language vocabulary is a continuous and long-term process (Nation, 2001, 2013), nonetheless, the findings of the current study indicated that the use of mobile devices and well-designed vocabulary learning applications have great potential in helping language learners to shortcut this process, and learn a considerable proportion of essential vocabulary in a short time. In this regard, language teachers and materials developers should pay more attention to the affordances provided by mobile devices for vocabulary learning to augment gaps in vocabulary knowledge. Second, the study investigated the effects of using mobile applications for out-of-the-class and self-directed vocabulary learning, and the obtained results further supported the use of these technologies to complement formal education. This is especially beneficial in teaching foreign language vocabulary, as it receives less attention in the language teaching classrooms (Webb & Nation, 2017), and the mobile devices make it possible to extend learning beyond the classroom. Moreover, the findings of the current study underscore the point that the true potentials of digital technologies for improving language education can be realized outside the classroom (Lai & Gu, 2011) by using anytime anywhere learning feature of mobile devices. One unique contribution of mobile technologies for vocabulary learning might be the possibility of creating episodic learning opportunities, where students can use short periods of time for language learning purposes. As out-of-the-classroom learning of foreign language vocabulary lends itself best to these strategies, teachers should consider training learners for such undertakings.

Conclusion

The current study investigated the contribution of a mobile application (i.e. NGSL builder) on EFL learners' vocabulary development. The findings indicated that the use of mobile devices and vocabulary learning applications contributed significantly to developing English language vocabulary among participants in the experimental group. The results also provided empirical support for long-term effects of these technologies on vocabulary knowledge development among EFL learners. Nonetheless, the current study had some limitations that should be acknowledged. First, due to contextual constraints and availability of the participants, randomly assigning participants to experimental and

control groups was not possible and intact classes were used in the current study as it is a common practice in educational research. In this regard, although the performance of the experimental group was compared with a control group and repeated measures were used across the study, this limitation in sampling procedures should be accounted for while interpreting the findings. Second, although the context of the study was an EFL context where the learners had very limited exposure to English language outside the language classrooms, it is not still possible to rule out the contribution of other factors such as media, internet, and social networks to their vocabulary development. This is particularly true for language learners who have easy access to a variety of English language learning materials in its broadest sense (Tomlinson, 2012) through digital technologies and mobile devices. And third, the current study was quantitative in nature, and despite providing some empirical evidence on the contribution of mobile applications for vocabulary development outside the language classroom, qualitative or mixed-method studies are needed to better understand learners' attitudes and behavior in these new learning environments. Future studies are encouraged to investigate these issues in more detail and add additional insights with respect to the different aspects of learning vocabulary with mobile devices.

Abbreviations

CEC: Cambridge English Corpus; DFs: Digital flashcards; EFL: English as a foreign language; GSL: General Service List; L1: First language; L2: Second language; MALL: Mobile assisted language learning; NGSL: New General Service List.

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Authors' contributions

All authors contributed to the design and implementation of the research, to the analysis of the results and to the writing of the manuscript. All authors read and approved the final manuscript.

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Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The present study adhered to ethical considerations in educational research by obtaining informed consents from the participants and also by ensuring them regarding the confidentiality of collected data.

Consent for publication

Not applicable.

Competing interests

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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