

Use of mobile applications in collocation teaching¹

Muhammed Sayid Özcan, Yıldız Technical University, Education Faculty, Department of Computer Education and Instructional Technology, İstanbul, Turkey <https://orcid.org/0000-0003-1305-9100>
Serhat Bahadır Kert², Yıldız Technical University, Education Faculty, Department of Computer Education and Instructional Technology, İstanbul, Turkey <https://orcid.org/0000-0002-1093-6326>

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Abstract

In this study, the importance of vocabulary knowledge in language education and the use of mobile applications in the teaching of collocations are emphasized. The application of collocation was realized through a mobile instant messaging application. It has been determined that students use a mobile application in a word learning process to provide more meaningful learning than in classroom learning. In this study, which was applied to 54 people using experimental and controls grouped research design, the experimental group was given mobile cards and the control group was given word cards in the class. In quantitative aspect, the study aimed to see the difference between the academic achievements of both group. At the end of the process, an academic achievement test was applied to the students, and a significant difference was found between the groups in favor of the experimental group. In qualitative aspect, the students opinions was given on use of mobile applications in teaching vocabulary. Individual interviews were conducted with the students at the end of the process accordingly and these interviews were used in the evaluation of the process.

Keywords: Educational technology; language learning, mobile learning; teaching collocations.

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² ADDRESS FOR CORRESPONDENCE: Serhat Bahadır Kert, Yıldız Technical University, Education Faculty, Department of Computer Education and Instructional Technology, İstanbul, Turkey
E-mail address: sbkert@gmail.com

INTRODUCTION

Learning vocabulary is one of the most essential requirements in the process of learning a new language. However, it is stated that teaching grammar is still the main focus in English lessons (Hill, 1999). It is seen that if a student, who achieves grammatical rules well, has poor vocabulary knowledge, he/she is mostly faced with a fluency and relevance problem while making a sentence. However, it is stated that vocabulary knowledge has a more important position than grammar in language learning (Flower, 1989). Accordingly, Choudhury (2010) emphasizes the importance of vocabulary knowledge as stated by Wilkins “Without grammar very little can be conveyed, without vocabulary nothing can be conveyed.” As it is said above, for a fluent communication, one ought to pay attention to learn more vocabularies instead of grammatical rules. (Flower, 1989). As a result, speaking will be more comprehensible.

Teaching vocabulary is a cognitive activity. It can be a quite a difficult process to manage this cognitive activity for teachers although it plays an important role for language teaching. It can be stated that the vocabularies which are learnt through memorizing are forgotten in time when they are not used; instead, learning vocabularies by collocating them with other words provides a permanent knowledge (Vinten & Humphries, 2015). Within this context, it may be assumed that it is more crucial to learn vocabulary phrases rather than the vocabulary itself. The vocabularies that can be used together are known as collocations.

Collocations are the phrases that are formed by being used two words or more together and they are preferred in vocabulary teaching (O'Dell & McCarthy, 2008). In literature, O'Dell and McCarthy (2008) describe collocations as the natural combination of words that can be closely linked. In line with these definitions, collocations can be defined as the word groups that consist of two or more words and which make a meaningful association according to the culture of that language. Collocations contribute to the vocabulary teaching process in some respects. The first is that individuals who use collocations in sentences have the opportunity to become a natural speaker (Shin & Nation, 2008). Secondly, collocative words increase the fluency in speech (Shin & Nation, 2008). There are thousands of collocations shaped by their own culture used by individuals who speak a language as their mother tongue, and those who learn this language as a foreign language also need to learn to use these words (Pawley & Syder, 1983). It was emphasized that using these words reduced the cognitive load during the conversation and encouraged learners to speak right away. In other words, it is stated that the use of collocative words will increase the fluency of individuals who learn this language as a foreign language (O'Dell & McCarthy, 2008). Finally, collocations offer the opportunity to teach in a context, not by memorizing words alone (Balci & Çakır, 2012). Longword lists and their meanings cannot go beyond memorization and are not useful for the use of the word (Flower, 1989). Instead, it may be more accurate to know how words are used in the text and the sentence.

The two main reasons why collocations are preferred among teachers are improving fluency and native-like speaking (Shin & Nation, 2008). However, as it is said above, it is rather possible that the collocations are forgotten if they are taught by only memorizing. Therefore, to provide permanent learning, the vocabularies should be made concrete in the learners' minds. At this point, smart phones, which have become an indispensable necessity in this age, can be used as a solution for making the word concrete during the learning process. Moreover, smart phones are quite useful and help with the continuity of education both inside and outside the class since they provide ubiquitous learning (Sung, Chang, & Liu, 2016). For this reason, it is considered that benefitting from the smart phones may contribute to learners' positive academic achievement during the process of learning vocabularies within the scope of English lessons. In this context, it may be expressed that research on the usage of mobile applications in collocation teaching must be done.

The use of multimedia materials in the teaching of words can be useful regarding its more natural learning and persistence (Saran, Çağiltay, & Sefereoğlu, 2008). Mobile learning environments provide an essential opportunity to use these materials. Mobile learning environments have become essential technology being both fast and available in any environment at all times (Caudill, 2007; Thomas & McGee, 2012). Mobile tools, which enable the sharing of multimedia materials, are also widely used in vocabulary teaching. When the studies related to mobile learning are examined, it is seen that vocabulary teaching is done by using text messaging, e-mail, multimedia materials, and developed mobile applications.

As we have seen, as technology advances in vocabulary teaching, many different applications are being developed. However, new applications are needed with the updating of mobile applications with each passing day (Başoğlu & Akdemir, 2010). In other words, many different technologies and applications were used in vocabulary teaching in the past; however, it is needed to utilize new kind of applications since they provide latest opportunities such as instant messaging, big size multimedia sharing. It is also needed to see students' views on new kind of technologies and applications in vocabulary teaching process. In this context, it was decided to conduct this study, and the following research questions were sought:

- Is there a significant difference between the pre-test and post-test academic achievement of the group using instant messaging software as a support tool in collocation teaching?
- Is there a significant difference between the academic achievement of the pre-test/retention test of the group who use instant messaging software as a support tool in collocation teaching?
- Is there a significant difference between the pre-test and post-test academic achievement of the group who use word cards as a support tool in the class?
- Is there a significant difference between the pre-test/retention test and academic achievement of the group who use the word cards as a support tool in the collocation teaching?
- Is there a significant difference between the post-test academic achievements of the groups that use instant messaging software and word cards in the classroom as a means of support in the collocation teaching?
- Is there a significant difference between the academic achievement of retention tests of groups using instant messaging software as a means of support in collocation teaching and groups of vocabulary cards in the classroom?

METHODS

RESEARCH DESIGN

In the research, the unbalanced control group model was used from the quasi-experimental model types (Karasar, 2014). In this model, no special effort has been done to assign the group unbiasedly; however, the group which includes more students with mobile vehicles is defined as the experimental group (Karasar, 2014).

Table 1
View of the Model with Unequal Control Group

Group	Pretest	Experimental Process	Posttest	Retention Test	Individual Interview for Mobile Learning
G ₁	O _{1.1}	X	O _{1.2}	O _{1.3}	O _{1.4}
G ₂	O _{2.1}		O _{2.2}	O _{2.3}	

G₁: Experimental group of collocative word cards in mobile environment

G₂: Control group where collocative word cards are presented in class environment

O: Measurement

X: Application Process

STUDY GROUP

This study was conducted on 9th-grade students in a public school in Midyat, Mardin, Turkey. With the presence of 6 classes at the same class level in the mentioned school, given the socio-economic status of the students, every student does not have the possibility of owning a smartphone. For this reason, before the study groups were identified, information was collected about whether students had access to smartphones, whether they had internet facilities, and the level of access to smartphones. In light of this information, the group with the smartphones was assigned as the experimental group. After the experimental group was determined, one of the other groups was determined as the control group. Although the process of determining the experimental group constitutes a limitation for the study, it is aimed to make maximum use of the study by checking the existing limitation rather than using the tools that should be used, as stated by Karasar (2014). As a result, 27 out of 54 participants were in the experimental group, and 27 were in the control group. In the experimental group, 10 of the students were male, and 17 were female. On the other hand, 11 of the students in the control group were male, and 16 were female. The total number of students participating in the study is 54 as seen in the table. While male students participated in the study accounted for 38.9 percent of the total, female students accounted for 61.1 percent of the participants.

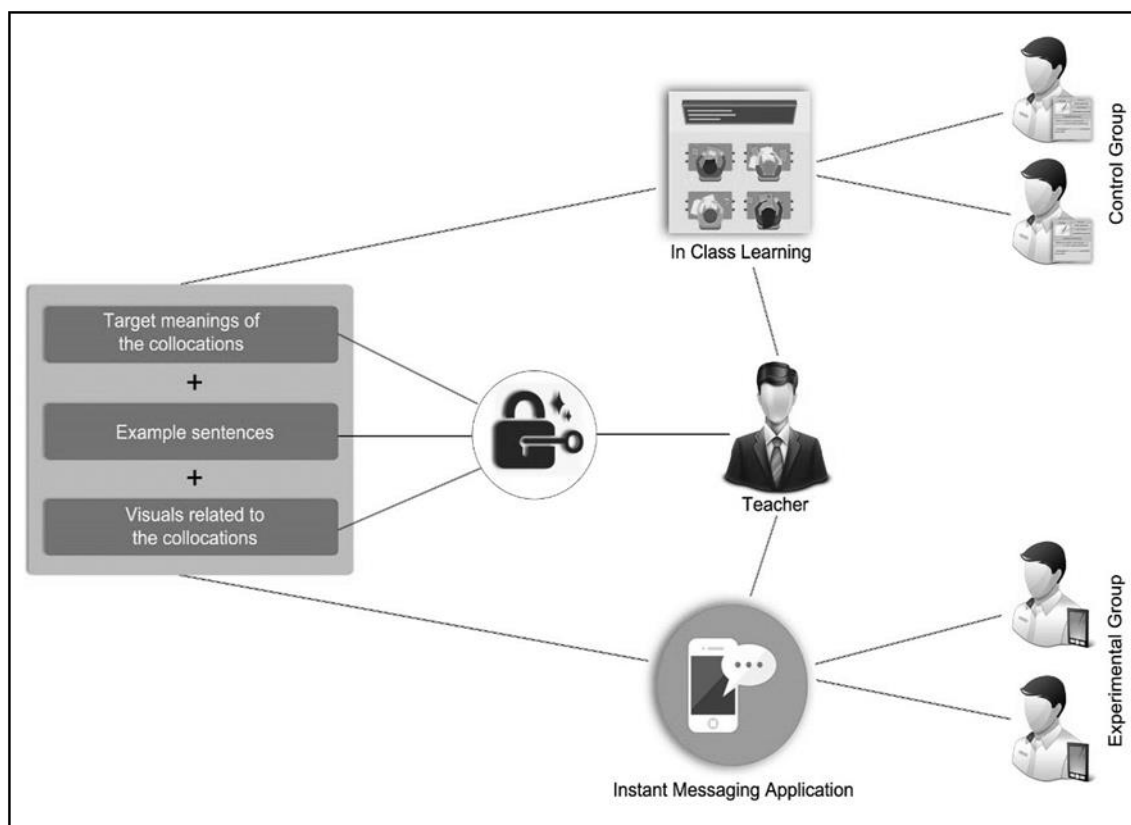


Figure 1

Schematic representation of the experimental and control group implementation process

The application process was carried out in two ways as shown in Figure 1. As shown in the figure, the teacher is in control in both groups. After the pretest was applied, vocabulary cards were sent to the experimental group and the control group students during the teaching process. The experimental group students were given the vocabulary cards via mobile software while the control group students received them in the classroom environment. Both groups were asked to write a sample sentence after receiving the word cards. Experimental group students sent their samples through the application; the control group students wrote their samples in their high school books. The purpose of the example sentences is to enable the students to think about and comprehend the syntactic vocabulary they see. Two groups of students were free to use the dictionary when writing their example sentences. It is not known whether the experimental group used any other dictionary or translation program using the mobile application. This situation was not deemed to cause any harm to the reliability of the research since the study focuses on collocations, not a single word. In other words, the students are expected to see the words in the context and know that these words are used together. Accordingly, questions were prepared on the use of words in the academic achievement tests applied to the students. Therefore, the use of any dictionary or other means will not have a negative effect on this process.

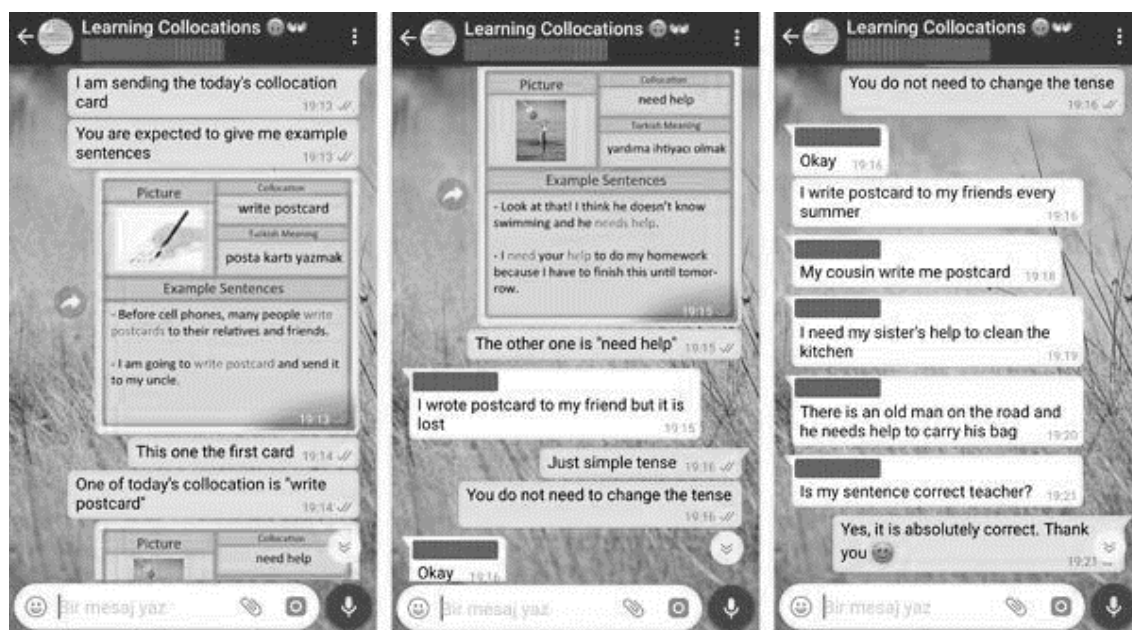


Figure 2

Conversions of experimental group students in the vocabulary learning process

The total duration of the use of the application, including the weekends, lasted for 22 days and included 27 experimental group students. In the experiment group where a word was sent each day, two words were sent in the last three days. The reason for this is that it is possible to tell the students that they do not spend too much time with their smartphones and, in turn, to prevent the working process from being affected negatively. For these 22 days, the experimental group was given words for daily work, and on weekends, three words were given. The sample sentences written by the control group students were examined, and it was ensured that everyone saw all the collocations.

The variables of in-class situation were minimized in both groups meaning that the same language, the same methods, and the same techniques were used in the lessons of the students of the two groups and efforts were made to differentiate the methods of learning words. While the experimental group students were not given word cards during the lesson, the control group students were given a new card at the end of the school day. However, word cards were sent to experimental group students in the evening time intervals. The teacher wanted the experimental group students to send their example sentence through mobile application. Meanwhile, the other group wrote the example sentences about the collocations which they acquired in the lesson on their notebooks during school time. The examples of the control group were written at home only during 2 days, on Saturdays and Sundays, which were holiday for students. On other days, the students wrote the sample sentences in the lesson. The control group students were prevented from entering the group for the experimental group even if they had smartphones.

In order to see the preliminary information of the students and to ensure the equivalence of the groups, a pre-test was applied (Karasar, 2014). Approximately eight weeks after the posttest application, the permanence test was applied to measure the persistence of words. In addition to quantitative data analysis, the opinions of the experimental group students on the use of mobile applications in language teaching were taken, and the implementation process ended in this way.

Data Collection Tools

The quantitative data of the study was collected by the academic achievement test , while the qualitative data was collected with student interview form. Academic achievement tests were utilized to see the difference between experimental and control groups. In addition, students' views were applied to see how this implementation was successful in vocabulary teaching. Academic achievement test consists of gap filling and matching questions in which approximately 45 randomly selected words from students' books are included. The academic achievement test which was prepared as 45 questions were presented to the expert opinion and applied to a sample group for reliability, item difficulty, and discrimination analysis after the corrections of the experts. This group includes other 9th-grade students in the same school. In the analysis of the item after the application, items with difficulty between .30 and .60; items with material discrimination of more than .30 were included in the test and others were excluded from the test (Büyüköztürk, 2014; Yıldırım, 2015).

For the reliability analysis of the academic achievement test, the KR-20 reliability method was used. The reliability of the test was found to be 0.87 in the KR-20 reliability analysis after correction of the items. It can be stated that considering this score, the test is quite safe (Büyüköztürk, 2014; Karasar, 2014). In addition to the academic achievement test, which is a quantitative data analysis, the opinions of some participants in the word-learning experiment group were taken from the mobile application. In the direction of a previously prepared guide, the interview form with five questions is designed to be structured (Karasar, 2014). At the end of the application, the students were asked to learn vocabulary through instant messaging and the views taken from the students were covered with the theme coding technique (Özerbaş & Erdoğan, 2015; Vaismoradi, Jones, Turunen, & Snelgrove, 2016). After the sound recordings were taken from the students, the answers of eight students to each question were examined one by one. According to the answers given by the students, primary keywords and expressions were identified. The themes and the keywords that were established to increase the reliability were presented to the opinion of other experts (Özerbaş & Erdoğan, 2015).

The application form, the problems experienced during the application and the opinion form where the general opinions are requested are composed of the following questions:

- 1) Can you tell us what the method contributes to?
- 2) What is the difference between learning vocabularies through mobile applications and the other methods that you have experienced before? Can you specify?
- 3) Can you indicate the difficulties (technique, time, etc.) you are experiencing during the implementation process?
- 4) What do you think about the use of mobile applications in language teaching?

In the individual interview with the students, the answers to the above questions were sought. Following the questions, the students were given the theme coding for the answers they gave, and the explanations were made in the headings. In the third and fourth questions from the interview questions, some of the students stated that they did not have any problems for the third question, but for the fourth question, the respondents answered that they had problems with the previous question. For this reason, the theme coding of these questions was prepared and interpreted within the scope of the responding students.

RESULTS

Quantitative Research Findings

In the study, quantitative data was obtained from the students by applying an academic achievement test to the experimental and control groups. SPSS program was used to analyze these quantitative data. As a result of the pre-tests applied to the groups, it was examined whether the groups showed the normal and homogeneous distribution; additionally, group balances were checked. The average scores of the students in the pre-test scores are taken into account. Accordingly, the experimental group students from each group of 27 people received an average score of 56.74 from the pretest, while the control group students received a score of 55.40. Results of single factor variance (ANOVA) analysis of the pretest scores of the groups showed there was no significant difference between the pretest scores of the groups ($F = .352$; $p > .05$). Also, normal and homogeneous distribution of experimental and control groups was determined in the normality test ($p > .05$). For this reason, parametric tests were used for the analysis of quantitative data (Büyüköztürk, 2014). The paired groups t-test was used to examine the pre-test and post-test scores of the groups. The participants in the experimental group scored an average of 56.74 from the pre-test, while the post-test had an average score of 85.48. There was a significant difference between the pre-test and post-test scores of the experimental group in the paired groups T-Test analysis ($t = -7.87$; $p < .05$). The pre-test scores of the participants in the control group were found to be 55.40, and the post-test means scores increased to 69.62. There was a significant difference between the pre-test and post-test scores of the control group as a result of T-Test analysis ($t = 5.37$; $p < .05$). When the paired groups' T-Test results were examined, a significant difference was observed in the vocabulary learning of the two groups. According to this, it can be stated that both using mobile cards as a support tool in the process of collocative word learning and using word cards in the classroom have a meaningful effect on the word learning process.

One-way analysis of variance (ANOVA) was used for independent measurements to determine the significant difference between the post-test scores of the experimental and control groups. The result of the analysis is as follows:

Table 2

Analysis of post-test points by single factor variance according to groups (ANOVA)

Source of Variance	Sums of Squares	sd	Squares Average	f	P
Between Groups	3392.296	1	3392.29	11.038	.002
In Groups	15981.037	52	307.328		
Total	19373.333	53			

As seen in Table 2, as a result of single-factor analysis of variance, there was a significant difference between the post-test scores of the experimental and control groups ($F = 11.038$; $p < .05$). According to the results of variance analysis, it can be expressed by the numerical data that the group using a mobile application as a support tool in the process of collocative vocabulary teaching has learned more effectively than the group using word cards.

Table 3
Test and control group pre-test/retention test paired groups T-Test results

Group	N	Pre-test		Retention Test		sd	t	p
		\bar{X}	SS	\bar{X}	SS			
Experiment	27	56.74	18.56	76.14	13.83	26	-5.11	.000
Control	27	55.40	15.87	64.44	23.35	26	-3.09	.005

Table 3 shows the paired groups T-Test analysis between the pre-test and retention tests applied to the experimental and control groups. According to this, the average score of the experimental group = 56.74 in the pre-test increased to = 76.14 in the retention test; the average score of the control group in the pre-test was 55.40, and it increased to = 64.44 in the retention test. According to these results, it can be stated that the collocations learned by the participants in both the experimental group and the control group were permanent ($t = -5.11, p <.05$; $t = -3.09, p <.05$).

In addition to the pre-test and retention test-paired t-test analysis of both groups, single-factor variance analysis (ANOVA) was performed between the groups' retention tests.

Table 4
Retention test scores according to groups of single factor variance analysis (ANOVA)

Source of Variance	Sums of Squares	df	Squares Average	f	p
Between Groups	1849.185	1	1849.185	5.018	.029
In groups	19162.074	52	368.501		
Total	21011.259	53			

When these data are taken into consideration, it is seen that there is a significant difference between retention test scores of experimental and control groups as in Table 10 ($F = 5.018; p <.05$). According to this result, it can be stated that the group, using the mobile application as a support tool in the process of collocative word learning, has a better understanding of the words compared to the group using word cards. Additionally, retention of the words is greater in the experimental group than the other one. However, when it came to the retention test, it was observed that the retention test scores of the experimental group decreased more than the control group scores. It can be stated that when the retention test scores are applied to the groups after a long time, the scores will be closer to each other and the significant difference can be eliminated.

Qualitative Findings

For the qualitative findings of the study, a 5-question interview form was prepared. While preparing the questions, the criteria such as being bright and comprehensible, being single-purpose and unpredictable, containing the data that the source person could give and being neutral were taken into consideration (Karasar, 2014). The interview questions presented to the expert opinion were interpreted below with the theme coding method (Özerbaş & Erdoğan,

2015). An interview was conducted with eight students who were volunteers from the experimental group (Dawson & Manderson, 1993).

Student Opinions about the Contributions of the Method

Table 5 Students’ views on contribution of the method

Can you tell us what this new method contributes to?	f	%
It helps me make sentences	7	58.33
It enables us to learn new vocabularies	3	25.00
It provides permanent learning	1	8.33
It contributes to our speaking skills	1	8.33

In the individual interview, firstly, in the experimental group, the question of how the mobile application used in the process of the teaching of collocative words contributed to the students was asked. The first question put forward to the students was inquiring about the contributions of the method. According to this, when the answers are examined, it can be seen that 7 of the eight students stated that this adaptation contributed to the formation of an English sentence. 58.33% of the 12 responses given show that the application is useful regarding sentence formation. Also, 25.00% of the responses stated that this application allows learning new words. One student (8.33%) states that this practice provides memorable learning and the other contributes to the ability to speak. When the answers of the students are examined, it can be stated that this practice contributed to the students' sentences. The students saw the use of the words they learned during the application in the sentence and stated that this was helpful regarding sentence building.

Student Opinions about the Differentiation of the Implementation

Table 6 Students’ views on differentiation of the implementation

What is the differentiation between learning vocabularies through mobile applications and the other methods that you have experienced before? Can you specify?	f	%
Highlighting how to use a word in context	4	36.36
Providing permanent vocabulary learning	4	36.36
Containing visuals	2	18.18
Providing ubiquitous learning environment	1	9.09

In the second question, students were asked how the use of mobile application as a support tool in vocabulary teaching were different from their previous methods. 36.36% of the answers received from the students indicated that this practice showed how the word was used. Looking at the other answers, a rate of 36.36% suggests that this practice offers a more permanent word in mind; 18.18% of this application in the vocabulary teaching process with the

support of the visual expression of the difference is expressed. Finally, a portion of 9.09% stated that this application makes a difference concerning providing word learning in every environment at any time. When the answers given to the questions are examined, it can be stated that this practice makes a difference in how the word is used in parallel with the answers given to the first question. It is also one of the ways that mobile applications offer more permanent vocabulary instruction.

Student Opinions about Problems in Practice

Table 7 Students' views on problems in practice

Can you indicate the difficulties (technique, time, etc.) you are experiencing during the implementation process?	<i>f</i>	<i>%</i>
Internet access problem	2	66.67
Lack of mobile tools	1	33.33

Students' opinions were taken to determine the problems experienced during implementation. According to the opinions, it was seen that many of the students did not have any problems during the application. Although there were certain issues, it was noted that the two students who did have difficulties were connection to the internet sometimes during the application. One student stated that he had problems accessing the mobile vehicle. In general, it has been observed that there are not many problems during the application period and necessary measures have been taken to ensure that these problems do not affect the implementation process negatively.

Student Opinions about Using Mobile Applications in Language Teaching

Table 8: Students' views on use of mobile applications in language teaching

What do you think about the use of mobile applications in language teaching?	<i>f</i>	<i>%</i>
Providing ubiquitous learning environment	4	40.00
Providing memorable learning	3	30.00
Positive effects of use of visuals on vocabulary learning	2	20.00
Accelerating the process of vocabulary learning	1	10.00

Students' opinions were also analyzed concerning the use of mobile applications in language teaching. When mobile applications take up much space in our lives and start to become an indispensable, students' opinions about using these tools in language teaching should be taken into account. According to this result, 30.00% of students whose opinions were received stated that mobile applications provided more memorable learning. They stated in the forms that the memorable learning occurs since they always deal with mobile phones and see the target vocabularies. This situations supports Grace's (1998) view that the students ought to

participate in learning activities outside the classroom. Another student view for the use of mobile applications in language teaching is that mobile applications provide learning in every environment at all times and provide access to information at all times. Students are making the learning activity permanent not only in the classroom but also outside the classroom. Hence, Lu (2008) stated that mobile vehicles offer students the opportunity to learn at any moment and expressed their opinions in the same direction as the students. 20.00% of the students stated that the visuals used by mobile vehicles contributed positively to vocabulary learning. Smith et al. (2013) also stated that multimedia materials had a significant effect on vocabulary learning. In this context, it can be stated that the contribution of multimedia materials to vocabulary learning and these materials can be easily used with mobile tools. 10.00% of the students stated that mobile tools accelerated the vocabulary learning process.

DISCUSSION AND CONCLUSION

Vocabulary knowledge, of course, has a vital place in the language learning process (Nematia & Malekib, 2014; O'Dell & McCarthy, 2008). In the literature, it is stated that the word is the core of a language (Ashrafa et al., 2014) and it is stated that boosting the vocabulary knowledge instead of grammar is influential in learning language (Uysal & Yavuz, 2015). The use of collocative vocabulary can be helpful as active teaching content used in vocabulary learning (Fanaee, 2014; Shokouhi & Mirsalari, 2010). The teaching of collocations in the mobile environment has a significant role in terms of the richness of teaching content (Saran, Seferoglu, & Cagiltay, 2009), providing ubiquitous learning environment (Saran et al., 2008) and offering a faster learning environment (YS Chen, Kao, & Sheu, 2003). In this study, teaching collocations through mobile applications is emphasized. The comparison of mobile applications with the teaching in the classroom during the teaching process and the opinions of the students about mobile education constitute the mainstay of the study. When the study findings are examined, it is seen that the use of collocational words through mobile applications provides more meaningful learning to students. Furthermore, according to the individual interviews with the students, it was found that this practice made a positive contribution to the students' collocative vocabulary learning processes.

As a result of the study, the answers to the research questions were determined by the findings. According to the research questions, it was found that post-test and retention test scores of the students who use a mobile application and their collocative words have increased significantly according to the pre-test scores of the students learning in the classroom. However, it was observed that the post-test and retention test scores of the students of the mobile application group were higher than the non-use group and had a significant difference. According to these findings, it is possible to state that mobile applications have an essential place in the teaching of collocative words. However, when the persistence test results of the groups were examined, it was observed that the average scores of the group using mobile application decreased more than the other group. We can assume that, if the retention test was applied 8 weeks later, the difference between the scores of the groups will decrease and thus the significant difference will disappear. In future studies, it may be recommended that the retention test is performed again after eight weeks after the post-test. If the difference between persistence test scores is decreasing, it can be seen that the use of the mobile application in long-term persistence in the syntactic vocabulary teaching is not meaningful. Also, considering that 25 collocations were chosen in the study, it is possible to question the effect of carrying out the study with more words on academic success. In this case, it can be stated that the academic success of the group learning both the mobile application and the learning group in the classroom will decrease at the same rate. Since the increase in the number of words will increase

the cognitive load for both groups of students and students will have difficulty learning the words (Mestre & Ross, 2011).

The importance of vocabulary teaching, which is the main subject of the study, in language education is seen. Contrary to previous methods for teaching vocabulary, in this study, a teaching process is planned under current technology, which can attract the attention of the students and keep them away from the social media that they already use. In the study conducted in line with this planned process, it was seen that the students learned the words with mobile applications in a more memorable way and the opinions supported this. At this point, it can be stated that the use of mobile applications in the vocabulary teaching process is a useful and necessary tool.

As a result of the study, several suggestions can be made for future studies. Vocabulary teaching with a mobile application is a process that requires proper planning first of all (Lawrance, 2014). How long this application will last, which mobile application to use, how to teach with this mobile application, how to measure whether or not teaching is performed is a process that requires serious planning before the study. Also, planning may be required in the control group. At this point, it can be suggested that a vocabulary teaching process with a control group using mobile applications and another technological infrastructure can be designed for future studies. In this way, two different technologies and vocabulary teaching process have been seen, which technology can be determined more efficiently.

As a further suggestion, the application should be designed by taking into account the possibility of access to mobile applications in the teaching process. If students are restricted to access the mobile application during the application process or if access to the Internet is restricted, the study may be adversely affected. For this reason, it may be stated that a prior control of such situations is necessary before taking advantage of technological applications.

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