Evaluating Efficacy and Usability of Mobile Devices for Learning New Vocabulary Items

by

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Declaration

I certify that this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person, except where due reference is made in the text.

Signed

Dated

31 / 10 / 2016

Siamak Mirzaei

Dedication

To the greatest blessings of my life:

“To the memory of my dad, Mohammad Esmaeil Mirzaei”

who unfortunately passed away on 7th of July 2016.

“To my mom Maryam, and my brothers Arash and Saber...”

&

“To my friend Rana who supported me at all times although being far from me”

Your support, encouragement, and constant love have sustained me throughout my life and successfully made me the person I am becoming. Thank you!

Abstract

Learning another language presents several challenges around learning grammar and new vocabulary items. Studies by prominent language researchers suggest vocabulary learning as the most difficult criterion, yet also the most important. Another problem learners encounter is the lack of exposure to the new language, as their interaction with the language is often limited to the classroom or other learning environment. Mobile devices are considered as an appropriate solution to these obstacles in second language learning due to their portability, constant user interactions, availability, and ease of use.

A relatively new research area has developed to investigate these issues: Mobile Assisted Language Learning (MALL). MALL is defined as language learning which is assisted or enhanced through the use of a handheld mobile device.

The purpose of this project was to evaluate efficacy and usability of mobile devices for learning new vocabulary items. This was evaluated through the implementation of a successful vocabulary learning method called the Keyword Method. With the Keyword Method, any two pieces of information can be linked together in memory with the help of a keyword. In this method, the meaning of the target vocabulary item, along with a keyword, is associated with an image, (or its concept), to accommodate learning. The image should be bizarre or funny while relating both the meaning of the target word and the keyword, with the emphasis on the meaning. Although numerous investigations have taken place on different methods and strategies to help learners in learning new vocabulary items, little research has been conducted on learning vocabulary items using this method on a mobile device.

For this purpose, mnemonic learning methodology was implemented within the mobile device application. The designed application had three sections; vocabulary teaching, vocabulary testing, and the System Usability Scale (SUS) questionnaire. SUS is an industry standard pen and paper based tool designed to evaluate the usability of software systems. Several customised algorithms were considered to facilitate appropriate mapping from the pen and paper traditional method to a mobile device version.

For the experiment, while the primary device type used was a tablet, this pen and paper method was included as a means of comparison. The participants were asked to use the Keyword Method on both mobile application as the experimental group, and subsequently on

pen and paper as the control group. The information provided by participants helped to establish whether mobile devices offer a usable and effective means of learning vocabulary items, and are beneficial to learners. This information was also useful to determine whether there is any advantage to utilising mobile devices for learning vocabulary items.

The results obtained from the experiments suggested that mobile device usage for vocabulary learning via keyword method improves vocabulary learning.

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Table of Contents

List of Figures

List of Tables

1 Introduction

Mobile device usage has recently been receiving a significant amount of notice in education. This is indicated by the increasing number of seminars, conferences and workshops in this field. Huang (2014) noted that IEEE has been sponsoring international events on Mobile and Wireless Technologies in Education (WMTE) since 2002. This chapter covers an overview of the conducted research project followed by research questions of this study.

1.1 Project Overview

English as a Foreign Language (EFL) learners encounter several challenges, such as learning grammar, learning new vocabulary items, and pronunciation. The majority of EFL students spend a considerable amount of time on vocabulary learning, which they consider as the most important learning criterion; this was also acknowledged in language learning research conducted by Nation (2001). Typically, students are expected to learn many new words and their meanings during their formal Foreign Language (FL) education. However, the majority of learners use repetition as a main method to learn new words, as they are not aware of other, potentially more effective, vocabulary learning methods. Also, vocabulary learning usually takes place in the classroom environment, or students learn it from textbooks which often are not easily accessible, and not convenient to use beyond home or classroom.

Mobile devices are considered as an appropriate solution to address such obstacles because of their numerous advantages; such as portability, constant user interactions, availability, and ease of use. Alexander (2004), Attewell and Savill-Smith (2004), and El-Hussein et al. (2010) considered mobile learning popularity to have an increased trend in educational contexts, since these devices facilitate the role of mobile learning in improving the quality of learning and teaching. Also, Taki and Khazaei (2011) discussed that mobile learning provides numerous *merits that help in the learning process* by improving the quality of instructions in several areas. Some of these areas include; attending to students' learning styles and preferences, interactive learning, multimedia capabilities, ubiquitous Internet connectivity, increased understanding of learning materials, increase in students' motivation, cost-effectiveness, easy access, student-friendliness, and effective feedback. These increase the potential of mobile devices to be considered as an appropriate and desirable solution for educational use, particularly in vocabulary learning.

In this project, a mobile device application was designed and implemented based on a currently available successful pen and paper method, (Wyra, Lawson & Hungi, 2007). Also, an experiment was designed to identify the usability and effects of this application; this aimed to compare the results of pen and paper with the developed application. The experiment utilised Android based tablets for the mobile option. It was conducted with 16 participants using both the tablets, and the pen and paper method in five distinct phases. Participants were asked to learn the new keyword method, (phase one), then to learn new vocabulary, (phase two). Then, (as required by the study design), the participants were distracted, (phase three). Phases two and three were conducted on both the tablet (to provide the mobile device) and pen and paper methods. Subsequently, participants' recall of the newly learned vocabulary was tested, (phase four). In phase five, the participants completed the System Usability Scale (SUS) questionnaire. The designed tasks in phases one to four aimed to determine the impact of each method on learning new vocabulary items, as well as to examine the effectiveness of the newly developed application to teach the new vocabulary learning strategy (the keyword method), and to teach and test vocabulary.

1.2 Research Goals

The goal of this thesis is to understand the current practices and challenges in Mobile Assisted Language Learning (MALL), and to design a new approach by implementing the keyword method in a mobile device application for the purpose of learning new vocabulary items. In order to address this goal, the following five research questions were considered:

RQ1. Is using the mobile device application designed for this study an effective vocabulary learning tool?

RQ2. Will the mobile device application help learners to remember and recall more words than the traditional pen and paper approach?

RQ3. What are the benefits and/or challenges of using the developed mobile device application to learn new vocabulary items?

RQ4. Do learners face any problems using the mobile devices to learn vocabulary item(s) via the keyword method?

RQ5. Will individuals prefer the mobile devices method to the pen and paper traditional method for learning vocabulary items?

To answer the RQ1 and RQ3, an in depth research on the topic was required. As a preliminary step in this research journey, these basic and critical questions were considered as a starting point. Thus, the result of different research studies was thoroughly inspected and considered to address these questions. After this step, the mobile application development phase started. All the development and implementation was conducted according to the adopted principles of the undertaken research, and studies in the previous steps.

For the other three questions (RQ2, RQ4 and RQ5), an experiment was designed. The experiment had to be designed in a way that it could answer all three questions. In the designed experiment, while the primary device type used was a tablet, the pen and paper method was included as a means of comparison that represented a commonly used traditional method. The information provided by participants helped to address the mentioned research questions.

1.3 Document Content

The remainder of this document begins with a review of related literature, in chapter 2. In this chapter, firstly mobile learning, its challenges and benefits are presented, then MALL with a focus on vocabulary learning is discussed. Finally, the keyword method and its implementation are explained.

Chapter 3 provides details of the methodology used for implementing the keyword method on mobile devices.

The document continues by describing how this application, the user experience and user interface are developed and what challenges were faced during this phase. An objective analysis of results is then presented, as well as some thought as to what these results can indicate. Considerations and ideas for future work in this domain are presented, and the document is concluded.

2 Literature Review

In this chapter, the relevant literature required for this research study is discussed in detail. Section 2.1 defines the scope of mobile learning and its challenges. A discussion on MALL and mobile usage in education is presented in sections 2.2 and 2.3 of this chapter respectively. In section 2.4, vocabulary learning strategies are outlined. Finally, in sections 2.5 and 2.6, the keyword method, and its implementation on mobile devices, is described.

2.1 Overview of Mobile Technology for Learning

In this section, some background information on mobile learning (m-learning) is presented; then, m-learning implementation challenges, (with the relative literature), is discussed.

2.1.1 Introduction to Mobile Learning

Nowadays, mobile learning (m-learning) is being used in education increasingly for several benefits of mobile devices such as accessibility, convenience, and being affordable for learners (Martin et al. 2011). A relatively recent survey which was conducted in the US shows that the number of American youth aged between 12-17 who own mobile devices, (i.e., cellular/mobile phone and tablet PC), is following an upward trend (Madden, Lenhart, Duggan, Cortesi & Gasser, 2013). This rising trend can help justify the increasing number of research papers in this field. The research concerning benefits of mobile technologies has been conducted in many academic disciplines including language education (Franklin & Peng, 2008; Wang & Chang, 2011). One specific area that has been receiving a growing research attention is MALL, as it is considered to have great capacity to improve FL learning and teaching experiences and outcomes (Viberg & Grönlund, 2012; Viberg & Grönlund, 2013).

Mobile learning is implemented in education in a variety of forms. Huang (2014) considered three categories for m-learning; the first one is based on the idea of transferring information via mobile devices; the second one is focused on pedagogical design, and the third one is based on context-aware technology usage (Wong & Looi, 2011). Puentedura (2010) delineated the role of mobile technology in the learning process in his study using the SAMR model which describes the roles mobile devices can play in education. Each of the letters of SAMR respectively stands for Substitution, (technology alternates a traditional learning tool while having no functional change); Augmentation, (technology alternates a traditional learning tool while having functional improvements); Modifications, (technology helps in redesigning of the learning task); and Redefinition, (technology helps with the creation of new learning tasks). This study is concerned solely with augmentation.

Another point to consider is the amount of allocated control and responsibility to the learner, in order to achieve effective mobile learning. McFarlane et al. (2007) defined three discernible mobile design activities: teacher-directed, teacher-set, and autonomous learning. In this study, the autonomous learning is of interest; this approach can allow the learners to use the mobile learning application at their own time of convenience and self-paced.

2.1.2 Mobile Learning Implementation Challenges

Although mobile devices are suitable means for learning, there are also some challenges when these devices are used for educational purposes. Maniar (2007) and Thornton and Houser (2005) investigated some of these implementation challenges such as the small screen size of most mobile devices. In addition to challenges relative to hardware, (and other physical aspects of mobile devices), new software development for different mobile devices was considered as a challenge by Chen (2014). The main issue in application development is mapping from a current learning methodology to a mobile application.

Considering the costs of mobile learning implementation, Chen (2014) pointed out this learning method is costly for students and institutions. He also regarded the distraction caused by mobile devices as a challenge and suggested mobile learning methods as rather more useful for non-academic purposes. However, Taki & Khazaei, (2011) claimed that a great number of educational institutions and universities have expressed tremendous interest in the integration of mobile learning in their curricula. Chen (2014) and Thornton and Houser (2005) both suggested elimination of the above mentioned barriers to facilitate mobile learning incorporation into educational curricula, and considered mobile learning as an efficient approach to learning in the future.

Considering the different aspects of mobile devices and their potential to be used for language teaching and learning, employing mobile devices in this field seems indispensable. Taki & Khazaei, (2011) aimed their research at effects of mobile-based presentation of vocabulary definitions with annotations, and considered mobile devices as a useful tool in language learning and teaching. They also concluded that pictorial and written annotations were a successful learning approach for both learning and teaching. This is the main reason why mobile devices are introduced/used for learning new vocabulary items in this study.

Mobile device features such as portability, connectivity, context sensitivity, social interactivity and personalisation allow these devices to be an appropriate option used both in learning environments, and in a self-based learning approach. However, according to Walters (2012), implementing successful pedagogical practices within mobile technology learning devices has its own difficulties and challenges. In her study, Walters counted the role of teachers in planning, designing, and facilitation technology enhanced modules as one of the key sources of these challenges. There is no doubt that this can cause significant usability problems. To tackle this problem, the approach in this study was to ask for educational recommendations in language learning of a professional and reliable consultant in every step of application design and development.

2.2 MALL and its Affective Benefits

As specified earlier, the interest in mobile device usage in education has emerged as a relatively new field known as MALL. Chinnery (2006) used the term MALL for the first time to elucidate a realm of mobile learning that is particularly applicable to second and foreign language learning. Chinnery (2006) defined MALL as language learning which is assisted or enhanced through the use of a handheld mobile device. As mobile devices are getting more advanced and improved, MALL is getting more popular, and more studies are being conducted. Ahmad et al. (2015) indicated that a large number of studies have been conducted in the MALL field over the past 20 years, following the rapid development and advancement in mobile technologies. They also considered MALL as part of Computer Assisted Language Learning (CALL) which utilises mobile devices.

Mobile learning has several motivational benefits for language learners. Sharples et al. (2010) counted factors such as "control over goals, ownership, fun, communication, learning-in-context, and continuity between contexts" (p. 9) as advantages of mobile learning. Some other studies indicated that using mobile technologies in learning provides motivation, interest and enjoyment (Chen, Tan & Lo, 2013; Gromik, 2012; Chang, Sung & Lan, 2007; Norbrook & Scott, 2003; Sandberg, Maris & de Geus, 2011). Hwang & Chang, (2011) justified the reasons for this by the amount of time which was spent on learning tasks; while Kondo et al. (2012) considered self-regulated learning as an encouraging factor. Furthermore, Gromik (2012) and Chang et al. (2007) implied that although MALL learners are away from other peers, the sense of physical privacy provided by MALL builds confidence in practising listening and speaking skills. Furthermore, as discussed above, mobile device features enable users to manage the learning tasks in their desired time and a chosen learning environment, and this can result in less stress, individualised learning and consequently improved performance.

2.2.1 Mobile Assisted Vocabulary Learning

There are several aspects of MALL research, with vocabulary learning being the most typical one. Mellow (2005) indicated that a large number of these studies were carried out on an information transfer, or "push" approach. In a push approach, unprompted email or SMS messages are delivered to learners in form of vocabulary lessons by language instructors. The purpose in the push method is to increase learners' exposure repeatedly to target vocabulary items via direct instructions through the mobile device for out of classroom environment. In other words, the mobile devices are considered as a physical medium for the delivery mechanism to extend learning space by adding to instructional time, which is only possible via the use of the device. Different studies indicated that vocabulary learning recall and recognition tests for English as a second language (L2) learners were improved via SMS messaging (Alemi, Sarab & Lari 2012; Cavus & Ibrahim, 2009; Thornton & Houser, 2005). An example of such approaches is described briefly in section 2.3 MALL in Education and Examples.

The common issue with these studies was that although vocabulary gains were proved via mobile device SMS or emails, the way these gains were produced was not obvious. Thornton & Houser (2005) deduced that constant messaging prompts learners to study vocabulary; while Cavus and Ibrahim (2009) concluded that learners study vocabulary more regularly because of enjoying the learning procedure of mobile learning.

According to Joseph and Uther (2009), multimedia and mobile devices facilitate language learners with authentic real word learning experiences by situating learning within the learners' cultural and linguistic schemata. They also referred to initial results of multimedia usage in mobile devices as 'promising', and considered the following as recommendations for an acceptable MALL pedagogy:

1. Consider learners' current ability and present learning material at their ability's level, or just beyond it.
2. Create genuine task-based learning.
3. Support interaction with others.
4. Connect with learner's current knowledge schemas.
5. Show visual and verbal information alongside each other.
6. Learners should have the choice of modality.

7. Learners should be prepared in advance. (p. 16)

The pen and paper traditional methods have lesser capacity when it comes to ease of preparation, and delivery of a wide range of tasks and activities; whereas MALL provides greater flexibility and functionality to facilitate learning and teaching with the mentioned pedagogies. Unique features of mobile devices, (as mentioned earlier), can facilitate the learning and teaching processes with these key pedagogical guidelines in mind.

Although numerous studies have been conducted about different methods and strategies to help learners in learning new vocabulary items, little research has been conducted on learning vocabulary items with help of a strong language learning method via mobile devices. In this study, a strong language learning methodology is implemented on mobile devices to provide the learners with an explicit strategy instruction that can effectively facilitate learning. As a result, the required modelling, guided practice and independent practice are making the key difference, and provide a significant contribution to MALL use for vocabulary learning. This study examines the use of mobile device applications for teaching the keyword method, for presenting a new set of word-pairs, testing learners' knowledge of newly learned word-pairs, and also evaluating the efficacy of learning vocabulary via mobile devices as a whole.

2.3 MALL in Education and Examples

MALL has been increasingly researched in the past years, and there are some studies which have made use of mobile devices for learning experiences via a strong successful vocabulary learning methodology. The following sub-sections will briefly introduce m-learning common practices in mobile and education, and some of the existing studies and their approaches.

2.3.1 Mobile Learning Application in Education

Huang (2014) defined as "the explosion of ubiquitous handheld technologies together with wireless and mobile phone network to facilitate, support, enhance and extend the reach of teaching and learning" (p. 9). Then, in the same study, mobile learning is described as "pedagogically similar" (p. 10) to traditional teaching. Of course, it is mentioned that there is a stronger request for media learning content, along with user-centred instructional procedure. Finally, different types of relationships between current pedagogical and educational practices relative to mobile learning are classified into four groups; situated learning, collaborative learning, argumentation and modelling, and scaffolding. The following outlines briefly describe the implementation of these teaching practices in mobile learning based on the research by Huang (2014).

- Situated Learning

This educational teaching practice has been used in mobile learning extensively. This is primarily due to the embedded location-aware function of most of mobile devices. In situated learning, learning is promoted in a genuine culture and context. With this approach, contextualised comprehension and real-life experiences are transferred to users/learners via mobile devices. This supports the learning process and increases problem understanding efficacy in education. Additionally, via situated learning, learners are able to physically shift their learning environment as they move. An example of situated learning usage in mobile device is language learning via Augmented Reality (AR) (Santos et al. 2016). This example is discussed later in the same chapter (see sub-section 2.3.2).

- Modelling and Argumentation

This educational teaching practice is used in mobile learning systems on rare occasions. In this approach, the students firstly observe the objects and then collect required information, analyse data or take notes. After this step, the gathered information is used by students to reflect on related scientific concepts under instructors' supervision. Mobile technologies can help students in providing the opportunity for modelling or argumentation. An example for this approach is an activity in which the learners firstly use a "toolkit" along with required hardware to collect data. Then, they are "guided through a process of posing inquiry questions, gathering and assessing evidence, conducting experiments, and engaging in informed debate" (Huang, 2014, p. 16).

- Scaffolding

This educational learning practice refers to the interactive support which is provided by instructors to the learners to "bridge the gap between their current skill levels and a desired skill level" (Huang, 2014, p. 13). This procedure gradually minifies as the learners' proficiency level increases, and in the end, the learner can complete the task on their own. Mobile-based scaffolding allows the learner to learn to create an interactive, media-supported, self-paced learning environment.

In our study, the above mentioned approaches were carefully analysed and considered when the application was being designed. After inspecting some MALL with vocabulary learning focus studies and research, explicit vocabulary learning strategy research reports could not be found in the existing literature. Thus, in current research, we focus on how to teach a learning strategy, how to present the vocabulary so that students can learn (teach themselves) new vocabulary. This is the major difference between the literature in this study and other previous research studies.

2.3.2 Augmented Reality (AR) for Language Learning

Santos et al. (2016) considered Augmented Reality (AR) as a potential tool for creating enthralling learning experiences. AR is a technology that superimposes a computer-generated image on a user's view of the real world, thus providing a composite view. In Santos et al. (2016) study, a combination of AR and environment along with a situated based learning approach was used. According to their study, visualising the information in context-rich environments using AR can aid students in creating meaningful associations between the content and the real environment. They also mentioned the only drawback of this method which is AR being prone to too much information presentation, leading to cluttered displays because of a lack of control of the environment. Besides this, AR is a rather new technology, and not everyone has access to it.

2.3.3 SMS for Vocabulary Learning

There also several studies which took advantage of SMS (Short Message Service) for language learning. Chen (2014) made use of SMS for learning English vocabulary. In his study, the participants were separated into two groups; a random group, and a concept mapping group, both receiving SMS for one week. Chen (2014) defined a concept map which was in the form of a diagram that included the ‘relationships of vocabularies’. The target vocabulary items were nouns (n), verbs (v), adjectives (adj), and phrasal verbs (phr v), which were further categorised into concept map categories. Then, the random group were receiving the target vocabulary via SMS once a day in a random order, whereas the concept mapping group were receiving the English vocabulary in two separate sections via SMS. At the conclusion, it was indicated the concept mapping group performed significantly better than the random group on the test scores of vocabulary learning.

2.3.4 PhotoStudy for Language Learning

In another study known as PhotoStudy, Joseph et al. (2005) produced a system to support vocabulary study on wired and wireless devices for EFL learners, to improve their vocabulary learning via word-image paired associates in a shared database. In their study, they considered a PhotoStudy system as the first mobile vocabulary study system for collaborative use of camera phone-generated images. In this study, the user was shown an image and a multiple choice quiz, and had to choose the word which described the shown image. Then, a feedback screen was available which led the user to the next quiz. In the end, they suggested that their PhotoStudy was evaluated as a popular feature in vocabulary learning tools with encouraging learning outcome, but needed more improvement on user interface design.

2.3.5 Email for Language Learning

Thornton & Houser (2005) made use of Email for EFL learners. In this study, several experiments were conducted, and different, short, mini-lessons were emailed to participants' mobile devices in different time intervals. Mainly, lessons included five words per week in multiple contexts, reviewed previously introduced vocabulary, and incorporated target words in story episodes. For evaluation, a questionnaire was employed. Besides these, a website for English idioms explanation was created in which students could produce an animation to show each idiom's literal meaning. Their study was evaluated as highly effective for language teaching, with few technical difficulties.

2.4 What Can Improve Vocabulary Learning?

Compared with the above mentioned practices, (which did not focus on facilitating learning with the use of an extensively studied and effective learning strategy), this study is based on a strong effective learning strategy - the keyword method - which can improve learning outcome significantly, and reduce the learning curve. This research is based on a successful and proven vocabulary learning method, which uses mental imagery or pictures, and a typical pen and paper classroom approach to learning and testing new vocabulary acquisition. The keyword method is described in the next section.

2.4.1 Vocabulary Learning Strategies

Ur (2012) discussed various vocabulary learning methods, and questioned the efficacy of using simple techniques such as learning lists of words. She suggested that learners avoid relying on extensive reading. Alternatively, learners should use effective instruction methods to remember a word's various meanings. Some of the available vocabulary learning instruction techniques are discussed below.

- <u>Decontextualized Techniques</u>

As the name implies, in decontextualized techniques, the vocabulary item is presented outside of any contexts. Unaldi et al. (2013) mentioned the keyword technique as a well-known decontextualized instruction technique for learning new words and their meanings. This technique is mainly used for memorising names, numbers, or new vocabulary items in a foreign language. Although the keyword method is well-researched, it is not commonly used by learners. Wordlists, flashcards and dictionaries are regarded as decontextualized instruction techniques as well. However, using these methods can rely on shallow processing, whereas using the keyword method requires elaborate processing through the use of images and associations; and because of that it creates strong memory paths.

- <u>Semi-contextualized Techniques</u>

In semi-contextualized techniques, the context is connected to other words or word-sounds, with the more extra-linguistic context or the provided context by multiple means, as in semantic mapping and keyword. Unaldi et al. (2013) listed words grouping, word or concept association, visual imagery, aural imagery, keyword, and physical response methods as semi-contextualizing techniques. They also regarded this technique as a sophisticated method which extend the common word lists that are not connected to any context.

- <u>Contextualized Techniques</u>

Contextualized techniques are defined as techniques which join new vocabulary with the full context. In other words, it is a vocabulary learning method to teach vocabulary items through the use of contextual tools. In these techniques, the meaning of words is inferred in a given context.

Finally, it is concluded that the keyword method, depending on how it is used, can be considered as belonging to any of these mentioned three types.

2.5 The Keyword Method

Atkinson & Raugh (1974) also described the keyword method as

> "a chain of two links connecting a foreign word to its English translation through the mediation of a keyword: the foreign word is linked to a keyword by a similarity in sound (acoustic link), and the keyword is

linked to the English translation by a mental image (imagery link) “ (p. 1)

The keyword method, which is the most studied mnemonic method in vocabulary learning, is a strategy for learning new vocabulary items such as foreign language words and their meanings. Via this method, two pieces of information can be linked together in memory with the help of a keyword. Kombartzky et al. (2010) defined a learning strategy as ‘‘(a) a sequence of efficient learning techniques, which (b) are used in a goal-oriented and flexible way, (c) are increasingly automatically processed, but (d) remain consciously applied’’ (p. 2). They also added that a learning technique should indicate specific internal learning activities. For instance, remembering a piece of information and establishing a relation between pieces of information is considered as an internal learning activity in a learning technique. Pressley et al. (1980) considered two steps for this keyword procedure:

The first step is to ask the student to associate the foreign to-be-learned word to the keyword which has similar pronunciation. The second step is to ask the student to form a mental image of the keyword ‘interacting’ with the translation of the foreign word. Thus, the foreign word is linked to a keyword by a similarity in pronunciation or sound (acoustic link), and the keyword is linked to the translation of the foreign word by a mental image (imagery link).

Lawson and Hogben (1998) defined the same stages as two elaborative procedures; foreign word and appropriate keyword generation, and interactive image development. Wyra et al. (2007) also used orthographic links to connect the new to-be-learned word with the keyword. They also mentioned that the keyword method may be effective only in initial stages of language learning; according to them, higher level students should be encouraged to develop “acquisition strategies that are either similar to, or as effective as the keyword method” (p 1). In their study, two groups of students were the participants of their experiment. One group was asked to use their own vocabulary learning strategy, while the other was asked to make use of the keyword method. In their final result, the keyword-trained students maintained a significant and substantial advantage in recall of word definitions over the control group students, over an extended period of time, and tested on four occasions.

Van Hell & Mahn (1997) considered the keyword method as a direct teaching method which has received notable positive attention; for example, they stated that the keyword method is an efficient method to facilitate foreign language learning. They also stated it enhanced recall when compared to ‘rote learning’, (in which the foreign word and its translation are simply rehearsed), and ‘unstructured learning’, (in which learners may choose their own strategy). They also mentioned that the keyword method increases immediate recall in vocabulary learning in a several languages such as Russian, German, Tagalog, and Chinese. Additionally, according to them, the keyword method is useful for both adults and children. They also found the keyword method to be effective no matter how the keyword was provided; whether being provided by the experimenter or being generated by the learners, the keyword method is an effective method for learning a new vocabulary item. Finally, they mentioned the domains of the keyword method to be much wider than just foreign language learning. Examples of learning botany concepts; and names and accomplishments of fictitious people were a support for their hypothesis.

On the one hand, the keyword method is found to be an effective and successful method for learning new vocabulary items. On the other hand, MALL is useful and popular among learners. Therefore, the keyword method is considered her as an appropriate option to be implemented on mobile devices; and it is feasible that implementing it in mobile devices could further enhance vocabulary learning experience, and increase learning effectiveness for learners. It is worth mentioning that the features of mobile devices can hopefully complement the keyword method and result in desired or even enhanced outcomes. The next section will briefly provide an overview of keyword method implementation on mobile devices.

2.6 The Keyword Method Implementation on Mobile Device

The keyword method has been studied for some time now in classrooms via different approaches, but all these studies were just based on pen and paper. This is the first time that this successful method is being implemented on mobile devices. In this study, the explicit keyword method instructions were adopted from the Wyra & Hungi (2007) study, and incorporated in the study design. Although the keyword method is known for its effectiveness in vocabulary learning, the keyword method is not well known and rarely used by learners. The aim of developing a mobile device application that teaches and facilitates the use of the keyword method will in turn increase the usability of this effective method by learners who will not need to rely on teachers to teach them how to use this method.

The motivation for studying mobile devices is that they offer a self-contained package for vocabulary learning, while providing a low cost/barrier of entry for end users and developers. Also, portability and self-teaching are other advantages of this method over the traditional one.

Given these factors and their overall popularity, mobile devices are more likely to play an important role in future adoption and acceptance of vocabulary learning of a new language.

3 Methodology

This study aims to evaluate the efficacy and usability of using mobile devices to learn the keyword method and to learn new words and their meanings. For this purpose, the keyword method was implemented within the mobile device application. In designing this study sound pedagogical principles underpinning explicit strategy instruction have been considered and applied. Some are directly linked with the MALL principles Joseph and Uther (2009) listed earlier. The first stage was concerned with teaching how to use the keyword method. Explicit instruction, examples, modelling and independent learning practice were used to facilitate the learning of the keyword method and its use. In the second stage learners used the keyword method to learn new rare English words and their meanings. In the third stage, learners' recall of newly learnt words and their meanings was tested.

For the programming environment, the Unity game engine was utilised to develop and implement the keyword method on mobile devices. The main reason for this was the beneficial features of Unity; such as being cross platform and supporting scripting. Also, C# and JavaScript languages were used for coding purposes. The development took around 4 months. Development is discussed in details in Chapter 4 Application Development.

For this study, two separate applications had to be designed: one for teaching how to use the application and the keyword method; and another one, which was the actual application. The actual application followed the same procedures as the pen and paper version of the keyword method instruction, along with some extra features - such as highlighting the common letter of keyword, and the target word. Also, a timer was shown to the user. The second application had three sections which were respectively, the section for teaching the vocabulary items, the section for testing the vocabulary items, and a System Usability Scale (SUS) questionnaire. SUS is an industry standard tool to evaluate the usability of software systems (usability.gov 2016). The first and the second sections were in the pen and paper method as well, but the third one was an extra feature designed specifically to measure the usability of the application. Figure 1 shows a screenshot of one scene from each of the mentioned application sections.

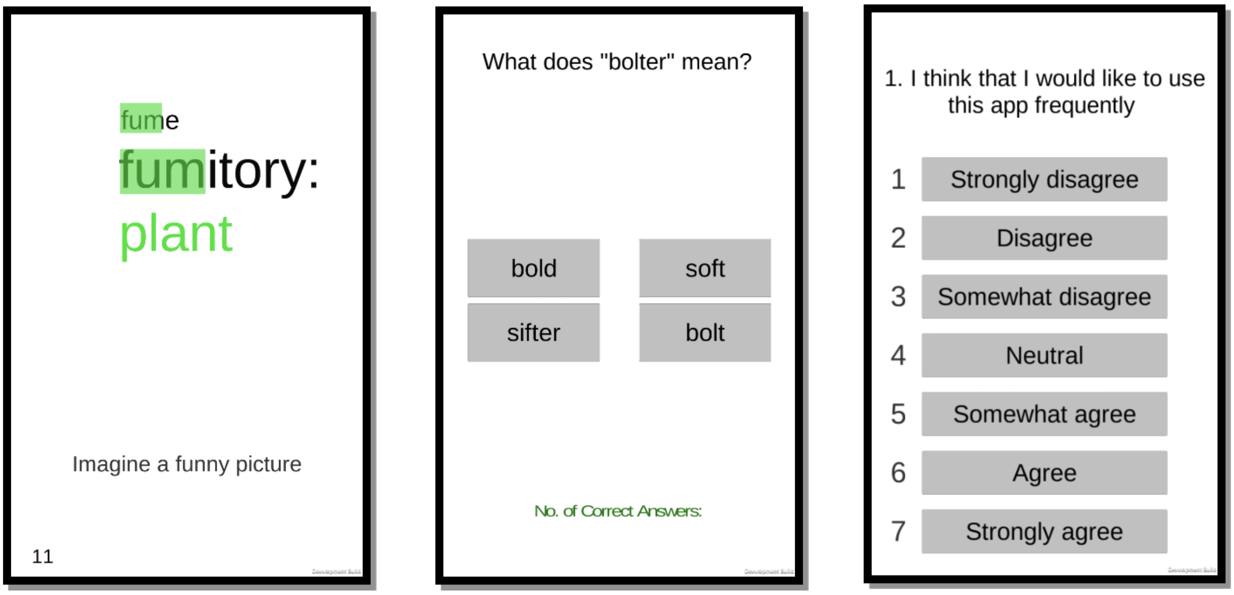

Figure 1: The teaching part of the app (left), the testing part of the app (middle), SUS questionnaire (right)

As shown on the left side Figure 1, there were no images shown to the user in this application, as the learner was required to create a mental image relating the meaning and the keyword which was provided for students, based on Van Hell and Mahn's (1997) findings, (as indicated earlier). They have stated that the keyword method is effective no matter how the keyword is provided; whether being provided by the experimenter or being generated by the learners, the keyword method is an effective method for learning a new vocabulary item.

While the primary device type used was a tablet, a pen and paper method was included as means of comparison that represents the commonly used traditional method. (Table 1)

Table *1*: Categories of form factor

Category	**Description**
Tablet	Mobile device with a screen size between 3-6 inches
Pen and Paper	Standard A4 paper and a pen; word learning booklet, test sheet

Data collection was done both individually and in groups; this data collection is discussed in more detail in Chapter 5, which describes the experimental study.

The information provided by participants helped to establish whether mobile devices offer a usable and effective means of learning vocabulary items with the help of the keyword method and are beneficial to novice learners. While there are a considerable number of applications which are designed for learning and testing new vocabulary, e.g., duolingo or memrise (colombiaimmersion.com 2016), the key benefit of this application is the use of a specific and supported learning strategy: the keyword method. Additionally, the collected data was useful to investigate whether there is any advantage to being able to use mobile devices for learning vocabulary. This is discussed in detail in chapter 6.

The participants were approached by mass Email sent to Computer Science Engineering and Mathematics and Education Faculties of Flinders University staff and students. The study was designed as a within and not between-participants experiment so that each participant could participate in both pen and paper traditional method and the application method.

4 Application Development

This study required two applications. One of these applications was a demo version for teaching the keyword method and the guide to using the application. The other one was the actual application; with three sections of learning vocabulary items, testing the recall on taught vocabulary items, and the SUS questionnaire. The second application was used for data collection, and the required statistical hypothesis testing to answer the second research question (RQ2. Will the mobile device application help learners to remember and recall more words than the traditional pen and paper approach?). The development Integrated Development Environment (IDE), implementation, algorithm design, application flow, user interface (UI) and user experience (UX) are discussed in this chapter.

4.1 Development IDE – Unity

Unity is a 3D game engine and a user-friendly Integrated Development Environment (IDE) which allows development on several platforms (unity3d.com 2016). Currently, it is possible to run Unity developed applications on iOS, Windows, Mac, Android, and Linux operating systems; as well as on Web browsers and in Flash instances. In this study, the application was developed on a Windows machine, and was developed to run on Android devices. The version of Unity used for development was 4.6.9.

One of the main reasons to use Unity for this project was its feature to deploy the application on different devices, allowing flexibility for future studies. Also, Unity offers a completely free version for educational and non-commercial use, which has most of the features of the paid version. Besides this, it has a relatively large development community which shares a considerable amount of documentation, support and information about different areas. What is more, Unity has some powerful tools and graphics which were used as per requirement in the produced applications.

At the beginning of the application development phase, basics of Unity was investigated and several online learning tools were used. The development was conducted on a laptop and a PC; both running Windows Operating System (OS); both the laptop and the PC were equipped with Intel Core i7 processors, and 8 gigabytes of RAM. The OS running on the laptop and the PC were respectively Windows 8 Enterprise edition and Windows 10 Professional edition.

The main programming languages used for development were C# and JavaScript. Scripting is also supported in Unity, and it was utilised to a great extent for development.

For the purposes of this study, two applications were developed; a version to provide instructions on using the main application; and the main or actual application. Besides this, two educational videos were produced to teach the keyword method and application functionality. In the next sections of this chapter, more details on Unity IDE and the developed applications are discussed.

4.1.1 Development and Implementation Tools

The default development environment which is provided by Unity for script writing is MonoDevelop (docs.unity3d.com 2016). Besides MonoDevelop, which is an Open Source Integrated Development Environment (IDE), Visual Studio was utilised as well. MonoDevelop IDE is shown in Figure 2.

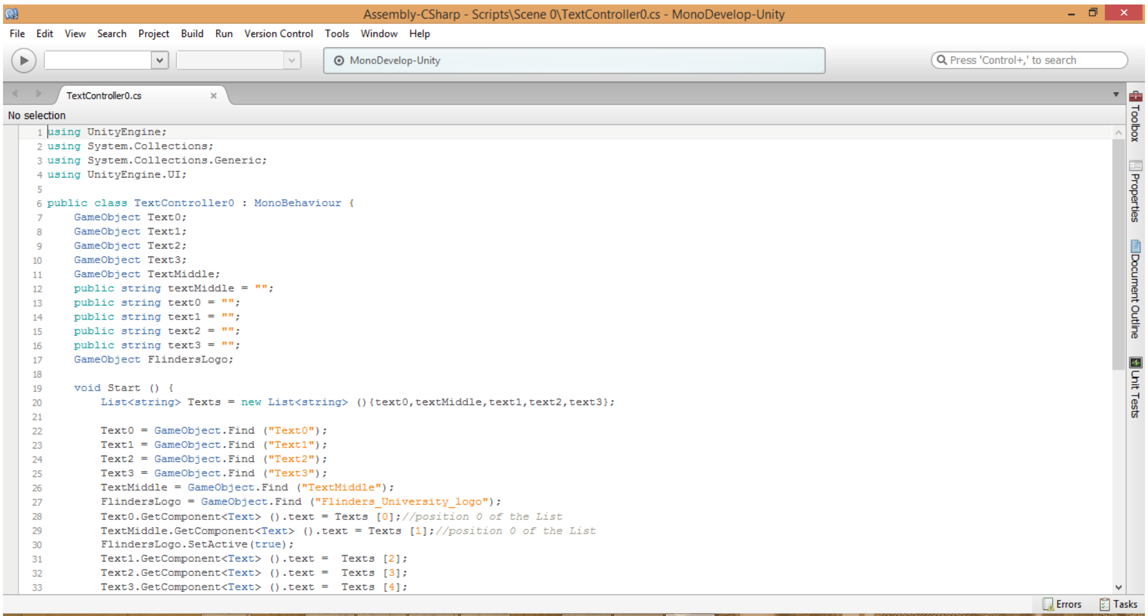

Figure 2: MonoDevelop IDE

MonoDevelop supports C# scripting which was primarily used for application development for the implemented mobile application; this is shown in Figure 2.

One useful development feature of Unity is its ability to integrate everything together; it uses scenes to keep everything, from the model and object to the levels, scripts and code, in a cohesive application development environment. It also manages organisation by keeping track of objects and their relations. This is done by creating a new object as a child of another object, which uses inheritance to allow the new object to keep the same position, scale and other attributes of the parent. In Unity, these relations are displayed as a hierarchy, with the children shown lower than the parent. Different parts of Unity along, with the discussed hierarchy structure in Unity, are shown in Figure 3.

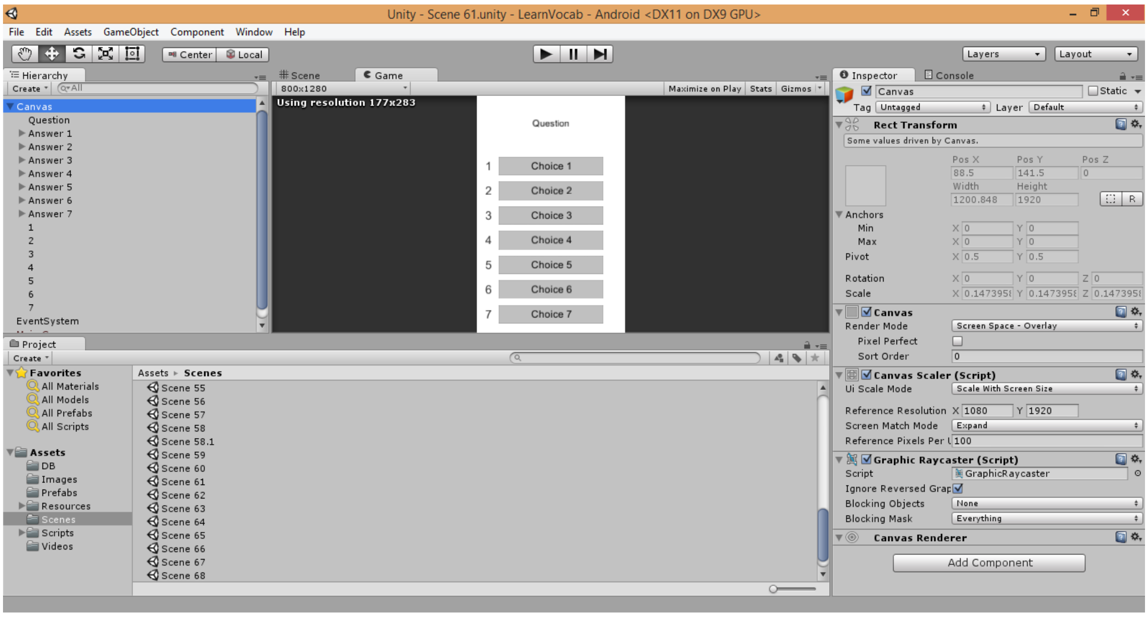

Figure 3: Unity Integrated Development Environment (IDE) and its features

As shown in Figure 3, on top left, the hierarchy of objects and their children is shown in the “Hierarchy” panel. In the middle, the “Game” and “Scenes” panels are located. It is also showing the Graphical User Interface (GUI) for the current level/scene. On the bottom left, the Project and its assets are shown in “Project” and “Asset” panels. On the right, the “Inspector” and “Console” are respectively shown, for object configurations and output.

In order to develop the application for mobile devices in this study, a level-based approach was utilised.

C# and JavaScript languages were used for coding purposes. Some of the customised algorithms for app development are discussed in next section.

4.2 Application Flow, Algorithm Design

The application starts with a splash screen which contains the name of the method, along with researcher and supervisors’ details, and the Flinders University logo. If the user clicked on this splash screen, they would be directed to the first vocabulary item to be taught; otherwise, after 5 seconds, the user would automatically go to the next scene. The splash screen is shown in Figure 4.

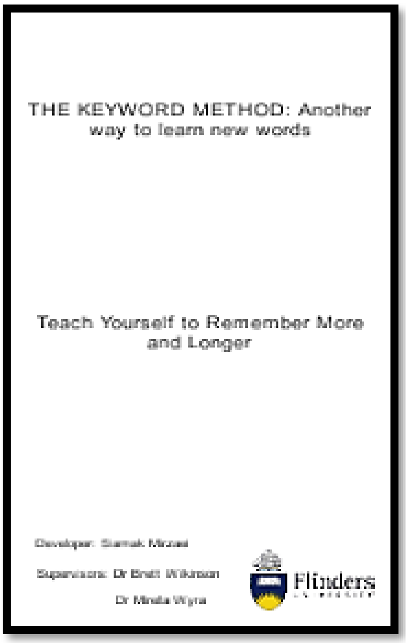

Figure 4: Splash screen

After the splash screen, the first part of the application which was designed to teach vocabulary items will appear; this is shown in the Methodology chapter in Figure 1. There were 22 vocabulary items to be taught; so 22 scenes of the same type were shown. For each of the scenes in these scenes, there were the following three steps:

Step one is to show the “Word” to be taught for one second (this is shown in Figure 5 - left).

Step two is to show “Meaning” after two seconds (this is shown in Figure 5 - middle).

Step one and two were mapping the previously mentioned step 1 of the keyword method which is called association (associating the foreign to-be-learned word to the keyword which has similar pronunciation, see 2.5)

Last step is showing the “keyword”, and highlighting in green the common letters (orthographic similarity) between the word and the keyword after 5 seconds (this is shown in Figure 5 - right). As mentioned previously, Wyra et al. (2007) used orthographic links to connect the new to-be-learned word with the keyword, and this is the reason to implement this feature in the application (see 2.5).

Figure 5: Different steps of teaching a vocabulary item in the application

After 20 seconds, the scene would automatically go to the next scene. The time allocated for learning new word-pairs (20 seconds) was adopted from Wyra et al. (2007) study. This was implemented by using the "Application.LoadLevel(Scene)" method which is provided by Unity, but of course some modification was required to apply it in a timely manner. Basically, this method only changes the scenes/levels whenever it is called. The algorithm behind this was having a counter starting from 20 to 0, and then scheduling each required action.

All these steps were designed according to methodology and study requirements adopted from Wyra et al. (2007).

After presenting the 22 vocabulary items to be learned, according to study requirements, participants were distracted, in order for them to stop thinking about the method and new vocabulary before engaging in the testing phase of this study. For this purpose, a simple algorithm was designed which has a game-like approach; the user was asked to tap on the "green" word while the answer to this question was shown as a multiple choice answer. This step was occurring repeatedly for 30 seconds with the word "green" showing randomly in different choices. If the user was tapping on the green, the number of correct taps was shown immediately. Otherwise, the correct choice was coloured green and the wrong choice was coloured as red. This step, (when the scene was updating every time and when the user was tapping on correct or wrong answer), is shown in Figure 6.

Figure 6: The step implemented in the application to distract the user (left – before tapping, right- after tapping correctly, middle – after tapping wrong)

The other algorithm which is considered here was a lock system, which was designed to not allow the user to tap on the correct answer more than once to get a higher score. This algorithm is discussed in detail in the next step.

After this step, a screen was shown to the user to ask them to start testing the taught vocabulary items; this was done by requiring them to click “Next” to start. The main reason for this was anticipating the user interaction; the user might have got bored with tapping on “green” and just tap continuously and thus miss a question; this scene is shown in Figure 7. Following the mentioned scene, the testing phase of the 22 taught vocabulary items started. If the user’s answer was correct, the choice was coloured in green; otherwise, the selected choice was coloured red, and the correct choice was then shown as green. In both cases, the number of current correct answers was displayed. This is shown in Figure 7.

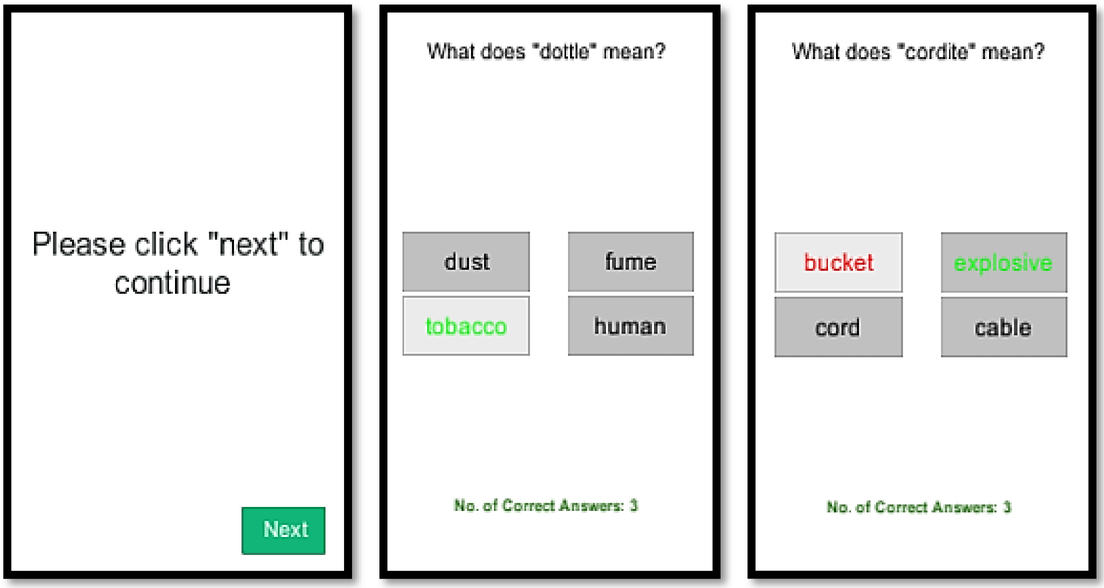

Figure 7: The screen to avoid continuous taps (left) – correct answer to question (middle) – wrong answer to question (right)

Showing the correct answer, while also locking out the choices so that the user cannot select several choices at the same time, (to get higher scores of correct answers), required research to design the needed algorithm. The algorithm for this purpose is functioning like a semaphore concept in OS; in this algorithm, a variable was used as a lock in the same way as in a semaphore, to make sure that the correct answer was counted only once. In other words, if the user was tapping two times on the correct answer, only the first tap was considered and evaluated. Then, the 'No. of Correct Answers: 'field which was showing the number of correct answers would be increased in case of choosing the correct answer.

Following this step, a screen was shown to the user for 5 seconds to request that they answer the SUS questionnaire about the application. After answering 10 SUS questions, a thank you screen was displayed, and the application was closed automatically. This is all shown in Figure 8.

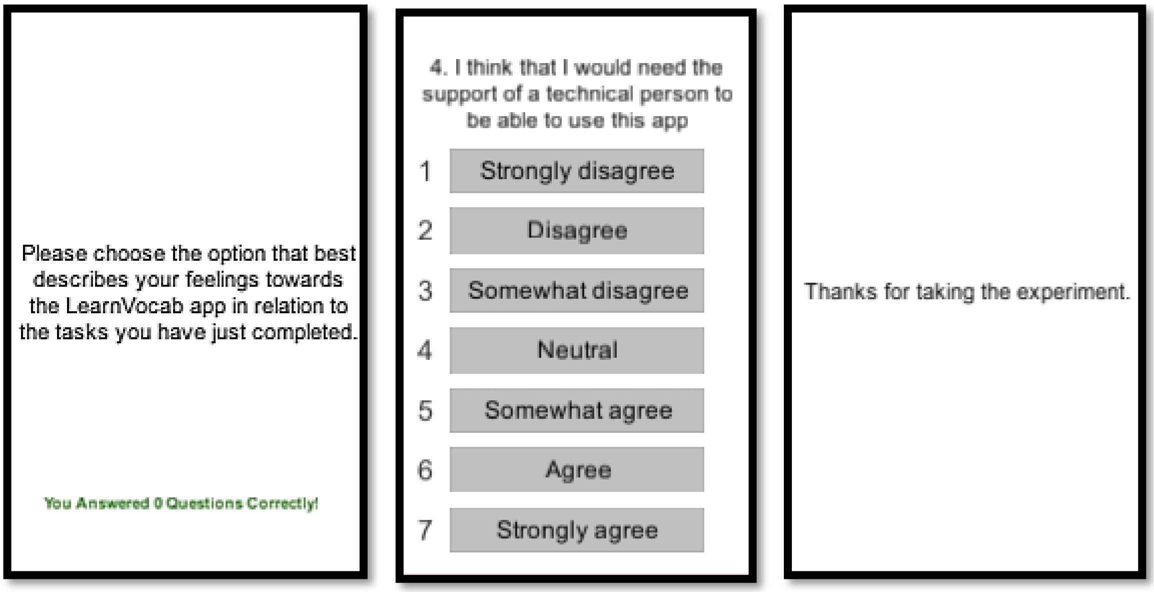

Figure 8: Announcement after testing vocabulary items (top left), SUS questions (top right) and thank you screen (bottom)

It is worth mentioning that all the steps were recorded via the “Unlimited Screen Recorder” application; and also by back end user interaction recording. In the end, all user interaction with both the multiple choice questions and the SUS questionnaire were saved as a file to the mobile device memory.

The two main algorithms considered to facilitate study requirements are discussed in the following sub-section.

4.2.1 Multiple Choice Randomisation Based on Factorial Algorithm

The reason to consider this custom randomisation algorithm was to show different options for the same question every time that the application was run. This is shown in the Figure 9.

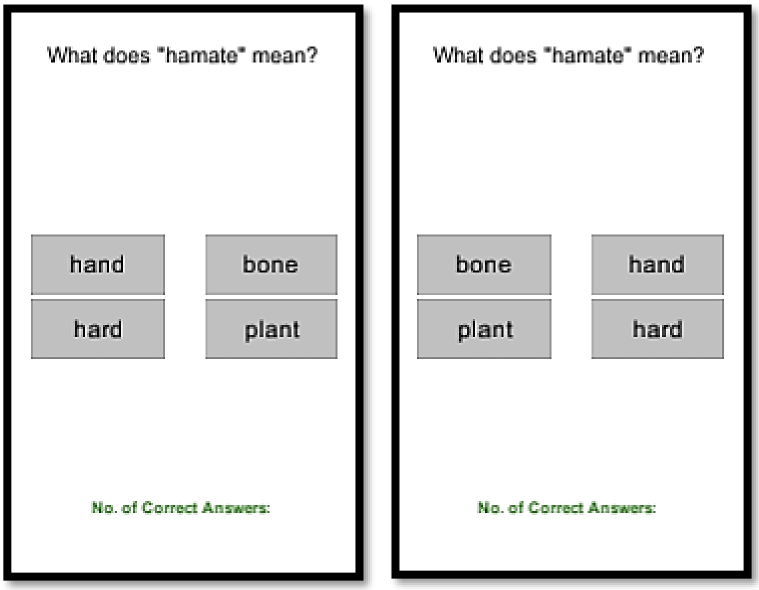

Figure 9: The first time the application runs a scene (left) and the second time the same scene is shown (right)

As shown in Figure 9, the implemented algorithm was only considered for the scenes which were testing the 22 taught vocabulary items.

Besides the mentioned algorithm, the number of learners' correct answers was recorded and shown both in the front end and the backend. The last step was to save all user interactions for further analysis. This was done by both saving the answer to each question and using a screen recording application called "Unlimited Screen Recorder". Figure 10 shows how the correct answers were shown to the users while answering each question.

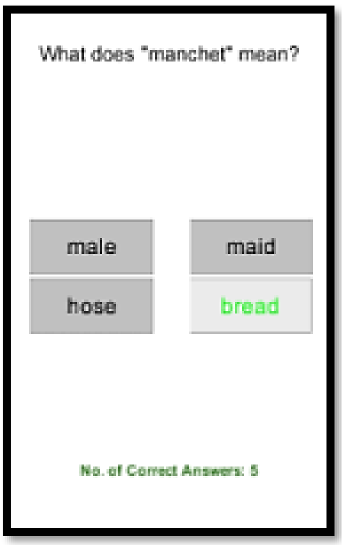

Figure 10: Application is showing the number of correct answers to the user

4.2.2 Saving the Number of Correct Answers and SUS Choices Algorithm

There was a need to design an algorithm to keep track of the number of correct answers along with the answers to the SUS questionnaire. This algorithm was used to save the number of correct answers and also the answers to SUS questionnaire answers. Android permission for saving the file and also how to name the file were the most difficult ones. The first problem was how to save a file on Android devices as there are permission issues. StreamWriter was utilised to tackle this problem. "Application.persistentDataPath" was utilised as the path to save the file for storage issues on Android devices. The second issue was having two file with the same name. In this case, files will overwrite one another and collected data will be lost. To solve this, randomisation methods were used and the file name consisted system DateTime as "hours^month@day!year!" plus a number between -5000 and 5000. This was giving a number with 10000! (factorial) possibilities which made it almost impossible to have the same name for two files. This is shown is Figure 11.

```
System.DateTime.UtcNow.ToString("HH^mm@dd!MM!yyyy!") +
UnityEngine.Random.Range(-5000.0f, 5000.0f)
```

Figure 11: The formula to solve the file name issue

4.3 User Experience (UX) Design

Mobile device functionality has changed dramatically over the past decades and a mobile device is not a device which is used just for voice communication solely. Deryckere (2008) pointed out this enormous growth in mobile applications as one the main grounds for which designers and incorporations need to consider their applications' usability and the ways to improve it.

Considering the important role of User Experience (UX) in user engagement any application is crucial in any studies. In order to evaluate the level of engagement and usability of an application, UX research has been introduced. However, researchers have defined UX differently. According to Nielsen-Norman Group (2016), UX is defined as "All aspects of the end-user's interaction with the company, its services, and its products. The first requirement for an exemplary user experience is to meet the exact needs of the customer without fuss or bother. Next come simplicity and elegance that produce products that are a joy to own, a joy to use. True user experience goes far beyond giving customers what they say they want or providing checklist features". As the definition implies, several factors should be considered in UX design. Mansoor & Mahboob (2011) considered the following as the UX factors in their study (see Table 2).

Table 2: UX factors (Mansoor and Mahboob, 2011, p 25)

UX Factor	Description
Aesthetics	Beauty, attractiveness, coolness, sexiness
Emotions	Joy to own, joy to use, fun
Feelings	To judge, to think, opinions
Expectations	Previous experiences make expectations
User Needs	User requirements
Context in Use	Environment, social and cultural issues
Usability	Functionality, learnability

4.3.1 UX Design and Evaluation in this Study

As UX is an important part of any research, in this research project, in the application design phase, some of these factors including feelings, expectations, user needs, and usability were considered (as shown in Table 3).

Table 3: UX factors considered in this study (based on Mansoor et al, 2011, p 25)

UX Factor	Description
Feelings	To judge, to think, Opinions
Expectations	Previous experiences make expectations
User Needs	User requirements
Usability	Functionality, learnability

The following is a brief explanation of how these factors were considered.

- UX Factors - Feelings, Expectations

In this study, there were two supervisors supplying different expertise. The first, Dr Mirella Wyra from the School of Education at Flinders University, provided list of vocabulary items along with supervision of different phases of both pen and paper and application methods (Wyra et al., 2007). The second, Dr Brett Wilkinson from the School of Computer Science Engineering and Mathematics at Flinders University, has a background in Human User Interaction in Mobile Device; as a result of his suggestions, each object alignment, colour of each objects, fonts size and selection, highlighting colour and positioning, and overall scene design were discussed at length, leading to several redesigns.

The to-be-learned word-pairs were selected carefully to ensure that they were new words to potential participants. Rare English nouns and their English meanings were used in both pen and paper and mobile device experiments

- UX Factors - User Needs, Usability

In order to examine the UX in this study, questionnaires, interviews, SUS and user interaction recording and storage were utilised. This was done at the time of each experiment.

4.4 User Interface (UI) Design and Interaction Design

Garrett (2010) defined User Interface (UI) as appropriate selection of suitable interface elements so that the user can easily accomplish the desired task. According to Valoris (2015), Interface elements are input controls such as buttons, text fields, lists, icons, navigation elements such as breadcrumbs and sliders, informational elements such as tooltips and progress bars, and containers such as accordions.

In the designed applications, elements such as buttons, texts, icons were available and in these elements several factors such as unity/consistency, arrangement and style of text, visual hierarchy (such as font size), texture, colour, shapes, spacing, contrast between colours, and typography were carefully considered and applied to meet User Interface recommendations for best practices provided by Valoris (2015). The following were the criteria:

1. Horizontal Scrolling: Application avoids horizontal scrolling
2. Graphics/Text: Graphics and text are not distorted, blurred or pixelated
3. Orientation: Application supports landscape and portrait orientation and is capable of rapid transition between orientations
4. Screen Space: Design is for a single window or full screen; main task is front and centre
5. Consistent Interface Design: The interface of the application is consistent – when application directs users to webpages they are mobile friendly and fit with the application interface design
6. Button Size: Application uses appropriately sized buttons and touch targets (i.e. buttons are easy to click and react appropriately to touches)
7. Back Button Navigation: Application supports/uses standard back button navigation

8. Labels and Icons: Labels and Icons are descriptive, clear, concise, and consistent (inform the user about what content will be provided when clicked)

9. Page Titles: Application provides descriptive yet concise page titles that clue the user into the content of the page

10. Main navigation utilizes a navigation format consistently (expanding menu, side menu, tabbed menu, hub and spoke menu)

(p 34)

According to the time constraints and the scope of this study, not all features of the applications were designed and some were postponed to be done as future work. Also, some of the above items like 7 and 10 were not required by the application design.

4.5 Challenges in Mobile Application Development

The research by Erfani Joorabchi (2016) indicated that mobile application developers encounter new sets of challenges and there has been some previous research conducted on this area recently. According to her, while there is a significant amount of qualitative studies on different areas of software engineering, there is not much research conducted on challenges the mobile developers are facing. Some of issues which were encountered regarding mobile application development in this project and the solution to these challenges are discussed in the following paragraphs.

- <u>Cross-Platform IDE</u>

One challenge that Erfani Joorabchi (2016) discussed in detail as general challenges that mobile developers encounter is "Moving toward Fragmentation rather than Unification" (p 20). She then discussed the two kinds of fragmentations which are across platforms (the difference for each mobile platform in User Interface (UI), User Experience (UX), Human Computer Interaction (HCI) standards, Application Programming Interface (API)/ Software Development Kit (SDK) and tools) and within the same platform (different properties such as CPU speed and graphical resolution of each mobile device causes this). As further explained in the same paper, an appropriate solution to this issue is making use of an available cross-platform tool.

- <u>Capabilities of Device Platform</u>

Another challenge that Erfani Joorabchi (2016) covered in her research was the different capabilities of each platform. For instance, among Android OS different versions, different potentials are causing different behaviours. In our study, Android OS version 4 (KitKat) and above were used for application development at first. This was possible through some configurations in Unity. After designing the application, Unlimited Screen Recorder application, which was video recording the screen while the participants were taking the experiment, caused some compatibility issues on the used devices (ASUS Nexus 7 and Samsung tablet SM-T330). The issue was that the mentioned application was only compatible with Android OS version 5 (Lollipop) or above. Therefore, after reconsidering this issue, Android OS version 5 was used as the base for the application development. Another possible solution was making use of another application for recording the screen. But, the problem with this solution was that other applications were not having the same performance and usability as Unlimited Screen Recorder application.

- Code Reuse or Coding from Scratch

A number of scenes were designed and developed for this study; out of which 60 scenes were allocated to the main application, and 7 scenes were considered for the demo application. In the main application, firstly with the coding from scratch approach, more than 70 different scripts were required to make the application ready. However, the application required rapid changing, and this approach would not meet this requirement. After facing this problem, code reuse approach was considered and the same code was applied to different scenes wherever possible. An example of this was the script which was run through the whole application during run time to handle changing the scene. After making use of code reuse approach, only 16 scripts were used for the main application.

5 Experiment

For the experiment, while the primary device type used was a tablet, pen and paper was included as a means of comparison that represented a commonly used traditional method. The details regarding the experiment are discussed in this chapter.

5.1 Experiment Process Description

Participants in this study were available staff, postgraduate, and undergraduate students in the School of Computer Science, Engineering, and Mathematics (CSEM) and School of Education at Flinders University. Also, some of the participants were overseas students in Iran with high English language proficiency. Rare English words were taught and tested for this study. The list of the vocabulary items and multiple choice questions, which were used for testing the taught vocabulary items is available in Appendices A to D.

The experiment encompassed five phases, each of which is described below:

At the start of the experiment, a document containing details of the task was made available for reference.

The first phase of the experiment asked participants to attend a brief training session on the use of the keyword method for learning vocabulary items on pen and paper and on a tablet. This phase was done via the help of two instructional videos which were created for this purpose. Also, part of this training involved completing a brief background questionnaire on prior experiences with vocabulary learning in a language via mobile devices. This background questionnaire is available in Appendix F. Completing the remaining phases involved using each of the methods.

In the second phase and third phase of the experiment and after completing phase one (learning the keyword method), participants were scheduled to learn the new words and then being distracted as required by the study design.

In the fourth phase, the participants were asked to test the learnt words.

Phases one to four were conducted either in individual or group session. The list of the vocabulary items and the multiple choice questions used in phases three and four are available in Appendices A to D. In group sessions participants were working independently, in the same manner as participants in the individual sessions.

As mentioned above, for phase two, three and four of the experiment, participants were asked to use the pen and paper traditional method to learn vocabulary items. Then, the participants were asked to use a tablet to learn vocabulary items. Phases two and four presented participants with a series of vocabulary items and asked them to use both methods to learn them. The same number of vocabulary items were used in each of pen and paper and mobile device application methods (2 x 22 vocabulary items). Each set contained different words but was controlled for the type and length of words (2-3 syllable concrete meanings nouns). The mobile device and pen and paper experiment orders were reversed for half of the participants to remove any potential bias. Thus, out of total 16 participants, 8 did the mobile device method first, and the other 8 did the pen and paper method first. The order of which method to do first or second was chosen randomly to remove any bias.

In phase five of the experiment, after the mobile device method, a SUS questionnaire which was embedded in the mobile application was completed by the participants. This phase only existed for the mobile device method.

Following completion of phase five, a brief interview was conducted by the researcher seeking the participants' feedback on the methods used. Interactions with the mobile device method was digitally video recorded during phases two end of phase five. A recording application was used to make this possible. This ensured that user interaction is recorded and stored for future study.

5.2 Collected Data

The answers to all the questions were stored automatically on the tablet internal memory card as a text file after the participants were seeing the last scene and before the application was closing. These data were stored as an array of comma separated 0s and 1s for the vocabulary testing section and as 1 to 7 range for the SUS questionnaire section of the application. For the testing section, if the answer to the question was correct, the saved data would be 1. Otherwise, a 0 would be saved. Each participant's completed questionnaire had a unique code and the date and time of the experiment was recorded by the researcher. As the mentioned text file was saved with a name format which included the exact date and time of participation, it was possible to check which participant did each experiment in each method for further analysis. After all participants took part in the experiment, all the data relevant to each participant were manually entered into an Excel file. Then, the comma was removed via Excel functions and the 1s and 0s were left. This is shown in Table 9 in Appendix E.

In Table 9, ‘Q’ stands for ‘Question’ and ‘P’ stands for ‘Participant’. Thus, ‘1’ in the ‘P’ column is the first participant in the experiment and ‘Q1’ is the first question of either the application testing sections. Participants’ correct answers to each question were extracted from Table 9. This was done by calculating the average of each row. For the pen and paper method, as the participants had to answer the multiple choice questions on paper, there was no other way than counting the number of correct answers for each participant. After doing so, the total number of correct answers for each participant was counted as well. Finally, the number of correct answers to each question out of 22 was calculated and recorded in an Excel file for data analysis purposes. The result of collected number of correct answers for both methods’ phase 4 (testing learnt vocabulary) is shown in Table 7 (see Appendix E).

In Table 7, the first column shows the number of participants, and the second and third column show the number of correct answers to questions 1 to 22 in the application and to questions 1 to 22 in the pen and paper methods respectively.

Also, with the same approach, the collected data for SUS questionnaire was collected as shown in Table 10 (see Appendix E).

Numbers 1 to 7 in Table 10 was showing users’ level of agreement/satisfaction and their meaning are shown in Table 11 (see Appendix E).

According to Table 11, if the participant has chosen ‘1’ as the response to question one of the SUS questionnaire, s/he strongly disagreed with this question. As the number is growing, the level is satisfaction is rising as well. The maximum number can be ‘7’ which means the user strongly agrees with the statement. The 10 statements (SUS question statements) are shown in Table 12 (see Appendix E).

The SUS questionnaire is analysed in chapter 6.

6 Results Analysis

The collected data analysis is described in this chapter. Section 6.1 is the analysis for the SUS questionnaire while section 6.2 is showing the analysis to examine if one method is improving vocabulary learning when compared to the other method based on the number of correct answers in each method.

6.1 SUS Analysis

System Usability Scale (SUS) which is an industry standard tool to evaluate the usability of software systems was used to evaluate the usability of the developed application for this study. Brooke (1996) defined SUS as a simple, ten-item Likert scale which gives a global view of subjective assessments of usability. Brook (1996) also suggested that SUS should be utilised after the user has interacted with the system and before any discussion. According to Brook (1996), the users "should be asked to record their immediate response to each item, rather than thinking about items for a long time" (p. 5).

For calculating the score of SUS, Brook (1996) considered a single number which represented a composite measure of the overall usability of the system being evaluated. He also mentioned that scores for individual items are not valid solely. He recommended the following method for calculating the SUS score:

> "First sum the score contributions from each item. Each item's score contribution will range from 0 to 4. For items 1,3,5,7, and 9 the score contribution is the scale position minus 1. For items 2,4,6,8 and 10, the contribution is 5 minus the scale position. Multiply the sum of the scores by 2.5 to obtain the overall value of SU. SUS scores have a range of 0 to 100."

(p. 5)

In our study, we applied the same rules as mentioned by Brook (1996) to calculate the SUS average score. 10 questions are usually asked in SUS questionnaire which were assigned a number. These questions are listed in Table 12 (see Appendix E).

Table 10 and 11 (see Appendix E) respectively include the answers to each question in Table 12 chosen by each participant and the meaning of chosen answer. The percentage of the participants who chose each of the options 1 to 7 in Table 10 is shown in Table 13. This can be interpreted as $\frac{C}{n} * 100$ where C is the count of each option in each column (in Table 10, count could be achieved via counting the number of occurrence of each option) and n is the total number of participants (which was 16 for this study).

After the experiment, the collected SUS answers were used to calculate the SUS score according to usability.gov. The SUS results showed that the application is user-friendly as the average SUS results for the 16 participants was 87.7. SUS scores less than 58 indicate that the application is not usable. Scores above 68 are acceptable and above 80 are considered as application with 'A' grade. This means that the designed app is an 'A' grade and it currently has perfect usability. Table 4 shows SUS scores, grades and the measurements used for it (Table 4):

Table 4: SUS Score Measurement (System Usability Scale (SUS), (2016))

SUS Score range	Grade	SUS score measurement
>80	A	Perfect usability
>74	B	Good usability, minor changes
>68	C	Acceptable usability but can improve
<58	D	Not usable

To better analyse this, a scatter diagram which is showing the individual score of each participant is shown in Figure 12.

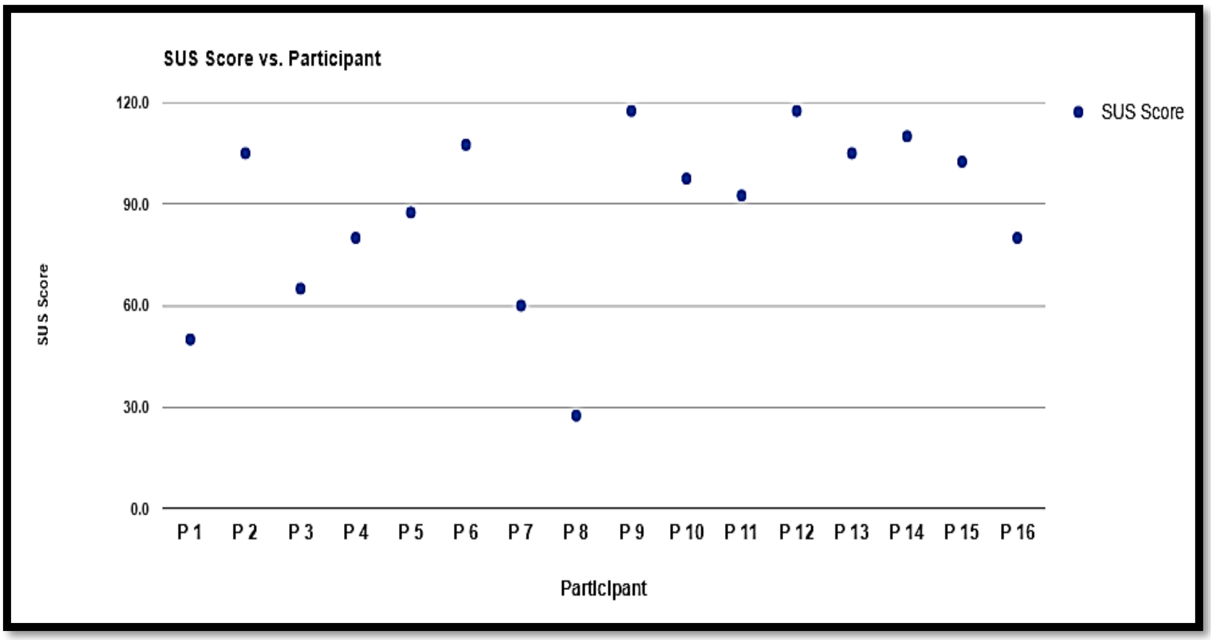

Figure 12: SUS Scatter Diagram (SUS average score = 87.7)

In Figure 12, each point shows the calculated SUS score for each participant P1 to P16. As shown in this Figure, only 1 participant was in the <51 SUS score range or has the D SUS grade (according to Table 4).

6.2 Student T-Test Hypothesis Testing Analysis

The information provided by participants help to establish whether mobile devices offer a usable and effective means of learning vocabulary items and are beneficial to learners. This information was also useful to investigate whether there is any advantage to being able to use mobile devices for learning vocabulary items.

A paired-samples t-test was conducted to compare the number of correct answers in mobile device method and pen and paper method. The main reason to make use of this test was to compare the changes before and after using the application.

Our null hypothesis was that "learners of the mobile device method answer fewer correct answers than the learners of the pen and paper method". After doing the statistical calculations, there was a significant difference in the scores for mobile device method (M= 18.9375, SD= 4.1226) and pen and paper method (M= 17.875, SD= 4.379878) conditions; $t (16) = 2.95932$, $p = 0.009747$.

These results suggest that the mobile device method improve vocabulary learning as p- value $< \alpha$ ($\alpha = 0.05$) indicates a significant difference. Thus, the null hypothesis is rejected for the alternative hypothesis which is "learners of the mobile device method answer more correct answers than the learners of the pen and paper method."

The results obtained from the experiments suggested that mobile device usage for vocabulary learning via keyword method improves vocabulary learning.

According to Table 7 (see Appendix E), the following can be extracted by considering 11 correct answers as 50% of correct answers: (Table 8, Appendix E):

As indicated by Table 8, while the application used in the experiment allowed 8 out of 16 participants to learn all of the new vocabulary items and 12 of them to have an average of 17 correct answers, the pen and paper traditional method allowed 4 participants to learn all of the new vocabulary items and 10 of them to have an average of 17 correct answers.

7 Conclusion

The goals of this project have been to evaluate the efficacy and usability of mobile devices in learning new vocabulary learning items. It attempted to achieve this through experimentation and measurement. By comparing two sets of collected data from the experiments on both mobile device method (application), and pen and paper traditional method, it is concluded that mobile device usage for vocabulary learning via the keyword method improves vocabulary learning. However, better results could be achieved if time, scope constraints and participants' availability allowed us to conduct more experiments. For this purpose, current participants' feedback in the pilot experiment can be applied to redesign the experiment for future.

As mentioned before, there are no other reports of an application that teaches how to use the keyword method, which is using the principles of the keyword method to teach, and tests new vocabulary acquisition. This research shows that the number of words learnt through the application was higher than through the use of the traditional pen and paper keyword method. However, as this is the first investigation of its kind, it is important that more studies are conducted with different populations (young children to adults) and using different languages.

According the results obtained by this research, mobile devices can increase vocabulary learning by heling the users recall more words. As indicated by SUS results, participants tended to use mobile devices instead of the pen and paper traditional method for its ease of use and their habit of using mobile devices rather than pen and paper. Challenges in using the developed mobile device application still exist for the designed application is a working prototype currently, however, participants' feedback can reduce these challenges.

7.1 Future Work

Besides a larger sampling set, with more variation (discussed in Limitations, below), to confirm these initial findings, future work in this area would likely include adding different techniques such as Virtual Reality (VR) and Augmented Reality (AR), testing different mobile devices for user experience, and utilising different language sets, (including technical language as well as foreign language).

The idea of adding AR seems more reachable, as it can be implemented with a game-like approach in Unity. It can also be associated with situated based and environment based learning. VR can be applied with the same concept and along with AR.

It seems clear that this application needs a proper database system to handle different files and add to its capabilities; a database can improve the application to a great extent by allowing it to have access to several sets of vocabulary items. This would be essential for a continuous use in formal, (e.g., school classroom), and informal, (independent learner), learning contexts. Also, it can further equip the application with features such as adding images and other media files to further strengthen the effects of using visual imagery to improve vocabulary learning and recall.

The study reported here provides valuable basis for such further work in this new, and yet unexplored area.

7.1.1 Limitations

The data reported in this thesis was based on a limited sample of 16 participants. While the data showed some fascinating trends, and presented acceptable figures in the efficacy and usability of using mobile devices, it was by no means a representative sample and therefore, cannot be used to make claims of that nature. Moreover, the sample of participants from which the data was derived were almost exclusively computer experts. These users are likely to hold some bias (even if it is on a subliminal level). A larger, more diverse sample would certainly be valuable for further investigation.

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Appendices

Appendix A: Pen and Paper Vocabulary Booklet

* The keywords are highlighted.

Table 5: Pen and paper vocabulary booklet

Rare English word	Meaning
casern*	barracks
bustard	a bird
claymore	sword
jarvey	driver
lapidist	dealer
paddle	hoe
ramekin	cheese dish
ratine	fabric
tarn	lake

oxter	armpit
afield	away
apace	quickly
portent	sign
bannock	bread-cake
bier (keyword: beer)	platform for carrying a coffin or body
bay	bark
lamprophony	loudness and clarity of enunciation
brood	children
cesspool	sewage
cob	spider
coney	rabbit
doodle sack	old English word for bagpipe

Appendix B: Pen and Paper Multiple Choice Questions

Name: Code:

Date:

1. What does casern mean?
   a. bar
   b. barracks
   c. case
   d. palace

2. What does bustard mean?
   a. bird
   b. cow
   c. bread
   d. honey

3. What does claymore mean?

a. bar

b. case

c. knife

d. sword

4. What does jarvey mean?

    a. jar

    b. bus

    c. driver

    d. war

5. What does lapidist mean?

    a. lap

    b. dealer

    c. bike

    d. smuggler

6. What does paddle mean?

    a. pad

    b. brake

    c. hoe

    d. hand

7. What does ramekin mean?

    a. cheese dish

    b. plate

    c. bone

    d. ham

8. What does ratine mean?

    a. fabric

    b. man

    c. bread

    d. beard

9. What does tarn mean?

   a. tar

   b. plant

   c. lake

   d. farmer

10. What does oxter mean?

   a. armpit

   b. animal

   c. ox

   d. bird

11. What does afield mean?

   a. rubber

   b. dealer

   c. bus

   d. away

12. What does apace mean?

   a. sword

   b. quickly

   c. pace

   d. hoe

13. What does portent mean?

   a. gorilla

   b. apple

   c. man

   d. sign

14. What does bannock mean?

   a. bread-cake

   b. water-bottle

c. orange-juice

d. dining-table

15. What does bier mean?

a. platform for carrying coffin

b. container for carrying letters

c. case for carrying books

d. car for carrying bikes

16. What does bay mean?

a. bark

b. bay

c. cat

d. flower

17. What does lamprophony mean?

a. loudness

b. signage

c. lamp

d. darkness

18. What does brood mean?

a. parent

b. puzzle

c. children

d. river

19. What does cesspool mean?

a. pool

b. sewage

c. plant

d. flower

20. What does cob mean?

a. female

b. honey

c. spider

d. cow

21. What does coney mean?

a. husband

b. rabbit

c. cigar

d. girl

22. What does doodle sack mean?

a. doodle

b. bag

c. wallet

d. bagpipe

Appendix C: Mobile Device Vocabulary List

Table 6: Mobile device vocabulary list

Word	Definition
fumitory (keyword: fume)	a climbing, vine-like plant
dogger	a fishing boat
catkin	a cluster of flowers
flamen	priest of ancient Rome
gunnel	salt-water fish
inkle	linen tape for trimming garments
fanfold	a writing pad
corniche	road built on a cliff
bullace	plum
antiar	poison used on arrows by natives

cotter	a tenant farmer
windling	a bundle of straw
hosel	part of a golf club
bolter	sifter
cowry	glassy seashell
gaskin	part of the leg of a horse
lumper	a person who loads and unloads boats
piggin	a small wooden bucket
cordite	an explosive powder
dottle	pipe tobacco
hamate	a wrist bone
manchet	a small loaf of white bread

Appendix D: Mobile Device Vocabulary Multiple Choice Questions

What does "hosel" mean?

house | part of golf club
hose | celery

No. of Correct Answers:

What does "cotter" mean?

plant | farmer
apple | cot

No. of Correct Answers:

What does "windling" mean?

straw | flame
seashell | fury

No. of Correct Answers:

What does "corniche" mean?

road | corn
cider | plum

No. of Correct Answers:

What does "antiar" mean?

gorilla | bread
fish | poison

No. of Correct Answers:

What does "bullance" mean?

fume | plum
straw | car

No. of Correct Answers:

What does "fanfold" mean?

fan | fold
explosive | tablet

No. of Correct Answers:

What does "fumitory" mean?

male | celery
straw | plant

No. of Correct Answers:

What does "inkle" mean?

gun | ink
tape | farmer

No. of Correct Answers:

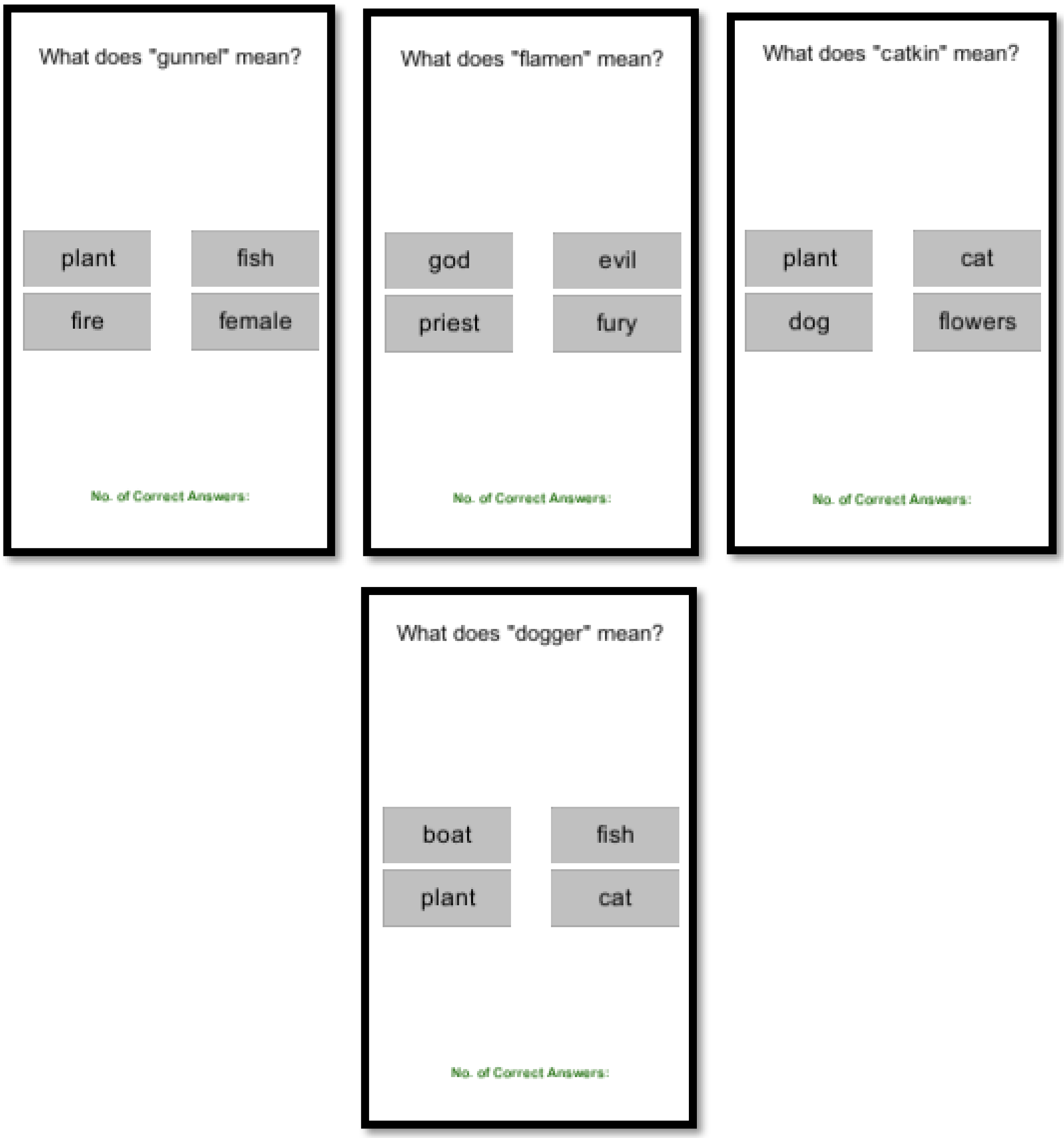

Figure 13: List of application multiple choice questions

Appendix E: List of Tables

Table 7: Number of correct answers in each method

Participant No.	No. Correct Answers - App	No. Correct Answers - Pen & Paper
P 1	10	8
P 2	19	15
P 3	12	12
P 4	19	18
P 5	15	16
P 6	22	20

P 7	13	12
P 8	19	15
P 9	22	21
P 10	22	20
P 11	22	21
P 12	22	22
P 13	20	20
P 14	22	22
P 15	22	22
P 16	22	22

Table 8: Percentages of correct answers

Percentage of correct answers (11 correct answers out of 22 questions is 50%)	No. participants answering correctly in application method	No. participants answering correctly in pen and paper
Under 50% correct	1	1
100% correct	8	4
Over 77% correct	12	10
Over 50% correct	15	15

Table 9: Saved data on tablet memory for all 16 participants (after being added to excel)

P	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22
1	0	0	1	1	1	1	1	0	1	1	0	1	0	1	0	0	0	1	0	0	0	0
2	0	1	1	1	1	1	1	1	1	1	0	1	0	1	1	1	1	1	1	1	1	1
3	0	0	0	0	1	1	1	0	1	1	1	0	0	1	0	1	0	0	1	1	1	1
4	1	1	1	1	1	1	1	0	1	1	1	1	0	1	1	1	1	1	1	1	0	1
5	1	0	1	0	1	1	1	1	1	1	1	1	0	1	0	1	1	0	0	1	1	0
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	0	0	1	0	0	1	1	1	1	1	1	0	1	1	1	1	0	1	0	0	1	0
8	0	1	1	0	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
13	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1
14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Table 10: Answers to SUS questions

P / Q	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
P 1	5	5	3	5	4	2	4	4	5	5
P 2	6	4	7	1	3	1	7	1	7	1
P 3	7	6	6	5	5	5	6	2	2	2
P 4	2	2	6	2	5	2	5	3	6	3
P 5	4	1	7	2	5	2	4	3	5	2
P 6	6	1	7	1	6	2	6	3	7	2
P 7	4	5	5	5	4	3	5	3	5	3
P 8	2	2	2	2	1	5	1	6	4	4
P 9	5	1	7	1	6	1	7	1	7	1
P 10	7	4	6	2	4	2	6	2	7	1
P 11	6	2	7	2	4	5	7	2	6	2

P 12	6	1	7	1	6	2	7	1	7	1
P 13	6	2	6	1	6	1	6	2	6	2
P 14	5	2	7	1	6	1	7	2	6	1
P 15	6	2	7	2	4	1	7	2	6	2
P 16	6	3	6	2	4	3	5	3	5	3

Table 11: Meaning of SUS collected data in Table 10

Options	Meaning
1	Strongly Disagree
2	Disagree
3	Somewhat disagree
4	Neutral
5	Somewhat agree
6	Agree
7	Strongly agree

Table 12: SUS questions and their numbers in this study

No. assigned to question	Question
1	I think that I would like to use this app frequently
2	I found the app unnecessarily complex
3	I thought the app was easy to use
4	I think that I would need the support of a technical person to be able to use this app
5	I found the various functions of this app well integrated (e.g. camera, screen, audio)
6	I thought there was too much inconsistency with this app
7	I would imagine that most people would learn how to use this app very quickly

8	I found the app very awkward to use
9	I felt very confident using the app
10	I needed to learn a lot of things before I could get going with this app

Table 13: SUS Satisfaction level percentage

Satisfaction level	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**
Strongly Disagree	0	0	0	0	0	0	0	0	0	0
Disagree	12.5	37.5	6.25	43.75	0	37.5	0	37.5	6.25	37.5
Somewhat disagree	0	6.25	6.25	0	6.25	12.5	0	31.25	0	18.75
Neutral	12.5	12.5	0	0	37.5	0	12.5	6.25	6.25	6.25
Somewhat agree	18.75	12.5	6.25	18.75	18.75	18.75	18.75	0	25	6.25
Agree	43.75	6.25	31.25	0	31.25	0	25	6.25	31.25	0
Strongly agree	12.5	0	50	0	0	0	37.5	0	31.25	0

Appendix F: Background Questionnaire

ID

Flinders UNIVERSITY

Background questionnaire

SBREC Project no. 7289

1. What is your age range?

   - [ ] under 21
   - [ ] 21 to 30
   - [ ] 31 to 40
   - [ ] 41 to 50
   - [ ] 51 to 60
   - [ ] 61 and over

2. What is your gender?

   - [ ] Male
   - [ ] Female

3. What school do you belong to within the University?

   ____

4. Do you currently own a smartphone device?

   - [ ] Yes
     - What device(s) do you own?

       ____

       ____

     - Do you use your smartphone for learning vocabulary?
       - [ ] Yes. Which language do you learn?

         ____

         ____

       - [ ] No

1

Figure 14: Background questionnaire page 1

Flinders University

Background questionnaire

SBREC Project no. 7289

ID

- Do you use pen and paper to learn vocabulary?
  - [ ] Yes. Which language do you learn?

    ____

    ____

  - [ ] No
- [ ] No

5. Have you ever used an application to learn vocabulary on your smartphone (on <u>any</u> device)?
   - [ ] Yes
     - Approximately how long ago?
       Please list as weeks, months, or years (as appropriate).

       ____

     - Overall, did you enjoy the experience?
       - [ ] Yes
       - [ ] No. Why not?

         ____

         ____

   - [ ] No
   - [ ] Don't know

That completes the background questionnaire. Please return it to your test moderator.

2

Figure 15: Background questionnaire page 2