A Case Study in Tablet-Based Augmented Reality Vocabulary Acquisition

Article · April 2023

DOI: 10.58887/ijodel.v8i2.96

1 author:

Adam Dabrowski
The University of Electro-Communications
2 PUBLICATIONS **1** CITATION

SEE PROFILE

A Case Study in Tablet-Based Augmented Reality Vocabulary Acquisition

Adam Dabrowski

Lecturer, The University of Electro-Communications, Japan, adam.dabrowski@uec.ac.jp

Abstract

Augmented Reality (AR) is a novel technology capable of embedding digital objects within a user's experience of reality via a smartphone, tablet, or head-mounted display. AR offers interesting pedagogical applications and research possibilities in the field of Second Language Acquisition, particularly in the deliberate study of vocabulary. Such applications also offer implications for distance learning. This case study examined a 25-year-old Japanese language teacher in her deliberate acquisition of three sets of 15 vocabulary items selected from the first 1,000 most frequent words of Basque. A word card study method was compared with two AR vocabulary study methods. One AR study method involved the study of physical objects and their signifying Basque vocabulary items within a context-independent scene which was unknown to the participant. The second AR study method similarly involved the study of physical objects and their signifying Basque vocabulary items within a context-dependent scene which was known to the learner. In terms of vocabulary retention as measured with meaning recognition, form recognition, and form recall tests, both AR methods of study appeared to be as effective if not more so than word cards. The study of vocabulary items represented by physical objects in a contextualized environment with the use of a tablet-based AR application was beneficial in leveraging the recall of meaning and form of those items. During reflective interviews regarding the use of AR, the participant indicated that she found the novel method of vocabulary study to be engaging and motivating. The findings of this study also indicate that mobile AR applications have potential pedagogical uses relevant to distance education practices.

***Keywords**: augmented reality, deliberate vocabulary learning, tablet-based AR, visuospatial bootstrapping, distance learning*

Introduction

Vocabulary study and acquisition in a second language is a well-established and researched area within the field of Second Language Acquisition (SLA). The use of word cards in the study of vocabulary and the opportunities they offer for retrieval, spacing, and feedback have been thoroughly examined by Nakata (2020). The use of word cards is touted for its efficiency and effectiveness in the four strands of language curriculum development proposed by Nation (2013).

In the last 50 years, computers have become smaller, faster, and more accessible. People can be seen operating handheld touch screen devices in both urban and rural settings. There are many applications that can be accessed using smartphones and tablets that replicate word cards and can be applied to language study. Entering the search terms *word cards* or *flashcards* in your mobile device's application repository or marketplace application returns hundreds if not thousands of word card applications.

As technology development advances and allows for more powerful computing possibilities, new modalities of technology known broadly as *immersive technologies* capable of providing access to *immersive realities* are becoming more popular. Virtual Reality (VR), which refers to an entirely immersive computer-generated environment, is now an accessible technology and head-mounted devices such as the Oculus Rift S, Meta Quest series, or HTC Vive series which allow users to play video games, communicate with other users virtually, and watch movies in a VR environment have been released for public consumption.

Augmented Reality (AR) is another similar immersive digital technology that can be used to enhance the environments we experience in our real, day to day lives. AR differs from VR and this is discussed in the following section. AR devices are relatively new and offer opportunities for research in the field of vocabulary acquisition in SLA and more generally in the field of education.

Literature Review

This literature review focuses on a selection of studies which have been conducted to understand how AR might aid in education and in the acquisition or study of vocabulary in a second language, and what are its implications to distance education.

AR technology refers to an emerging set of technologies that allows users to experience additional digital information which is overlaid onto the reality experienced by the individual in their current bodily capacity. Such additional information could be visual, auditory, or sensed in another way (e.g., haptic feedback, shifting masses, or supplemental fragrances). AR technology allows for real and virtual objects to be interacted with in real time (Azuma, 1997). AR differs from virtual reality (VR) in that VR engulfs the visual field of the user to provide a completely computer-generated environment, whereas AR technology aims to enhance what can be experienced rather than obstruct and replace. The objects that can be experienced in AR and VR exist on the Reality-Virtuality Continuum, a theorized scale that encompasses all possible physical, real-world objects and virtually experienced objects (Milgram et al., 1994).

AR devices come in a variety of different shapes and sizes. It is likely you have a device capable of providing an AR experience in your pocket right now. Any smartphone can be used as a device capable of overlaying virtual objects, labels, or other AR experiences into reality. Tablets, haptic feedback bands, and headsets are other devices which can also offer AR experiences.

With the development of these new technologies, many novel applications are emerging. The application of AR in pedagogy and education contexts is of growing interest. AR allows for the creation of new integrated and immersive spaces by educators (Squier & Jan, 2007). Previous research has shown that AR use in the classroom can help to boost student motivation (Billinghurst & Dueser, 2012). It can be used to gamify learning and encourage student-to-student interaction (Liu et al., 2016). AR can also support many pedagogical approaches such as constructivist learning, situated learning, games-based learning, and enquiry-based learning (Bower et al., 2014).

Vocabulary Study: AR Technology versus Traditional Methods

A common theme in the very few studies published currently about AR use in vocabulary acquisition is the comparison of AR technology use, either with an AR mobile handset or a head-mounted display, with word cards and teacher fronted lessons.

He et al. (2014) conducted research on the promotion of vocabulary study with the use of a smartphone-based AR application among EFL learners in a Chinese preschool. They investigated how an AR software application designed for fetching images and pronunciation of vocabulary performed as compared to teacher-centered vocabulary lessons. The researchers concluded the mobile based AR treatment appeared to be far more helpful in teaching the vocabulary set as compared to the traditional teacher-centered lesson. The teachers shared comments on their perceived benefits of the tactile, auditory, and visual elements that the technology was able to provide. They also shared concerns about the distracting nature of such devices used in the classroom.

Chen and Chan (2019) investigated the vocabulary learning and acquisition through an AR system among kindergarten-aged English language learners in Macau. The researchers were interested in understanding if the use of vocabulary word cards in instruction via an AR software, which was smartphone and tablet based, would yield significant improvements in performance between a pretest and posttest. They also wanted to understand how and if the students instructed with the AR based word cards would significantly differ in their ability to acquire vocabulary as compared to a traditional paper-based method of instruction. They investigated what the teachers involved thought about the use of the AR technology in pedagogy. The researchers concluded that both the AR technology treatment group and the paper-based groups made significant gains over the course of the treatment when pretest and posttest scores were measured against each other. They also found that there were no statistically significant differences between the two groups in terms of their learning gains. Both groups performed similarly to each other in their ability to acquire the instructed vocabulary.

Ibrahim et al. (2018) assessed the use of head mounted AR technology in the study of a set of 30 Basque words at a university in California. The researchers sought to understand if there was a benefit to using AR for vocabulary learning over the use of electronic word cards. They also investigated if vocabulary recall varied from vocabulary recognition. Their third interest was how users

perceived the language learning experience with the AR technology as compared to the traditional method. Participants studied the vocabulary set by viewing real-world items in a laboratory with a Microsoft HoloLens headset. The vocabulary set was from the Basque language, chosen for its isolated features and lack of homonyms in English. Participants took part in 90-second activities and then completed a distraction task before taking a posttest. The participants were tested with both recognition and recall tests. A delayed test, accomplished four days after the treatment, was conducted remotely to collect delayed posttest data. The results suggested that participants who studied with the AR system scored significantly better on both immediate and delayed posttests as compared to a word card control group. The paper suggested that a real potential exists for the use of AR systems in language learning, especially because of the observed sustained recall ability of the AR participants.

Geng and Yamada (2020) carried out research to better understand the effect of an AR vocabulary learning system on learners of Japanese in their acquisition of compound verbs. They investigated whether an AR system capable of displaying animations developed to exemplify compound verbs made a difference in their learning experience as compared to a paper-based treatment method, which made use of image schemas theorized to exemplify the compound verbs. They also sought to understand if the different methods influenced the participants perceived cognitive load and if the cognitive load perceived was related to their performance in each respective treatment. Both methods of study led to growth. They also found that intrinsic and germane cognitive loads experienced by the participants were higher for those in the AR group, while the extrinsic cognitive loads of paper-based groups were higher. Despite these descriptive differences, there was no significant difference in overall cognitive load experienced between the two groups, which the researchers noted was unexpected, and could perhaps be explained by a poor design in the application they used for the AR system. The researchers noted that lower intrinsic and germane cognitive loads of the AR group correlated with longer retention of knowledge and that perceived cognitive load was related to the participants' learning performance and likely had been affected by their motivation.

In a study by Larchen Costuchen et al. (2021), two vocabulary learning technologies were contrasted: AR under visuospatial bootstrapping (VSB) and the Quizlet method (electronic word cards). The researchers investigated whether the AR-VSB method could improve the retention of learners and reduce the rate at which learners forget when they are learning Spanish vocabulary within idioms as compared to study with Quizlet. The design involved a pretest, treatment session, posttest, and delayed test. The AR treatment group placed AR barcodes which triggered AR events around their living space on walls near objects which were familiar to them. The study discovered that the AR-VSB treatment was significantly more effective than the Quizlet procedure on both posttests and delayed posttests. This novel use of a visuospatial bootstrapping method for vocabulary language learning seems to have some implications for further research and offers many gaps to be researched. For example, what is the relationship between the study of vocabulary items via AR in a known environment and the retention of those items? Do environments which

are more familiar and personally known to the participant offer more leverage for retention in AR vocabulary study as compared with less contextually rich environments? In this study, the learners set up the system in their room or living space. Do variations in influence provided by the personal spaces in which learners studied vocabulary exist? Each of these questions are worthy of further investigation.

AR Vocabulary Study and Motivation

Another focus of existing AR vocabulary studies is the investigation of how the implementation of AR for vocabulary study in pedagogy affects the motivation of language learners. In a study by Solak and Cakır (2015), researchers investigated on the effect of teacher-directed AR EFL vocabulary activities and materials on language learners' motivation towards the materials as assessed with Keller's (1987) Material Motivational Survey. The experiment also focused on understanding motivational differences towards the materials based on gender or field of study. In this study, 130 'false beginners' (*false beginners* were defined as students who are made to study a subject again from a perceived beginning despite prior ability or knowledge) of English spanning four majors: Turkish Language Teaching, Computer and Instructional Technology, Psychological Counseling, and Theology Teaching, engaged with AR in lectures. Based on the results of the survey, the researchers concluded that the AR treatment had a positive effect on the motivation of the participants, and it encouraged the students to participate in AR vocabulary activities in the classroom. They found no statistically significant differences in perceived motivational benefits based on the participants' gender nor major. There also was a significant positive correlation between the academic achievement levels of the students and their motivation related to the use of AR in the classroom for vocabulary activities.

Chen and Wang (2016) investigated the effects of learning styles determined by the Group Embedded Figures Test (GEFT), a psychological test pertaining to field dependence, and prior English ability on performance in AR vocabulary study. They investigated the results of L2 vocabulary study and perceived motivation when AR technology was used for EFL vocabulary study among elementary school students in Taiwan. The researchers sought to understand if there was a significant difference in the motivation and/or vocabulary acquisition by students designated to two different learning styles, field independent (FI) and field dependent (FD), and based on their levels of proficiency, after learners took part in a vocabulary learning task which made use of an AR technology. The researchers concluded that FD participants made significantly higher gains on the vocabulary tests than FI participants indicating that learning styles might interact with an ability to learn vocabulary with AR. They observed that the motivation levels of the participants were relatively similar across both groups and noted that a higher proficiency in English was very likely to have a strong effect on learning achievement while using the AR treatment, though there were no statistical differences between the groups in terms of their motivation.

In a study on acquiring Arabic vocabulary with AR enhanced word cards, Zainuddin et al. (2016) explored the use of AR as a scaffold to support 24

elementary-level students of Arabic attending a university in Malaysia. The researchers sought to understand what steps and procedures might be involved in the development of personalized vocabulary word cards in an AR application to provide scaffolding and help students retain the vocabulary. The satisfaction that students experienced when using personalized word cards in the AR application in their vocabulary studies was also explored. A procedure in which the students created personalized word cards with an AR application based on their own reading experiences while focusing on a text of Arabic was introduced. The students first scanned an image which served as a trigger image for one of the vocabulary items to be studied. The trigger image was uploaded by the students to the AR application *AURASMA*. The students then created a video which contained information about the vocabulary item the image served to trigger. The video was attached to the AR trigger. The students shared these augmented word cards to a directory and used them as group tasks for study. After a round of treatment, the students filled out a questionnaire adapted by the researchers from Martin-Guitarrez et. al (2010). These results were theorized to be a survey of the satisfaction levels of the participants.

In a study by Taskiran (2019), the use of AR gameplay and its motivating elements in an EFL context were examined. The researcher sought to know if AR games could help to motivate Turkish EFL learners. They also wanted to investigate the differences in interest/enjoyment and value/usefulness subscale scores. Four different AR games which employed a smartphone or tablet to trigger different AR objects embedded with English vocabulary were examined. These games were created and designed by the researcher using the application AURASMA. The four games were used in four separate classes. After gameplay, the participants were assessed using Ryan and Deci's (2000) Intrinsic Motivation Inventory to understand how the experiences of the participants affected their motivation. Forty-one low and 42 intermediate-Turkish EFL university students, ages 18-24, engaged in mobile AR vocabulary games. The researcher concluded that all students who participated in the study appeared to have enjoyed the AR games. Many of the participants found the activities to be highly motivating and rewarding. The games drew the attention of the learners and caused students to focus on the task at hand. The researcher also found that the positive affective results show that social aspects, cognitive aspects, and affective aspects could be leveraged by AR vocabulary games to create an environment conducive to language learning. The outcome of the value/usefulness subscale scores indicated that students thought that such games were valuable for their own language learning experience.

Mobile AR Applications: Practical Utility and Distance Learning Implications

When the reader thinks of an AR apparatus, the image of a bulky, head-mounted device that is similar in shape and form to current virtual reality headsets may come to mind. Currently, state of the art head-mounted AR devices are available for purchase. However, these devices are generally expensive and are therefore impractical solutions for most researchers, teachers, students, or independent learners who might want to engage in vocabulary study with the use of AR. A practical answer to the inaccessibility of these expensive AR products is the ubiquity of mobile devices (i.e., smartphones and tablets) which are readily

available around the world and allow users to engage in budget-friendly AR pedagogical experiences. The findings of the studies mentioned above that utilized mobile devices offer an implication regarding distance learning: deliberate vocabulary study with mobile devices is possible and practical; mobile devices are likely to meet the pedagogical needs of researchers, teachers, students, and learners, especially in distance education scenarios.

Gaps and Purposes

As AR technology continues to advance, it will likely present more applications and opportunities for research in SLA. One area worthy of research is the use of AR in deliberate vocabulary acquisition, specifically with the use of mobile devices. Smartphones and tablets are widely available and are currently capable of running AR software and applications. If novel AR study methods indeed compare to or exceed traditional methods in L2 vocabulary study, the ubiquity of smartphones and availability of AR software offer great pedagogical implications. Additionally, no previous studies have sought to examine how variations between AR study environments and scenes populated by realia representative of vocabulary items might affect their acquisition. As the scene or environment in which AR is used is a necessity and yet highly variable, the importance of the environment in which AR is used to study vocabulary is worthy of investigation.

Research Questions

1. How does a tablet-based AR method of vocabulary study perform as compared to paper-based vocabulary word cards in terms of vocabulary acquisition and retention?
2. How do context-independent AR environments compare to context-dependent AR environments in terms of vocabulary acquisition and retention?
3. How does the participant perceive the AR study method?

Methodology

Participant

The participant was a 25-year-old Japanese woman who lives in Tokyo, Japan. The participant is referred to with the self-chosen pseudonym Rachel. Rachel is a university graduate and works as a Japanese language teacher of foreign and exchange university students living in Japan. Rachel has a limited command of English and rarely uses English in her daily life. Rachel has lived most of her life in Japan but studied English intensively for a three-month period while in a university in New Zealand. Rachel has not had any exposure to the Basque language according to a preliminary interview and questionnaire. Rachel was oriented to the study with a consent form, which described her right to end her participation in the study at any time with no consequence, the removal of personal identifying information from the stored data, the consent to use data and photographs taken during the study in future academic manuscripts and presentations, and the storage of the data collected–all data collected was

stored in a password protected folder on an external hard drive kept in a locked drawer.

Instrumentation

Vocabulary Sets

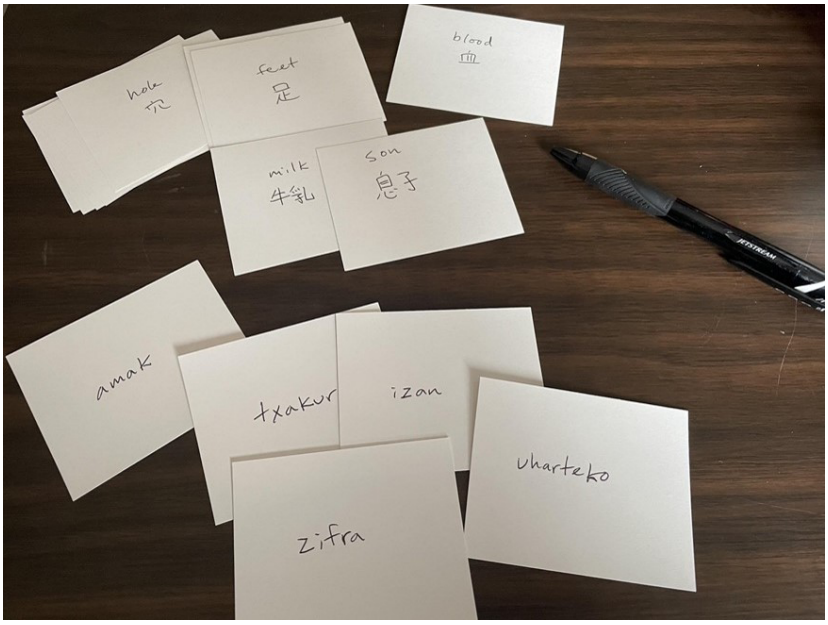
Forty-five concrete nouns from the Basque language were selected for this study. These words were selected from the first 1000 most frequent words of Basque (Terminologia eta Lexikografia Zentroa, 2017). Concrete nouns of this level were selected for two reasons. First, they are capable of being embodied by commonly known, physical items which were placed into AR study scenes. Second, words from this band of frequency were deemed to be level-appropriate for a complete beginner to the study of Basque. Each of the three sets of vocabulary consisted of 15 concrete nouns.

Treatment Set 1: Paper-Based Word Cards

The first treatment method employed paper-based word cards on which 15 Basque concrete nouns were written. These word cards were created by the researcher. One side of each word card displayed the target word in Basque with the reverse side displaying the equivalent term in both English and Japanese. Figure 1 shows a sample of the word cards used in Set 1. A list of the words in Set 1 and their meanings in English and Japanese are in Appendix A.

Figure 1

Paper-Based Word Cards Format



AR Application: ARIO

The second and third treatment methods employed an iPad to run a tablet-based AR application called ARIO (Ario Technologies Incorporated, 2022). ARIO is an application which allows the user to place a variety of virtual elements into a physical location which can be experienced and interacted with through the camera and screen of the tablet. Virtual labels containing the Basque target words and their equivalent meanings in English and Japanese separated by slash marks were anchored to real world items in a scene embodying those words. A 2018 10.5-inch iPad Pro was used. When creating an AR environment in ARIO, first a scene is captured with the camera. The information about the scene collected is processed automatically by the application which uses optical recognition technology to create a visuospatial map of the environment. The researcher prepared both environments with the application.

Treatment Set 2: Context-Independent AR Labels

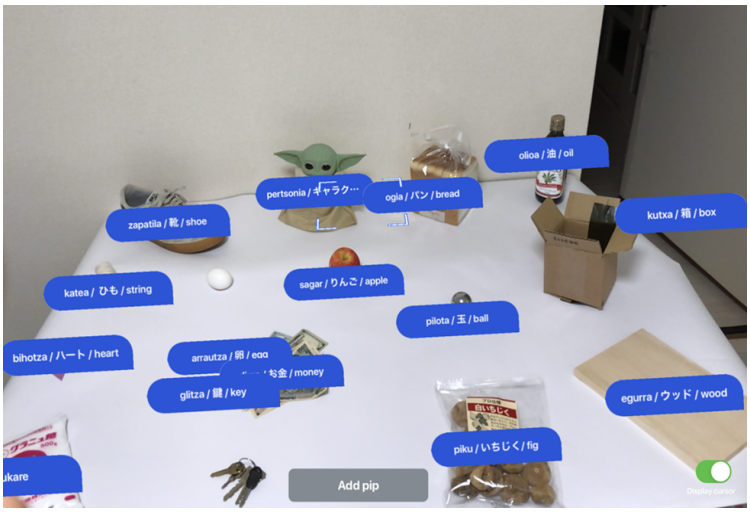
Treatment Set 2 contained 15 Basque non-thematically linked concrete nouns. These items were anchored visuospatially in the AR application in a context-independent environment (see Figure 2). The context-independent environment was a table with white paper on top of it. Physical items which corresponded to each vocabulary item in Set 2 were placed onto the table and were tagged with an AR label. The items were arranged in the scene to keep thematic connotations to a minimum. A screenshot of the view of the scene through the AR application on the iPad which shows the visuospatially anchored labels can be seen in Figure 3. The items and corresponding translations of Set 2 are in Appendix B.

Figure 2

Context-Independent Environment Scene and Items

Figure 3

Context-Independent Environment Scene and Items with AR Labels



Treatment Set 3: Context-Dependent AR Labels

Treatment Set 3 contained 15 Basque concrete nouns thematically related to a desk space. These nouns were anchored visuospatially in the AR application within a context-dependent environment, a desk space. The scene in which the vocabulary items were tagged via the AR application was known to the participant. She has used this desk space and is familiar with the items that populate it and their possible locations in the space. Figure 4 depicts the context-dependent AR treatment scene. The view of the scene through the AR application including the anchored vocabulary labels is depicted in Figure 5. A close-up view of some of the tested items in the AR application attained by moving the tablet physically closer to the desk is depicted in Figure 6. The set of Basque words and their English and Japanese equivalents used in Set 3 are in Appendix C.

Figure 4

Context-Dependent Environment Scene and Items

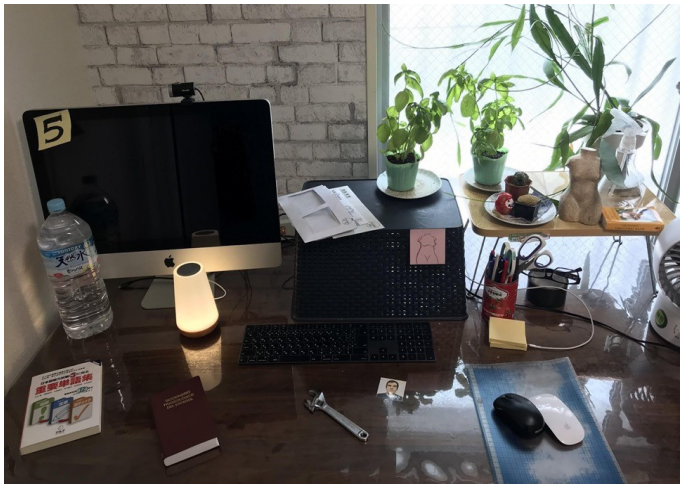
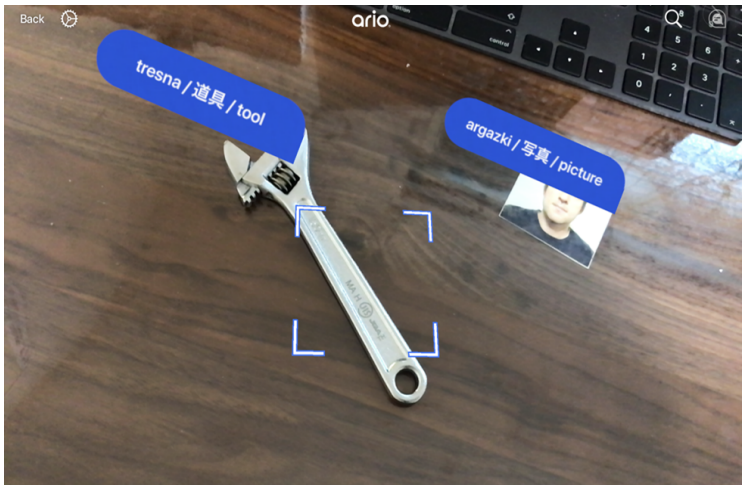


Figure 5

Context-Dependent Environment Scene and Items with AR Labels

Figure 6

Context-Dependent Environment Scene and Items with AR Labels, Closeup



Pre, Post, and Delayed Tests

For each of the three vocabulary sets, a pretest, posttest, and delayed posttest were conducted using Google Forms. The format of each test was uniform except for the pretests. The pretests offered the option “I do not know this word” so that the participant could establish an accurate baseline of her knowledge of the words being tested. Each test contained three sections: meaning recognition tasks, gap fill form recognition tasks, and form recall tasks. Each meaning recognition task provided a target Basque word the participant was prompted to answer with the equivalent meanings in English and Japanese from five choices. Each gap fill form recognition task provided two sentences of the same meaning with a missing word, one sentence was provided in English and one in Japanese. The participant was prompted to choose the appropriate Basque word to fill the gap from five choices. For each form recall item tested, the meaning of the target word was provided in English and in Japanese. The participant was prompted to spell the Basque equivalent and only correct

spellings were scored as correct. Five of each of these three task types were included in each test for a total of 15 items per test. The orders of the test items were randomized across the pre, post, and delayed tests to prevent a possible ordering effect. Links to each of these tests are available in Appendix D.

Basque as a Target Language

Basque was used as the target language of study due to its low number of cognates and false friends shared with English and Japanese; this was in line with a similar study conducted by Ibrahim et al. (2018). In the current study, the participant was given a preliminary questionnaire to determine her exposure to a variety of languages and her attitudes regarding vocabulary study with new technologies. Although the participant had studied English as a foreign language, she indicated that she had not studied Basque or any Romance language. The participant was not made aware of the target language she studied until after the research project had concluded.

Procedure

The procedures followed a pretest, intervention, posttest, delayed posttest design for each set of words. Before the administration of each pretest, the participant was oriented to the format of the test. She was made aware that the Japanese and English equivalents of the target words would be tested in the meaning recognition section, that a cloze gap fill style sentence available in English and in Japanese would prompt a missing word in the target language in the form recognition section, and that the spelling of the target words would be tested in the form recall section. She was informed by the researcher to choose "I do not know this word" for the items on the pretest. The pretest for each set was administered to the participant. For all sets, the participant confirmed that she did not have any prior knowledge of any of the items in the sets. In one case, during the pretest for Set 2, she attempted to guess the meaning of one item in the set but was incorrect. The participant was not notified of the results of the pretests (or post and delayed tests) until after the research project had concluded.

The participant was oriented to the paper-based word cards and instructed that she would have 20 minutes to study the set of vocabulary items. She was instructed to remain on task for the entire 20 minutes. She was also instructed not to write anything on paper or use any resources outside of the word cards. She was made aware that she would be given a test similar in format to the pretest 15 minutes after her study of the word cards, Set 1. She was given the goal to make a form-meaning connection and to recall the spelling of the target words. The participant was provided with a timer to display the allotted 20 minutes. She was seated at an empty table and given the word cards. The participant studied the word cards for 20 minutes and was observed to remain on task for the entire length of time.

After her study of Set 1, the researcher set a 15-minute timer. The researcher held a conversation with the participant about topics unrelated to any of the vocabulary items or any topics related to language study in general. This

conversation served as a distractor task. The posttest was administered and timed. The participant was given five minutes to finish and submit the Google form.

The participant was then oriented to the ARIO application on the iPad. She was introduced to how she could view a scene on the screen of the device and that the scene displayed on the screen was a real-time view of the camera of the device. She was introduced to a training scene which included the type and format of the labels she would study for both AR treatment sets, sets 2 and 3. Five minutes were allocated to orientation followed by a 20-minute break.

The participant was then oriented to the context-independent AR environment. It was explained that she would have a total of 20 minutes to use the AR application to study the AR labels available to her in the context-independent scene. A timer was set and made available to the participant. As with Set 1, the participant was instructed to make use of the entire 20 minutes for deliberate study and not to write anything or to use any other resources outside of the AR application for the study of the vocabulary. She was instructed that she would be given a posttest 15 minutes after her study session and that the test would be similar to the pretest format. She was again asked to focus on the meaning and form of the target words. The participant studied Set 2 in the context-independent environment for the entire 20 minutes and was observed to be on task for the entire 20 minutes. Figure 7 shows the AR application in use to study the target words of Set 2.

Figure 7

Participant Use of AR in Context-Independent Environment

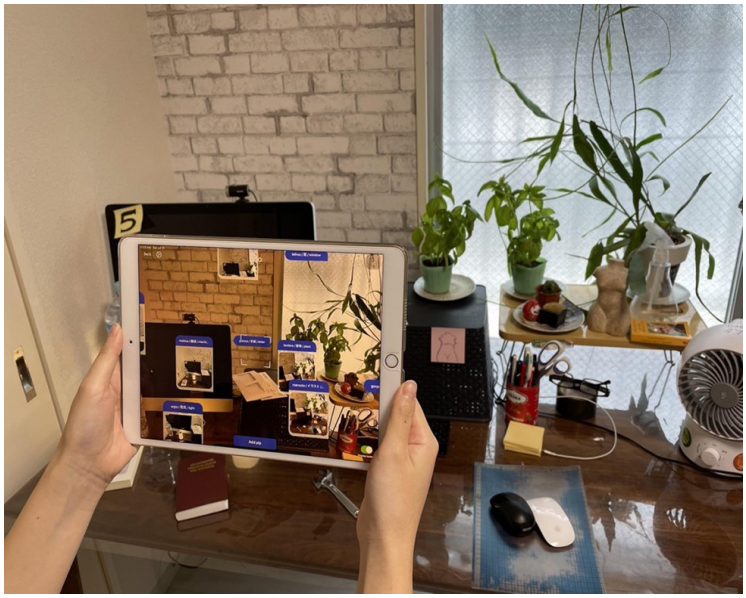
Following her study session, the researcher held a 15-minute distractor conversation. Afterwards, the posttest for Set 2 was conducted. The participant was given five minutes to finish and submit the posttest Google form for Set 2.

The participant was given a 20-minute break.

The participant was then oriented to the context-dependent AR environment with the AR application. She was again given 20 minutes, visible on a timer, to study the words in the scene with the AR application without writing anything or making use of any other resources. She was again instructed to focus on the form and meaning of the target words. She was again informed that the posttest would be similar in format to the pretest. The participant was observed to diligently make use of the entire 20 minutes for deliberate study of the target words. An unrelated 15-minute conversation was held with the participant after her study of Set 3. She completed the Set 3 posttest on Google Forms within a five-minute time limit. Figure 8 depicts the participant studying the context-dependent scene with the AR application.

Figure 8

Participant Use of AR in Context-Dependent Environment



The following day, roughly 24 hours later, the participant took each of the delayed posttests via Google forms. The participant was given a 20-minute break between each delayed posttest. She was not given any access to any AR resources or the environments in which she had studied.

On the same day, the participant was interviewed in Japanese regarding her experience and feelings toward the study. This interview was recorded and transcribed. The interview was conducted before the participant was made aware of her performance on the pretests, posttests, and delayed posttests to help ensure that the information gathered in the interview was not influenced by the results.

Results and Discussions

Table 1 shows that the pretest established a baseline for each of the vocabulary study sets; the participant did not know any of the Basque words. For Set 1, the

word cards set, the participant made a gain on the initial posttest, answering 8 out of the 15 questions correctly for a total of 60%. She answered all meaning recognition questions correctly, two of the form recognition questions correctly, but none of the spelling tasks correctly. On the delayed posttest for Set 1, the participant answered 10 out of 15 questions correctly, a larger gain than that on the initial posttest, for a total of 66%. She answered all meaning recognition questions correctly, all form recognition questions correctly, but not any of the spelling tasks correctly. For Set 2, the context-independent AR scene, the participant made a gain on the initial posttest, answering 12 out of the 15 questions correctly for a total of 80%. She answered all meaning recognition questions correctly, all form recognition questions correctly, and two of the form recall tasks correctly. On the delayed posttest for Set 2, the participant answered 13 out of 15 questions correctly, for a total of 87%. She answered all meaning recognition questions correctly, all form recognition questions correctly, and three of the form recall tasks correctly. For Set 3, the context-dependent AR scene, the participant made a gain on the initial posttest, answering 13 out of the 15 questions correctly for a total of 87%. She answered all meaning recognition questions correctly, all form recognition questions correctly, and three of the form recall tasks correctly. On the delayed posttest for Set 3, the participant answered 10 out of 15 questions correctly, for a total of 66%. She answered all meaning recognition and form recognition questions correctly but did not answer any of the form recall tasks correctly.

With respect to RQ1, which asked how tablet-based AR technology performs as compared to paper-based vocabulary word cards, both AR treatment methods were more effective than the word cards on the immediate posttests, and the delayed posttest scores of the AR treatments matched and exceeded the word card treatment.

With respect to RQ2, which asked how context-independent AR environments compared to context-dependent AR environments, the initial posttest data showed the context-dependent AR scene to be more effective than the context-independent AR scene. However on the delayed posttest, the participant's score on the set studied in the context-dependent AR scene decayed, and the participant scored higher on the set studied in the context-independent AR scene. This change in score might suggest that the context-dependent AR scene might have offered the participant temporary resources that benefitted her performance on the immediate posttest with access to those resources quickly decaying by the time she took the delayed posttest.

Table 1

Descriptive Statistics

Set / Study Mode	Pretest	Posttest	Delayed Posttest
Set 1 Word Cards	Total - 0/15 - 0% M.Recog. - 0/5 F.Recog. - 0/5 F.Recall - 0/5	Total - 8/15 - 60% M.Recog. - 5/5 - 100% F.Recog. - 2/5 - 40% F.Recall - 1/5 - 10%	Total - 10/15 - 66% M.Recog. - 5/5 - 100% F.Recog. - 5/5 - 100% F.Recall - 0/5 - 0%
Set 2 AR: Context Independent	Total - 0/15 - 0% M.Recog. - 0/5 F.Recog. - 0/5 F.Recall - 0/5	12/15 - 80% M.Recog. - 5/5 - 100% F.Recog. - 5/5 - 100% F.Recall - 2/5 - 40%	Total - 13/15 - 87% M.Recog. - 5/5 - 100% F.Recog. - 5/5 - 100% F.Recall - 3/5 - 60%
Set 3 AR: Context Dependent	Total- 0/15 - 0% M.Recog. - 0/5 F.Recog. - 0/5 F.Recall - 0/5	Total- 13/15 - 87% M.Recog. - 5/5 - 100% F.Recog. - 5/5 - 100% F.Recall - 3/5 - 60%	Total- 10/15 - 66 % M.Recog. - 5/5 - 100% F.Recog. - 5/5 - 100% F.Recall - 0/5 - 0%

Note.
M.Recog.= meaning recognition tasks
F.Recog.= gap fill form recognition tasks
F.Recall= form recall tasks.

With respect to RQ3, which asked how the participant perceived the AR study methods, the participant offered positive and enthusiastic reviews of both modes of AR. During the delayed interview with the participant, Rachel remarked on how the word cards mode of study was the most familiar to her and that she had studied similarly when she studied English in high school and university. Because of this experience with word cards, she predicted that this method of treatment would be the most effective in helping her to remember the meanings and forms of the target words in this study. Regarding the AR treatment method, she expressed that it was *"interesting and entertaining"* and *"a new idea"*. Rachel expressed that if she could use the application on her own, she would like to try to study vocabulary using this method so long as it could be considered an *"effective method"* of study. Rachel said that the AR study generally made her feel motivated to resume her study of English vocabulary and caused her to think of ways in which she might employ AR technology in her own classroom.

Discussion

All treatment modes helped the participant establish a form-meaning link between some of the vocabulary words tested in each set. Out of the three

initial posttests, the participant performed the best on Set 3 (87%), similarly on Set 2 (80%), yet somewhat lower on Set 1 (60%). These data indicate that both AR treatment methods were more effective in helping to establish a form-meaning link than the word cards. As compared with the scores of the immediate posttests, the participant made unexpected gains on the delayed posttests for Sets 1 and 2, by 2 points and 1 point respectively which indicate a test effect. Her score decayed by three points on the delayed posttest for Set 3, as would be expected.

Similar to the findings of Chen and Chan (2019), both the word cards and AR-based treatments appeared to be similarly effective in helping the participant to recall the vocabulary items on a posttest. Unlike the findings of He et al. (2014) and Geng and Yamada (2020), though the AR treatments of the current study appeared to be more effective in recognition of meaning, recognition of form, and limited recall of the target words on the initial posttests, the delayed posttests seem to indicate that the AR treatments and the paper-based treatments performed similarly. In the scene that He et al. (2014) investigated, the researchers were comparing a teacher-fronted vocabulary lesson with the results of AR vocabulary word card study. Perhaps their results were affected by a moderating variable such as teaching styles and differences between the teachers who were involved in their study. As for the discrepancy with the findings of Geng and Yamada (2020) (and is relevant with He et al. (2014)'s findings as well), the current study is a case study involving only one individual and might not be comparable. Furthermore, Geng and Yamada (2020) investigated compound Japanese verbs whereas the current study only focused on Basque concrete nouns.

Ibrahim et al. 's (2018) study was perhaps the most influential in terms of design on the current study in that Basque was used as the target language of the vocabulary sets. The participant in the current study is also of similar age to the participants examined in Ibrahim et al.'s study. The current study also investigated reception as well as production with the use of a spelling test. However, Ibrahim et al. (2018) found promising indications that their AR treatment performed significantly better than the traditional word card group - a finding that was not echoed in this case study. Again as noted above, there might indeed be moderating variables present in the current study. The difference in findings could be the result of the limitation presented by a n size of one. The current study should be conducted again on a larger scale with a larger sample size.

The current study was also influenced by Larchen Costuchen et al. (2021), in that an element of visuospatial bootstrapping was tested by placing physical items and their signifying vocabulary items into environments and scenes known to the participant with the use of AR. Larchen Costuchen et al. (2021) found that the AR treatment group performed significantly better than the electronic word card group. The results of the current study appeared to show that AR treatment was initially better than paper-based word card treatment, but delayed posttests showed that all treatment modes performed relatively equally. Larchen Costuchen et al. (2021) conducted the delayed posttest a

week after treatment whereas the delayed posttest was conducted after 24 hours in the current study.

In He et al.'s (2014) study the teachers involved remarked that the tactile and visual elements of AR could potentially benefit pedagogy. Similarly, in Chen and Chan's (2019) study, one of the teachers who was interviewed indicated that one of the benefits of AR was the power to draw students' attention to vocabulary in a lesson. While Rachel was a participant in the capacity of the current study, she is herself also a language teacher. In our interview, she discussed how the development of AR technology could be promising for her own pedagogical use, echoing some of the points made by the instructors surveyed in the research of He et al. (2014) and Chen and Chan (2019).

A handful of studies have gathered information and the perspectives of the participants and students in terms of their motivation and feelings about using AR to study vocabulary, to supplement materials in the classroom, to create personalized vocabulary study sets, and to gamify learning (Chen & Wang, 2016; Solak & Cakır, 2015; Taskiran, 2019; Zainuddin et al., 2016). While the current study set did not dive deeply into the motivation orientations or other individual differences of the participant, it did examine the perspective of the participant through an interview to better understand her feelings about the study. During the interview, the participant remarked that by using an iPad for the current study that it "felt like I was playing a game". She also stated that it was an overall entertaining experience, and that she felt motivated to study vocabulary after the experience.

Finally, the finding that the participant in this study was able to make relatively lasting form-meaning links between many of the target Basque items and their Japanese equivalents with a tablet-based AR application is a finding that reinforces the call for more research of mobile AR technology as applied to deliberate vocabulary study and in wider SLA contexts. Also, while expensive head-mounted AR devices are attractive and have been successful in previous studies of AR as applied to deliberate vocabulary study, the current study shows that tablets which are currently available at a fraction of the cost are capable of being used for comparable pedagogical applications. Furthermore, this study indicated that such applications of mobile-based AR can be easily extended to distance education settings.

The current study makes a small contribution to the field of SLA in that at the time of writing this manuscript, AR assisted vocabulary study is a subject that has been very lightly researched. Based on the findings of this study and of previous studies mentioned above, AR appears to be an effective vocabulary study method for learners of a second language. The novelty and application of AR was shown to pique the interest of and motivate the participant. What is not yet clear is how the physical environment interacts with and leverages the retention of vocabulary studied in AR. More related studies which further investigate these areas are needed.

Conclusions and Recommendations

This case study observed a Japanese participant, a 25-year-old teacher, who used paper-based word cards and two modes of AR treatment to study a total of 45 Basque concrete nouns. The AR treatments were different in that one mode of treatment did not require that the physical items which corresponded to their AR vocabulary cards be contextually or thematically dependent, whereas the other AR treatment method required the items and their corresponding vocabulary to be relevant to the environmental scene. The participant was asked to complete meaning recognition, form recognition, and form recall tasks. The results of the immediate posttests appeared to show that both AR treatments were superior in their ability to help the participant learn and retain the vocabulary items, with the context-dependent AR treatment being slightly superior to the context-independent AR treatment. The results of delayed posttests of all treatment methods appeared to show that delayed gains were made in the retention of the paper-based word card set, and that the participant's ability to remember the vocabulary items studied in both AR treatment methods deteriorated slightly. The participant was generally motivated by the AR technology, commented on its game-like features, and considered how she might use AR in her own classroom. Finally, this study serves as an example as to how researchers, teachers, students, and self-directed language learners might practically implement readily available mobile devices to make use of augmented reality in vocabulary study.

References

Ario Technologies Incorporated. (2022). *ARIO* (Version 2022.1) [Mobile app]. App Store. https://apps.apple.com/us/app/ario/id1371688918

Azuma, R. T. (1997). A survey of augmented reality. T*eleoperators & Virtual Environments, 6*(4), 355–385.

Billinghurst, M., & Duenser, A. (2012). Augmented reality in the classroom. *Computer, 45,* 56–63.

Bower, M., Howe, C., McCredie, N., Robinson, A., & Grover, D. (2014) Augmented Reality in education – cases, places and potentials. *Educational Media International, 51*(1), 1–15, https://doi.org/10.1080/09523987.2014.889400

Chen, C. P., & Wang, C. H. (2016). The effects of learning style on mobile augmented-reality-facilitated English vocabulary learning. *2015 IEEE 2nd International Conference on Information Science and Security (ICISS),* 1–4. https://doi.org/10.1109/ICISSEC.2015.7371036

Chen, R. W., & Chan, K. K. (2019). Using augmented reality flashcards to learn vocabulary in early childhood education. *Journal of Educational Computing Research, 57*(7), 1812–1831. https://doi.org/10.1177/0735633119854028

Geng, X., & Yamada, M. (2020). An augmented reality learning system for Japanese compound verbs: study of learning performance and cognitive load. *Smart Learning Environments.* https://doi.org/10.1186/s40561-020-00137-4

He, J., Ren, J., Zhu, G., Cai, S., & Chen, G. (2014). Mobile-based AR application helps to promote EFL children's vocabulary study. *Proceedings - IEEE 14th International Conference on Advanced Learning Technologies, ICALT 2014*, 431–433. https://doi.org/10.1109/ICALT.2014.129

Ibrahim, A., Huynh, B., Downey, J., Hollerer, T., Chun, D., & O'Donovan, J. (2018). ARbis Pictus: A study of vocabulary learning with augmented reality. *IEEE Transactions on Visualization and Computer Graphics.* https://doi.org/10.1109/TVCG.2018.2868568

Keller, J. M. (1987). *IMMS: Instructional materials motivation survey.* Florida State University.

Larchen Costuchen, A., Darling, S., & Uytman, C. (2021). Augmented reality and visuospatial bootstrapping for second-language vocabulary recall. *Innovation in Language Learning and Teaching, 15*(4), 352–363. https://doi.org/10.1080/17501229.2020.1806848

Liu, Y., Holden, D., & Zheng, D. (2016) Analyzing students' language learning experience in an augmented reality mobile game: an exploration of an emergent learning environment. *Procedia-Social and Behavioral Sciences, 228*, 369–374. https://doi.org/10.1016/j.sbspro.2016.07.055

Martín-Gutiérrez, J., Saorín, J. L., Contero, M., Alcañiz, M., Pérez-López, D. C., & Ortega, M. (2010). Design and validation of an augmented book for spatial abilities development in engineering students. *Computers & Graphics, 34*(1), 77–91.

Milgram, P., Takemura, H., Utsumi, A., & Kishino, F. (1994). Augmented reality: A class of displays on the reality-virtuality continuum. *Proc. SPIE 2351,* 282–292. https://doi.org/10.1117/12.197321

Nakata, T. (2020). Learning words with flash cards and word cards. In Webb, S. (Ed.), *The Routledge Handbook of Vocabulary Studies* (1st ed.). Routledge. https://doi.org/10.4324/9780429291586

Nation, I. S. P. (2013). *Learning vocabulary in another language (2nd ed.)*. Cambridge University Press.

Ryan, R., & Deci, E. (2000) Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist, 55*(1), 68.

Squier, K., & Jan, M. (2007). Mad City mystery: Developing scientific argumentation skills with a place-based augmented reality game on

handheld computers. J*ournal of Science Education and Technology, 16*, 5–29.

Solak, E., & Cakır, R. (2015). Exploring the effect of materials designed with augmented reality on language learners' vocabulary learning. *Journal of Educators Online, 13*(2), 50–72. https://doi.org/10.9743/jeo.2015.2.5

Taskiran, A. (2019). The effect of augmented reality games on English as foreign language motivation. *E-Learning and Digital Media, 16*(2), 122–135. https://doi.org/10.1177/2042753018817541

Terminologia eta Lexikografia Zentroa (2017). Euskaltzaindiaren erakunde atxikia. *Basque frequency Dictionary.* UZEI. https://uzei.eus/en/services-and-products/catalogue/frequency-dictionary/

Zainuddin, N., Sahrir, M. S., Idrus, R. M., & Jaafar, M. N. (2016). Scaffolding a conceptual support for personalized arabic vocabulary learning using augmented reality (ar) enhanced flashcards. *Journal of Personalized Learning, 2*(1), 102–110.

Appendix A

Set 1: Vocabulary List Studied with Word Cards
(Basque - English / Japanese)

etxea - house / 家
amak - mother / お母さん
egun - day / 日
zuhaitz - tree / 木
mendia - mountain / 山
haurrak - children / こども
oinak - feet / 足
txakur - dog / 犬
uharteko - island / 島
zifra - figure / 数字
izan - fact / 事実
odol - blood / 血
semea - son / 息子
esnea - milk / 牛乳
zulo - hole / 穴

Appendix B

Set 2: Vocabulary List Studied in Context-Independent AR Environment
(Basque - English / Japanese)

egurra - wood / ウッド
kutxa - box / 箱
dirua - money / お金
arrautza - egg / 卵
pilota - ball / 玉
bihotza - heart / ハート
olioa - oil / 油
giltza - key / 鍵
pertsonaia - character / キャラクター
katea - string / ひも
ogia - bread / パン
azukre - sugar / 砂糖
piku - fig / いちじく
sagar - apple / りんご
zapatila - shoe / 靴

Appendix C

Set 3: Vocabulary Studied in Context-Dependent AR Environment
(Basque - English / Japanese)

argia - light / 電気
argazki - picture / 写真
ura - water / お水
landare - plant / 植物
marraztu - drawing / イラスト
liburua - book / 本
gutuna - letter / 手紙
gorputza - body / 体
makina - machine / 機械
bost - five / 五
taula - table / テーブル
leihoa - window / 窓
horma - wall / 壁
hiztegia - dictionary / 辞書
tresna - tool / 道具

Appendix D

Pretest / Posttest / Delayed Posttest Google Forms Links

Pretests

Set 1: Paper-based word cards - https://forms.gle/CX2r8AFe63PEqvpRA
Set 2: Context-Independent Environment - https://forms.gle/S7eDo7LvXZ7MfpzP6
Set 3: Context-Dependent Environment - https://forms.gle/QayaLwNEQaQ9cNa17

Posttests / Delayed Posttests

Set 1: Paper-based word cards - https://forms.gle/FukvVqTXrRcmDHQFA
Set 2: Context-Independent Environment - https://forms.gle/HWXhz5rN7hgSRrk5A
Set 3: Context-Dependent Environment - https://forms.gle/pMqMjXe6DWT67CN3A