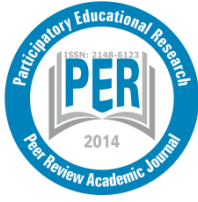TITLE: Augmented Reality (AR) in Language Learning: A Principled Review of 2017-2021

AUTHORS: Nermin PUNAR ÖZÇELIK,Gonca EKSI,Meltem Huri BATURAY

PAGES: 131-152

ORIGINAL PDF URL: https://dergipark.org.tr/tr/download/article-file/1957369

Augmented Reality (AR) in Language Learning: A Principled Review of 2017-2021

Nermin PUNAR ÖZÇELİK *
Foreign Languages Department, Tarsus University, Mersin, Turkey
ORCID: 0000-0001-8772-0075

Gonca YANGIN EKŞİ
English Language Teaching Department, Gazi University, Ankara, Turkey
ORCID: 0000-0003-3555-7258

Meltem Huri BATURAY
Center for Teaching and Learning, Atılım University, Ankara, Turkey
ORCID: 0000-0003-2402-6275

With the changing and developing technology, numerous new systems that cannot be given up and have a great impact are becoming a part of our lives. Augmented reality (AR) is one of these systems which can be claimed as magic. AR has been gaining considerable interest in the field of education, and language learning since Pokémon Go, the most well-known AR location-based game, was launched. There has been much evidence to support the effectiveness of AR in education. The present study set out to review in detail the current research studies published in SSCI/ESCI/ERIC indexed privileged journals in the field of language education and technology within the last five years, on the topic of augmented reality in language learning. The selection of articles was made on the basis of empirical studies on the use of AR in language education. Surprisingly, only seventeen studies seem to fall into the said category in these selected, SSCI/ESCI/ERIC journals. On the grounds that there emerges a lack of such studies and complying with the nature of the present study, all these articles have been reviewed in detail, in terms of three aspects: (1) research features, such as research focus, design, data collection tools, study, and educational context; (2) the use of AR, such as theory behind AR use, and AR applications used in the studies; (3) results of the studies. The results showed that much emphasis has been on vocabulary learning, the learning effectiveness, attitudes, and motivations of language learners with scant attention given to language skills. There is a current paucity of empirical research focusing specifically on different language skills. Hence, it is desirable to examine the effects of AR on different language skills of language learners.

---

* Correspondency: nerminpunar@gmail.com

Introduction

In the era we live in, lots of technological tools and items might be considered magic. One of these magical technologies is the Augmented Reality (AR). AR has different definitions by different scholars. The most well-known, which is adopted as 'the' definition in the present paper is Azuma's (1997): "Augmented reality is a field in which 3D virtual objects are integrated into a 3D real environment in real-time." As for a dictionary definition, Merriam-Webster Dictionary defines augmented reality as "an enhanced version of reality created by the use of technology to overlay digital information on an image of something being viewed through a device –such as a smartphone camera.". Based on these two definitions, it might be defined that augmented reality is the process of combining interactive digital 3D elements with the components of physical world.

AR is not a new thing though. Ivan Sutherland, a pioneer in the field of computer graphics, and his students used a see-through Head-Mounted Display in the 1960s at Harvard University and the University of Utah with The Sword of Damocles (Sutherland, 1986). So it was the world's first creation of AR technology even if it had only some poor graphics and an inconvenient headset. Nevertheless, the first "augmented reality" term was introduced in the 1990s by two scientists at Boeing Corporation, Caudell and Mizell (1992). They were developing an AR system for workers helping them bundle harnesses together. Nevertheless, AR was still easily inaccessible. With the development of computing and tracking systems in mobile devices, AR came into stage more than before. It was the time of the very first mobile AR system created by Feiner et al. (1997) as a tour guide offering 3D graphical information with buildings. Within time, AR started to be seen in TV commercials, military, and navigation systems. One of the most important AR technology was introduced by Google called as Google Glass. It aimed to display notifications from smartphones, accessing to hands-free information, sustaining workers in the manufacturing industry, providing instant access to the internet in regard to the device. Most important and the most well-known of all AR applications was the creation of Pokémon Go, which is a kind of AR location-based game.

AR is divided into two types viz. location-based and vision-based. Location-based AR is a type of AR technology that allows the users to track the distance from a current location to different ones by using a mobile device accredits with Global Positioning System (GPS). Location information might be combined with data catered through the GPS, gyroscope, compass, or camera, etc. to be able to provide information about the physical surroundings (Godwin-Jones, 2016). The other type is vision-based AR which focuses on image recognition techniques used to determine the position of physical objects in the real environment for appropriate location of virtual contexts related to these objects. Its tracking system has two types i.e., marker-based and markerless. A marker-based tracking system requires specific labels such as quick response (QR) code to register the 3D images, and a markerless tracking system requires no such labels, any part of the real environment can be used to trigger the virtual images. The labels, QR codes, or the virtual images are called as "triggers" or "markers". The markers or the triggers might be inserted anywhere and anything. Just as the AR application identifies the markers through the camera, 3D images or the other kinds of actions can be seen on the device screen (Godwin-Jones, 2016).

Augmented Reality in Education

Technology has been flourishing day-by-day and AR is a magical technology renewing itself each day. According to Azuma et al. (2001), the goal of AR is to enhance users' interaction with the real world by means of 3D virtual objects in real environments. This is not limited to visual channels but also it appeals to auditory channels. Hence, AR is a great way to bridge virtual and real worlds, and to be able to bridge two worlds, many scholars investigated AR in terms of its effects on education. Utilizing various ways and developing technology, the quality of education might be increased. Latterly developed technology enables AR to be used with mobile devices effectively. The features and affordances revealed by the studies on AR in education are as follows:

- AR offers accessible learning materials anywhere and anytime. Instead of using paper-based textbooks, models, posters, or printed manual, it offers portable and less expensive learning materials.
- AR requires no special equipment. In the era we live, most teens own a smartphone with a camera, which means they are immediately available for the use of AR.
- AR contributes to the understanding of abstract concepts better (Klopfer & Squire, 2008; Wu et al. 2013). By means of visualization, it enables learners to see the visual concepts of abstract things. AR provides a better understanding of subjects with the help of visualization (Shelton & Hedley, 2002).
- AR offers authentic, contextual, and situational learning environments (Johnson et al., 2011; Dunleavy et al., 2009; Wu et al., 2013).
- AR offers safe and efficient workplace training. In the department of medicine, the example of this benefit might be seen clearly in the case of heart surgery. Practicing a heart surgery with the help of AR puts no one in danger if something goes wrong (Barad, 2019).
- AR offers learners a collaborative and social learning environment (Squire & Jan, 2007; Wu et al., 2013).
- AR engages the attention of learners and enhances their motivation (Di Serio et al., 2012).
- AR makes learners enjoy the learning process (Nunezet al.,. 2008).
- AR develops the critical thinking and problem-solving skills of learners (Dunleavy et al., 2009).
- AR fosters the self-efficacy beliefs of learners by giving them control of their own learning environments (Majoros & Neumann, 2001).
- AR is not limited to only one case or field of application, so it can universally be applied to any level of education and training.

Besides these features, a study conducted by Yuen and Yaoyuneyong (2011) reveals the most five significant AR applications used in education. These are AR books, which are the books offering 3D objects; AR games, which are the games using mostly marker-based AR technology; discovery-based learning, objects modeling, and skills training.

The most well-known location-based AR application has been Pokémon Go released in 2016 by Niantic Labs. It has not been designed particularly for education; however, it helps players gain lots of benefits such as motivation while learning (Godwin-Jones, 2016). A specifically recognized location-based AR application for education is the use of AR as a digital tour

guide. One of the noted studies on the use of location-based AR as a tour guide was the study by Liu and Tsai (2013), examining the effect of a designed AR campus tour on students' English language learning. These kinds of AR applications give learners a real chance of being an active learner during their learning processes. Mentira might be considered as an eminent, well-designed location-based AR, guiding intermediate learners in the way of learning Spanish pragmatics (Holden & Sykes, 2011). Not only it contributes to learners' comprehension, but also it enhances learners' motivation and engagement during the learning process.

Figure 1 demonstrates a sample of an AR application screen designed to teach some English vocabulary. This type of AR has been used widely in different fields to create new games, advertisements, magazines, books, etc. In language education, one of the reputable marker-based AR environments was designed by Liu (2009), with the name of "Handheld English Language Learning Organization" HELLO, addressing to enhance English language learners' speaking and listening skills.
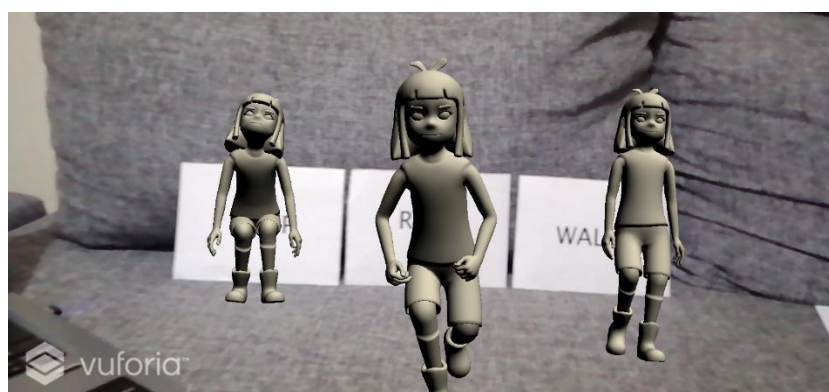

Figure 1. A sample of an AR screen designed to teach English action verbs (Source: An AR scene created by the authors).

Due to its features, a vision-based AR is easily applicable in classroom environments. To be able to conduct a lesson with the help of AR, there is only a need for an internet connection, a mobile device with a camera, an AR app developed for educational purposes, and triggers or markers (AR in Education, 2019).

While AR has lots of benefits for learners and educators in the field of education, it has also some challenges. In the case of the lack of necessary knowledge on how to integrate AR into language education environment, no effective benefit can be gained from the use of AR. Additionally, there is a dependency on hardware, so without access to the necessary hardware, such as a handheld device, the use of AR might be falling behind.

As it is obviously inferred from these studies, AR has an enormous effect on education, and it has been conducted lots of research studies on the use of AR in different parts of education. In addition to these studies, the present paper tries to reveal the use of AR in specifically language education. Globalization and digitalization have given significance to language learning and teaching in terms of mostly economic or educational reasons (Block & Cameron, 2002, p.5). The members of communities are required to learn new languages except for their mother tongues in order to meet the needs of globalization effects. On the grounds of these

reasons, it is thought that it might be a fruitful interest to review the studies both including language learning and AR technology, which is an innovative technology growing faster and faster with the help of globalization and digitalization.

Theories and Approaches behind Augmented Reality in Language Education

Among various language acquisition and learning theories, constructivism, sociocultural theory (SCT), and connectivism are believed to guide the use of AR, on the ground that some of their features are associated with AR (Zhang, Wang & Wu, 2020, p.219). On the other hand, Communicative Language Teaching (CLT) and Task-based Language Teaching (TBLT) are the approaches on which AR may be predicated.

In the view of constructivist theorists, learners construct their knowledge by combining newly acquired knowledge with previous ones (Bruner, 1996; Dewey, 1916; Piaget, 1973). The core of this theory is the active engagement of learners. Discovery-based, situation-based, and problem-based learning theories are derived from the view of constructivist theory. Wang et al. (2018) offer that AR-supported learning is a contemporary theory and it is also based on constructivism, inasmuch as it helps learners to gain knowledge in a contextualized environment, and with the help of AR-based language materials, the learners can acquire, internalize, construct knowledge and use it in their productive tasks through using their critical thinking and kinesthetic abilities (Liu & Tsai, 2013).

In the process of language learning, cultural and social factors have also a considerable magnitude. Based on this significance, sociocultural theorists claim that meaningful learning requires not only the innate capacity to learn but also social interaction with cultural elements (Lantolf & Thorne, 2006, p. 59). One of the core issues of SCT is the role of the Zone of Proximal Development (ZPD). The fundamental relationship between SCT and AR lies here, relatively with scaffolding. With the help of AR technology, language learners have a chance to work collaboratively in a contextualized environment (Godwin-Jones, 2016). Collaboration in such an environment leads to social interactions and scaffolding between language learners.

Apart from these traditional theories, connectivism, which is relatively a new contemporary theory, is about constructing a connection between the technology-enhanced learning environment with learning opportunities for learners while prompting interaction and collaboration (Greenwood & Wang, 2018). By the agency of AR-based technology, which is context-based, learners can have a chance to bridge their learning skills with the real contextualized environment enhanced by different modalities (Godwin-Jones, 2016). HELLO designed by Liu (2009) might be considered as an example of a connectivist approach to language learning by virtue of AR, since it enables learners to enhance their speaking and listening skills in AR-based contextualized environment.

Even if language acquisition and learning approaches depend on the abovementioned theories, it might be fruitful to briefly mention CLT and TBLT in terms of AR. CLT puts interaction at the center of the language learning process. Any kind of interaction (i.e with the teacher, with peers, with authentic texts, etc.) combined with the use of language outside leads to better learning. Supporting this, AR technology allows for this mentioned process, enables learners to engage and interact with technology inside and outside the classroom, anytime and

anywhere.

On the other hand, TBLT mainly concentrates on the use of authentic language and meaningful tasks in the process of language learning. Through the medium of AR, learners can have a chance to take place in meaningful tasks combined with real and virtual worlds, and they can perform their language skills within these tasks to learn more effectively.

Method

It is significant to know the research trends and applications on the related topics for researchers and practitioners, as they can then be aware of the existing literature, carry out new research studies based on the gaps in the literature, and develop new models or applications. The studies on the use of AR technology in the realm of language education is a recent topic and it would be better to know the current literature to be able to enhance it with new studies based on the trends and gaps. On the grounds of this significance, the purpose of the present paper to provide a detailed and principled review and analysis of the existing research of augmented reality in language learning in the journals with high impact factors published between the years 2017-2021.

The articles for principled review for the current study have been collected from prominent academic journals indexed in the Social Sciences Citation Index (SSCI), Emerging Sciences Citation Index (ESCI), ERIC, having high impact factor, and publishing articles related to technology integration into language teaching in the field of foreign and second language education and technology. Here, the focus is on the reputable journals as they reflect the significant and novel studies on the related field, and it brings forward the reliable resources. For the articles of the present review, the following keywords are used; 'augmented reality', 'language learning", 'language teaching'. Obtained research papers are filtered according to the publication years on condition that being published in the last 5 years since AR technology renews itself with the development of technology and sequenced by relevance to language teaching. Based on these criteria, 33 studies have been obtained, and out of these studies, 16 of them have been eliminated since they are review or informative studies and the present principled review will focus on only the practical use of AR in language education. All the selected articles have been published between 2017-2021. As a result, 17 studies have been decided to be selected for inclusion in the present paper. For the aim of the present study, empirical studies were included for review. The distribution of the types of the studies according to the years has been demonstrated in Table 1.

Table 1. Distribution of the studies analysed
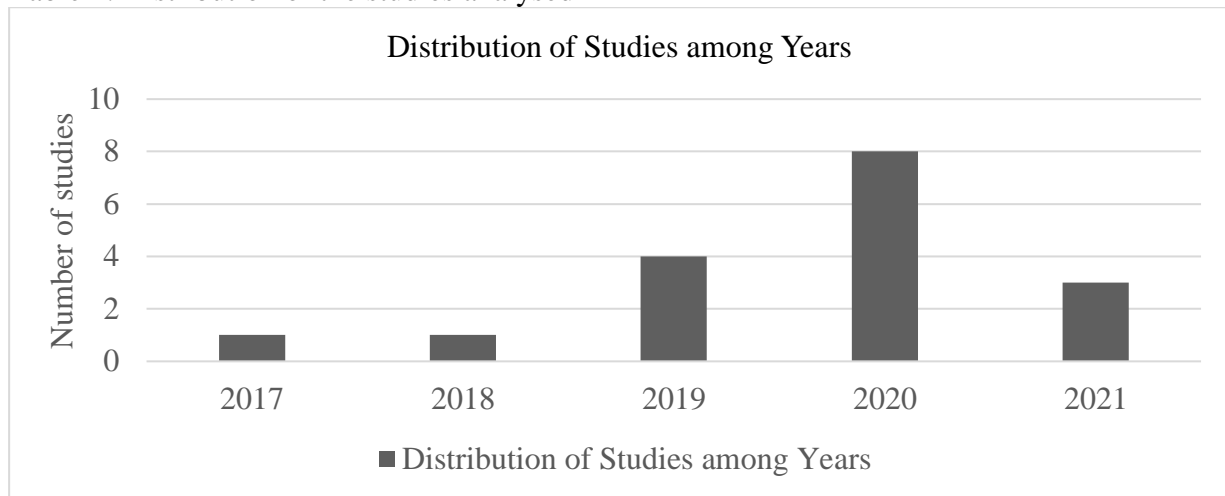
The selected empirical studies are examined mainly under three categories; in terms of features of research, and terms of the use of AR, and lastly their results. The investigation based on research features category includes their research focus, research method and data collection tools, participant, study, and educational context. On the other hand, the review based on the use of AR category focuses on the theory behind AR research and used AR applications. The last category includes only the review of the results of the studies.

Findings and Discussion

Findings related to the features of a research

Out of seventeen studies, six of them are focused on learning achievement, learning effectiveness, and motivation of learners. Three of them are focused on the investigation of attitudes, perceptions, and satisfaction of learners. Three of them are focused on the cognition, such as cognitive load, cognitive engagement, and self-regulated cognition. The other research's focuses are on learning styles, flow state, foreign language learning anxiety, communication and intercultural exchange, and vocabulary retention. All learning environments in the studies are enriched with AR technology.

Hsu's (2017) research focused on the flow state, cognitive load, foreign language learning anxiety, and learning effectiveness of learners with different learning styles in the case of two different AR environments. This study did not engage directly with the effect of AR, instead, it used two different kinds of AR environments to be able to find the effects of learning styles on the abovementioned aspects. Yang and Mei (2018) tried to find out Japanese language learners' perceptions and experiences on the use of AR technology while learning Japanese orthography. Chen and Chan (2019) utilized AR flashcards to teach English vocabulary and focused on the impacts of these flashcards on learners' vocabulary learning. Redondo, Cozar-Gutierrez, Gonzales, Calero, and Ruiz (2019) concentrated on the effects of AR on learners' motivation, enjoyment, and establishing social relationships. Taskiran (2019) carried out a

study about the influences of AR-enhanced games on language learners' motivation, interest, and enjoyment while focusing on value and usefulness of these kinds of games. Wu (2019) examined the use of the Pokémon Go AR game in the process of learning English, and focused on learners' attitude, satisfaction, and achievements. Chen et al. (2020) focused on the learning achievements, motivation, and satisfaction of learners in an AR-enhanced video environment in his study. Chen et al. (2020) tried to explore the effects of captions and English proficiency on language learners' learning effectiveness, motivation, and attitudes in an AR-enhanced contextualized environment in their paper. This study is similar to the study by Hsu (2017) in terms of the way of using AR. The study carried out by Costuchen, Darling and Uytman (2020) investigated the effect of the combination of AR and visuospatial bootstrapping on vocabulary retention of second language learners. The study by Lee and Park (2020) investigated the effect of AR scenes created by the students on language learning outcomes. On the other hand, Lin, Liu, and Chen (2020) investigated the effects of AR-enhanced writing application on English language learners' writing instruction in their study published in CALL Journal. In discordance with the other studies, this paper engages with writing skills. Another distinctive study was carried out by Yeh and Tseng (2020) investigating the use of AR in order to enhance multimodal literacy of English language learners while communicating with others. Tsai (2020) conducted a study to discover the effects of AR on language learners' vocabulary learning, and instructional materials motivation. Wen (2020)'s study focused on cognitive engagement of learners in an environment which is donated by AR-enhanced classroom-based collaborative learning activities. Binhomran and Altalhab (2021) investigated the use of AR technology to enhance learners' motivation and vocabulary retention. Jalaluddin, Darmi and Ismail (2021) developed an application to find out the influences of AR on vocabulary learning of language learners, which is similar to previous studies. A recent study by Hadjistassou (2021) focused on a different aspect and tried to find out the role of AR on enhancing intercultural telecollaboration of language learners with the help of AR applications.

Due to the administration of mixed data collection tools in related studies, the details of the research method and data collection tools are demonstrated in Table 2 and Table 3.

Table 2. Research methods

Research Method	N*
Experimental	12
Factorial Research	1
Case Study	1
Quantitative	1
Mixed Research	1
Design-based Research	1
Total	17

N* Number of studies

Table 3. Data collection tools

Data Collection Tools	N*
Pre and Posttest	12
Motivation Questionnaire	2
Satisfaction Questionnaire	2
Survey	2
Reflection Papers	3
Achievement Test	1

Attitude Questionnaire	2
Semi-structured Interview	6
Structured Interview	1
Focus-group Discussion	1
Questionnaire of Flow State	1
Questionnaire of Learning Style	1
Questionnaire of Foreign Language Learning Anxiety	1
Questionnaire of Cognitive Load	1
Direct Observation	2
Intrinsic Motivation Inventory (IMI)	1
Instructional Materials Motivation Survey	1
A Specific Instrument for the Bits of Intelligence	1
British Picture Vocabulary Scale	1
Total	17

N* Number of studies

To be able to see the effects of AR-enhanced technology on language learning achievement, out of seventeen studies, twelve of them conducted an experimental research design with mixed data collection tools (Binhomran & Altalhab, 2021; Chen, 2020; Chen & Chan, 2019; Costuchen et al., 2020; Hsu, 2017; Jalaluddin et al, 2021; Lee & Park, 2020; Lin et al., 2020; Redondo, et al., 2019; Wu, 2019; Tsai, 2020; Yeh & Tseng, 2020) and the others conducted various designs such as a factorial research design (Chen et al. 2020), a case study (Yang & Mei, 2018), a quantitative study (Taskiran, 2019), a mixed method study (Wen, 2020), and a design-based research (Hadjistassou, 2021).

For data collection tools, most experimental studies carried out pre and posttests, and different questionnaires in accordance with their research focus. Hsu (2017) implemented various questionnaires since his focus was on different aspects. For data triangulation, some of the studies administered interviews and examined reflection papers, as well. In some studies, there were administered some specific instruments such as a specialized instrument grounded on the bits of intelligence (Redondo et al, 2019), and British Picture Vocabulary Scale (Jalaluddin et al, 2021).

Out of seventeen studies, seven of them was carried out in Taiwan (Chen, 2020; Chen et al. 2020; Hsu, 2017; Lin, Liu & Chen, 2020; Tsai, 2020; Yeh & Tseng, 2020; Wu, 2019), which demonstrated a real gap in the literature having the lack of various study contexts published in the selected privileged journals. The other studies were carried out different countries such as Spain (Redondo et al. 2019; Costuchen et al. 2020), Turkey (Taskiran, 2019) etc. Nine of them was conducted with university students (Costuchen et al., 2020; Hadjistassou, 2021; Jalaluddin et al., 2021; Lee & Park, 2020; Lin, Liu & Chen, 2020; Taskiran, 2019; Yang & Mei, 2018; Yeh & Tseng, 2020; Wu, 2019), two with early language learners (Chen & Chan, 2019; Redondo et al. 2019), one with second graders (Wen, 2020), one with third graders (Hsu, 2017), one with fifth graders (Tsai, 2020), two with sixth graders (Binhomran & Altalhab, 2021; Chen, 2020), and one with ninth-graders (Chen et al. 2020). Table 4 and 5 shows the detailed information about the study and educational contexts. In conclusion, the analysis of features of research, most studies were administered experimental research design with various data collection tools by focusing mostly on vocabulary learning achievements, motivation, and attitudes of mostly university students in Taiwan.

Table 4. Study contexts of the studies

Study Context	N*
Taiwan	7
Korea	1
New Zealand	1
Macau, China	1
Turkey	1
Spain	2
Saudi Arabia	1
Malaysia	1
Singapore	1
Cyprus & UK	1
Total	17

N* Number of studies

Table 5. Educational contexts of the studies

Educational Context	N*
Kindergarten	2
Primary School	1
Elementary	4
High School	1
University	9
Total	17

N* Number of studies

Findings related to use of AR

The theories behind the studies, the types of AR and AR applications used in these seven studies are demonstrated in detail in Table 6 and 7.

Table 6. Theories and methods in studies

Theories	N*
Situated-Learning	3
Contextualized Learning	2
Game-based Approach	2
Dual Coding Theory	2
Experiential Learning	1
SCT	1
Cognitive Theory of Multimedia	2
SCT (Scaffolding)	1
Project-based Learning	1
Total	15

N* Number of studies

Table 7. AR apps used in studies

AR App	N*

ARVEL	1
Interactive LBA Mobile App	1
AR-Travelling around the USA	1
AR Application	1
ARCAUW	1
AR Game	4
AR-VSB	1
MAVR	1
AR Tourist App	1
AR-based Animation Guide	1
AR Flashcards	3
AR Storybook (Storybooks Alive)	1
Total	17

N* Number of studies

As it is clearly seen, most of them were based on the situated-learning theory since it aligns with AR features well (Chen, 2020; Hsu, 2017; Wu, 2019). According to the researchers of these three studies, meaningful learning occurs in actual environments of learners, so the use of AR enables learners to perform and learn the language in a real environment and situation. Lee and Park (2020) claim that learning is associated with the physical and social contexts, and learning occurs when they are combined. They report that with the help of AR, language learners can engage and interact both with their physical and social environments. In the case of Cognitive Theory of Multimedia, Chen et al. (2020) mention that the use of videos, namely multimedia, is related to Cognitive Theory of Multimedia, since the use of AR appeals to language learners different learning modalities in their brains, by enhancing their learning. Yeh and Tseng (2020) adopt project-based learning for their study in order to enhance language learners' multimodal literacy and communication by making them develop their own AR artefacts by means of collaboration. The core issue of their theoretical framework is the use of collaboration with the help of project-based learning. Some studies do not directly refer to an approach or theory behind the study; however, they report the relations among AR, contexts, and situations by supporting each other.

In terms of the type of AR, while four of them used location-based AR applications, thirteen of them used vision-based AR applications. Among these two types of applications, created and used applications in the studies are as follows; AR flashcards, self-directed and task-based AR game (Hsu, 2017), Pokémon Go (Wu, 2019), specifically designed four AR games (Taskiran, 2019), Interactive location-based AR application (Lee & Park, 2020), ARVEL (Augmented reality video-enhanced learning) (Chen, 2020), location-based AR tourist application (Yeh & Tseng, 2020), theme-based contextualized AR application (Chen et al. 2020), and ARCAUW (augmented-reality ubiquitous writing application) (Lin, Liu & Chen, 2020). In conclusion, the analysis of studies' use of AR demonstrated that mostly they grounded on situated-learning theories mostly adapting vision-based AR games and applications including specifically designed different kinds of them.

Findings related to use of AR

In this section, seventeen research studies will be chronologically reviewed one by one based on their whole design and results. Hsu (2017) carried out an experimental study with 38 third graders in Taiwan, investigating the effect of two different AR game systems on English

language learners' flow state, cognitive load, foreign language learning anxiety, and learning effectiveness in terms of two, namely serial and global, learning styles. In the experimental design, a group engaged with a task-based AR game, and the other group engaged with a self-directed AR game. The result of this study demonstrated that both AR game systems enhanced learners' learning, while the self-directed system exceeded in terms of flow state. In terms of learning styles, both AR systems showed no significant difference in the case of cognitive load and foreign language learning anxiety. The results with regard to learning styles were not included in this review.

Yang and Mei (2018) administered a case study with seven university students in New Zealand to find out the Japanese language learners' perceptions and experiences of the use of an AR-based animation guide which was designed to teach Japanese orthography. The data were collected by means of semi-structured interviews and observations and analysed by thematic analysis. The results revealed all the learners adapted a positive attitude towards AR application to learn Japanese orthography as they claimed it was helpful for them to learn how to write Japanese characters, and they reported their wish for inclusion of more AR content for their learning process. Even if some learners experienced a few practical problems related to the application or technological constraints, the study showed positive results on the benefit of AR.

A quasi-experimental study by Chen and Chan (2019) aimed to examine the effects of AR flashcards by comparing them with traditional flashcards on kindergarten learners' English vocabulary learning. The study was carried out with 98 children at an early age (5-6 years-old), and data were collected with pre and post-tests and interviews with teachers on their views and perceptions of AR technology adaptation in kindergarten. There was a treatment process in the study which was lasted four weeks; the experimental group was exposed to AR flashcards about animal-related vocabulary while control group was exposed to traditional word-image flashcard about animal-related vocabulary. The results of the study showed no significant difference between AR and traditional flashcard use in kindergarten setting to teach animal-related vocabulary, as with both ways learners increased their vocabulary knowledge. On the other hand, teachers reported that the students enjoyed AR process and keeping the cognitive load in mind, more detailed lesson plans can be applied to teach English in kindergarten.

Redondo et al (2019) carried out an experimental study to see whether AR is useful to increase early language learners' motivation and to see the effects of it on learners' socio-affective relationships. The study was conducted with 102 kindergarten children in Spain. Following a quasi-experimental study, control group was administered the traditional way of teaching, while experimental group was exposed to AR-based tasks developed by AURASMA or QUIVER. The study applied a pre-test to check the motivation, enjoyment and socio-affective relationships of early language learners, and after the intervention, a post-test to check again the motivation, enjoyment, socio-affective relationships in addition to learning achievement. To see the learning achievement, a specific instrument which was based on the bits of intelligence was used. The results were in line with other studies showing the positive effects of AR on motivation, enjoyment, and learning. Besides, AR group established better positive relationships with their peers. So, the study confirmed AR is not only effective to teach language skills, but also to enhance socio-affective skills.

Taskiran (2019) administered a quantitative study including a descriptive survey model in order to find out EFL learners' experiences of motivation, interest, and enjoyment by means of AR-enhanced learning materials with a game-based approach. In total, 83 EFL learners studying in a state university in Turkey participated in the study and for the study, four AR games were designed with the help of AURASMA, which is a common platform in the field of AR material design, and data were collected with Intrinsic Motivation Inventory (IMI), which was used to find out learners' motivation, interest, enjoyment, effort, and some aspects (i.e. value, usefulness, etc) of applications. The results of the study demonstrated that all the learners had positive attitudes towards AR-enhanced game-based learning showing great enjoyment, interest, and motivation. Students believed that AR-based learning materials were beneficial for them to learn English better and enhanced their collaboration skills. This study also confirmed the positive aspects of AR-enhanced materials to teach English and other skills.

Another experimental research was carried out by Wu (2019) with 61 students in Taiwan to examine the effects of Pokémon Go on English language learners' achievement, attitudes, and satisfaction. On the grounds of the analysis of questionnaires, interview results, and pre-post test results, the experimental group, which was exposed to the use of AR mode of Pokémon Go, showed more positive results with regards to achievement, attitude, and satisfaction. The study reported three significant points for language learning; the combination of AR games and technological tools would enable learners to be more interested in learning, Pokémon Go game would enable learners to boost their vocabulary learning, and as the study focused on the achievement of single word usage such as prefix, suffix, root, etc., AR game would enhance learners' use of single word utterances in language learning.

Chen (2020) performed an experimental study with 97 sixth graders in Taiwan, investigating the effect of AR videos from the point of scaffolding on language learners' achievement, motivation, and satisfaction. The application and the method employed in this study was the use of AR video-enhanced learning (ARVEL), it means, the students used AR video-enhanced materials in order to learn vocabulary related to insects. The results revealed that ARVEL method was successful with regards to students' achievement, intrinsic motivation, and higher satisfaction levels. This study showed the importance of combination of AR technology with other multimedia elements, such as videos and immediate cues.

Chen et al., (2020) run a factorial study with 204 ninth graders studying in Taiwan to examine the effects of captions and English proficiency on English language learners' achievement, motivation and attitudes in an AR environment. Due to the nature of the study, it had various variables to be identified, so a factorial research design was carried out by the researchers. Based on the Cognitive Theory of Multimedia, they designed two AR video-enhanced (captioned and uncaptioned) contextualized system for learners. The results in terms of AR showed students' positive motivation for AR-enhanced learning. The study did not directly examine the effect of AR, it just employed an AR environment to compare the other variables. Nevertheless, the study reported the significance of innovative technologies to enhance learners' meaningful learning and motivation, and to adapt positive attitudes towards learning.

An experimental study focusing on the vocabulary retention of students was carried out by Costuchen, Darling, and Uytman (2020) with 62 students in English language teacher training

department in Valencia, Spain. The study adopted a novel approach, which was the combination of AR and visuospatial bootstrapping with the use of Quizlet, and data were collected with a diagnostic vocabulary test and a post-test. In the study, control group was exposed to Quizlet digital cards to learn new idioms, while experimental group was exposed to papers with QR codes including augmented pictures related to idioms and words. Since the study focused on the retention, the post-tests were administered 15 minutes and one week later. The importance of this study was that it compared two technological materials at the same time, and the results showed that experimental group outperformed on the retention level, so it confirmed the benefits of AR-based instruction in order to enhance retention of learners.

To examine how language learners use physical contexts in an AR application and how AR technology facilitates language learning, Lee and Park (2020) run a project with 40 college students in Korea. As a consequence of the analysis of students' outcomes (scenes), it was found that students utilized their physical contexts into their AR app in three different ways as real, fictional, and blended reality places. Using these kinds of contexts enabled them to interact and engage with their environments and authentic language use by making meaningful learning. The results of students' reflection papers revealed that the students enjoyed and felt motivated during engaging with AR, and they found this technology as a meaningful learning experience. In the study, learners developed their own AR applications and studied on them, the results confirmed their positive perceptions regarding context-based AR for their meaningful language learning. The significance of this study was that it enabled learners to have a role of designer, which demonstrated the importance of active learning.

Lin, Liu, and Chen (2020) conducted a pilot project with 34 university students in Taiwan to examine the effects of AR-enhanced writing applications on students' writing achievement. They designed an AR-enhanced context-aware ubiquitous writing application (ARCAUW) in order to enhance language learners' retention, motivation, and self-regulated cognition for writing development. It was an experimental study, so one group was exposed to the use of ARCAUW for writing, and the control group was exposed to the traditional, in-class writing mode. The comparison between students' writing performances and perceptions on ARCAUW was completed. The results demonstrated that both groups showed positive improvements in terms of writing performance; while the ARCAUW group outperformed in terms of retention, motivation, and self-regulation in writing. In the study, it was reported that the adoption of innovative applications such as ARCAUW in academic writing courses would lead learners to have better writing outcomes, as it supported self-regulated writing competence.

Another experimental study was done by Tsai (2020) by concentrating on the vocabulary learning and instructional materials motivation of elementary school learners. In the study, 42 fifth graders from Central Taiwan were participated and they were separated into two as control and experimental group. While experimental group was exposed to AR models including 3D pictures of target words, control group was only exposed to English and Chinese translation of target words. Before and after the treatment, all learners were tested with "Instructional Materials Motivation Survey" and "English Vocabulary Competence Test", and at the end they were interviewed on their opinions of comparison of AR-enhanced and traditional teaching method. In conclusion, AR group outperformed about vocabulary learning, so they reported AR teaching was more beneficial for them to learn English words

than traditional teaching. On the other hand, in terms of instructional materials motivation, AR group again showed better improvement than the control group. The results of the study also confirmed the positive aspects of AR integration into vocabulary teaching.

Another study analysed was conducted by Yeh and Tseng (2020) with 52 English language learners at a university in Taiwan. The aim of their study was to enhance language learners' multimodal literacy for communication with the help of an AR-enhanced environment. They used an AR tourist application as an AR material to implement project-based learning. In the project, the students used visual or auditory modes to communicate with each other; in the way of students' using these different modes (visual or auditory) in a location-based AR application so as to introduce tourist spots was examined. The use of two modes was interpreted with the help of students' reflection essays. The results demonstrated that visual mode users in their AR app aimed to get others' attention on the important aspects, and they provided more concrete ideas and information by making them more engaged. On the other hand, auditory mode users aimed to awaken others' feelings and enhance alluring experiences. The most significant result of this study was that using different modes in location-based AR applications enabled learners to improve their multimodal literacy.

Another study was carried out by Wen (2020) to explore the effects of AR-enhanced game, which was developed to enhance Chinese character learning, on young Chinese learners' cognitive engagement. The study was administered a mixed research design, including an intervention process, focus group discussions with students, interviews with teachers, and observation notes during the process. The cognitive engagement of the learners in study was evaluated within the Framework of Interactive, Constructive, Active and Passive (ICAP). The participants of the study were 53 second graders, and two Chinese language teachers in Singapore. The study was a part of a project called ARC&S (Augmented Reality Enhanced Creating and Sharing), and based on this project, professionals developed AR games, and the experimental group in the study was exposed to these games during the process, while the control group was exposed to videos and teachers' explanations. Within the framework of ARC&S, the experimental group created their own products via some AR platforms, while control group created basic cards with pages, and at the end they shared their own products with their peers. During the process, the groups were video recorded. The results of the study showed that during the design process, both groups showed an increased engagement with the learning process, showing no significant difference between groups. However, in terms of sharing process, the learners were more interested in checking AR products which were created by their peers. The study confirmed the benefit of AR enhanced material creation on the learners' engagement and attention, as it enabled learners to actively participate their own learning processes.

A recent study was carried out by Binhomran and Altalhab (2021) to find out the effects of AR on motivation and vocabulary retention of young EFL learners in Saudi Arabia. Having a control and experimental group, in total there were 73 sixth grade students aged between 11-12 in the study. Before the treatment, all learners were administered a vocabulary pre-test, and then control group was exposed to traditional way of vocabulary teaching while experimental group was exposed to AR storybook series with target words for four weeks. At the end of the treatment, all the learners were administered a vocabulary post-test and three weeks later a delayed-post-test to check the retention. Between the post and delayed post-test, learners were interviewed to explore their attitudes towards both traditional and AR enhanced ways of

teaching. The results of this study showed no significant difference between the groups in terms of vocabulary learning and retention, as it might be because of some negative aspects of AR technology such as lack of technological knowledge, as reported by the learners. On the other hand, in terms of motivation, AR group reported more motivation during the treatment, which is a common result of AR studies. An important implication from the study is that AR-enhanced materials should be designed by considering individual differences, and learners should be trained in order to use these kinds of novel technologies better.

Another recent and a novel study was carried out by Hadjistassou (2021) by adopting design-based research to investigate the role of AR on intercultural exchanges of the students majoring in Teaching Chinese as a Second Language in the UK, and first-year college students majoring in a teaching department in Cyprus. In order to examine the intercultural exchanges, some professional designed a learning management platform, called ReDesign, and they integrated some AR-enhanced activities in this platform. Participants used this AR simulated platform, and they had a chance to behave like a teacher and manage the classroom environment. During the project, participants gave written responses and reflections, and the analysis of these reflections showed beneficial results in favor of AR-mediated simulations and activities. The results confirmed that AR enabled learners to experience experiential learning which might be fruitful for their teaching practices.

The last study analysed for this review, which was an experimental and a recent study was conducted by Jalaluddin, Darmi and Ismail (2021) to identify the effects of Mobile Augmented Visual Reality (MAVR) on low achiever learners' English vocabulary learning. The participants of this study were 45 primary school students in Malaysia. For the present study, researchers developed a program (MAVR) which included AR games for mobile devices to teach English vocabulary. The program combined the use of AR and visual reality, and the experiment lasted 6 months. Participants were administered British Picture Vocabulary Scale to check learners' vocabulary knowledge before, during, and after the treatment. As in line with other studies, this study also confirmed the benefits of AR on learners' attention, engagement, and learning process. The study reported that not only the students' vocabulary learning increased, but also their involvement boosted during the activities. As implication, the study claimed the combination of AR and visual reality was child and teacher-friendly and beneficial for teaching effectively.

Table 5 demonstrates the summary of the reviewed articles in detail.

Table 5. Reviewed articles in detail

Authors	Title of the Article	Research Focus	Research Design	Data Collection Tools	Pa
Hsu, (2017)	"Learning English with Augmented Reality: Do learning styles matter?"	Flow state, cognitive load, foreign language anxiety, learning effectiveness of learners with different learning styles in the case of different AR environments	Experimental	Pre-test/Post-test The questionnaire of (1) learning style, (2) flow state, (3) foreign language learning anxiety, (4) cognitive load	38 gra
Yang & Mei (2018)	"Understanding leaners' use of augmented reality in language learning: insights from a case study"	Learners' perception and experiences of using AR	Case Study	Semi-structured interview Direct observation	7 un stu
Chen & Chan (2019)	"Using augmented reality flashcards to learn vocabulary in early childhood"	The effects of AR flashcards on English vocabulary learning	Experimental	Pre-test/Post-test Interview with teachers	98 kir stu
Redondo, Cozar-Gutierrez, Gonzales-Calero, & Ruiz (2019)	"Integration of augmented reality in the teaching of English as a foreign language in early childhood education"	Motivation and enjoyment, skill acquisition	Experimental	Pre-test/Post-test Specific Instrument based on the Bits of Intelligence	10 kir stu
Taskiran (2019)	"The effect of augmented reality games on English as foreign language motivation"	Learners' motivation, interest, and enjoyment. The value and usefulness of AR games	Quantitative	IMI (Intrinsic Motivation Inventory)	83 stu
Wu, (2019)	"The applications and effects of learning English through augmented reality: a case study of Pokemon Go"	Learners' attitude, satisfaction, and achievements.	Experimental	Pre-test/Post-test Attitude & Satisfaction Questionnaires Semi-structured interview	61 stu
Chen, (2020)	"AR videos as scaffolding to foster students' learning achievements and motivation in EFL learning"	Learning achievements, motivation, satisfaction of learners in an AR-enhanced video environment	Experimental	Pre-test/Post-test Questionnaire of learning motivation Questionnaire of satisfaction	97 gra
Chen, Wang, Zou, Lin, Xie, Tsai (2020)	"Effects of captions and English proficiency on learning effectiveness, motivation and attitude in augmented-reality-enhanced theme-based"	The effects of captions and English proficiency on language learners' learning effectiveness, motivation, and attitude.	Factorial Design	Learning Achievement Test Motivation Questionnaire Attitude Questionnaire	20 gra

	contextualized EFL learning"				
Costuchen, Darling & Uytman (2020)	"Augmented reality and visuospatial bootstrapping for second language vocabulary recall"	Vocabulary retention	Experimental	Pre-test/Post-test	62 stu
Lee, S.M. & Park, M. (2020)	"Reconceptualization of the context in language learning with a location-based AR app"	The effects of learners' scenes of AR as context on language learning.	Experimental	Pre-test/Post-test Open-ended questions of survey Reflection papers	40 stu
Lin, Liu, & Chen, (2020)	"The effects of an augmented-reality ubiquitous writing application: a comparative pilot project for enhancing EFL writing"	The effects of AR-enhanced writing application on English language learners' wiritng instruction.	Experimental	Pre-test/Post-test Semi-structured interviews	34 stu
Tsai (2020)	"The effects of augmented reality to motivation and performance in EFL vocabulary learning"	Vocabulary learning performance and instructional materials motivation of learners	Experimental	Pre-test/Post-test Instructional Materials Motivation Survey Structured Interview	42 gra
Yeh & Tseng, (2020)	"Enhancing multimodal literacy using augmented reality"	Multimodal literacy of learners to communicate with other by using AR	Experimental	Pre-post administrations of multimodal literacy survey Reflection essays	52 stu
Wen (2020)	"Augmented reality enhanced cognitive engagement: Designing classroom-based collaborative learning activities for young language learners"	Cognitive engagement of learners	Mixed	Focus group discussion Teacher interviews Observation	53 gra
Binhomran & Altalhab (2021)	"The impact of implementing augmented reality to enhance the vocabulary of young EFL learners"	Usefulness of AR technology in vocabulary learning	Experimental	Pre-test/Post-test Interview	73 gra
Hadjistassou (2021)	"(Re)Designing augmented reality applications to facilitate intercultural telecollaboration"	The role of AR on intercultural exchanges of language learners	Design-based	Written responses and reflections	15 stu
Jalaluddin, Dormi, & Ismail (2021)	"Application of mobile augmented visual reality (MAVR) for vocabulary learning in the ESL classroom"	The effect of MAVR on vocabulary learning	Experimental	British Picture Vocabulary Scale	45 stu

Conclusion

On the basis of this principled review, it was dawned on that there was a serious lack of research studies on the topic of the use of AR in language education which were published in the distinguished, reputable academic journals in the field of foreign and second language education and technology within last five years, as it is a highly new research area in this field. As distinguished academic journals are important sources in order to reach reliable data in each field, having a lack of published studies on the related topics unfolds the gap in the field. Between the years 2017 and 2021, only seventeen empirical research studies were published in the selected privileged journals which are relevant to language education and technology. Additionally, it was seen that the context of the published studies was mainly on Taiwan context, which is a real gap in the literature, that it has the lack of generalizability of the results. Based on these limited published studies, it might be concluded that AR technology in language education is a highly new research area, therefore more research studies should be carried out in different geographical and educational contexts to be able to see the impacts of AR technology in different aspects and to reach more generalizable results. The results of the review demonstrated that the researchers center mainly on vocabulary teaching and the measurement of learning achievement, attitudes, and motivation of students by proving that there is a need for further studies on the effects of AR in language education focusing on measuring other skills development of students. Based on the suggestions for further research from analysed studies, more AR-enhanced materials enabling learners from different educational levels to actively participate in the learning process might be designed and developed, by considering individual differences, strengths, and weaknesses of learners. On the other hand, for to be designed and developed AR materials, there is a need for better theoretical and detailed plans for teachers. Whilst several studies have shown that the positive effects of AR on language achievement, motivation, attitude, and satisfaction, even if there are some novel studies focusing on different use of AR in language education, only one study, for example, has attempted to investigate effects of AR on writing skill development which is a real gap in the field. The efficacy of AR has been proved by many scholars and research articles, so there must be much more inclusion of AR in the field of language education to enhance other language skills, such as reading, listening, speaking etc. of language learners. It is obvious that the effective integration of AR into language classes is still insufficient, which creates a need to conduct more research on how to successfully integrate AR technology in language education classes in terms of various aspects.

Acknowledgement

References

Azuma, R. (1997). A survey of augmented reality. *Presence: Teleoperators & Virtual Environment, 6*(4), 355–385.

Azuma, R., Baillot, Y., Behringer, R., Feiner, S., Julier, S. & MacIntyre, B. (2001). Recent advances in augmented reailty. *IEEE Computer Graphis and Applications*. DOI: 10.1109/38.963459

Barad, J. (August 16, 2019). Virtual and augmented reality can save lives by improving surgeons' training. STAT. Retrieved from https://www.statnews.com/2019/08/16/virtual-reality-improve-surgeon-training/

Binhomran, K. & Altalhab, A. (2021). The impact of implementing augmented reality to enhance the vocabulary of young EFL learners. *The JALT CALL Journal, 17*(1), 23-44. https://doi.org/10.29140/jaltcall.v17n1.304

Block, D. & Cameron, C. (2002). *Globalization and Language Teaching*. Routledge.

Bruner, J.S. (1996). *The culture of education*. Harvard University Press.

Caudell, T. P. & Mizell, D. W. (1992). Augmented reality: An application of heads-up display technology to manual manufacturing processes. *Proceeding of the Twenty-Fifth Hawaai International Conference on System Sciences*, 2, 659-669. doi: 10.1109/HICSS.1992.183317.

Chen, C. (2020). AR videos as scaffolding to foster students' learning achievements and motivation in EFL learning. *British Journal of Educational Technology, 51*(3), 657-672. doi:10.1111/bjet.12902

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

Chen, M., Wang, L., Zou, D. Lin, S. Xie, H. & Tsai, C. (2020). Effects of captions and English proficiency on learning effectiveness, motivation, and attitude in augmented-reality-enhanced theme-based contextualized EFL learning. *Computer Assisted Language Learning.* https://doi.org/10.1080/09588221.2019.1704787

Clarke, A. C. (1973). *Profiles of the Future: An Inquiry into the Limits of the Possible.* Popular Library.

Costuchen, A. L., Darling, S., & Uytman, C. (2020). Augmented reality and visuospatial bootstrapping for second-language vocabulary recall. *Innovation in Language Learning and Teaching,* 1-12. https://doi.org/10.1080/17501229.2020.1806848

Dewey, J. (1916). *Democracy and Education*. The Free Press.

Di Serio, Á., Ibáñez, M. B., & Kloos, C. D. (2012). Impact of an augmented reality system on students' motivation for a visual art course. *Computers & Education*, 68, 586–596. DOI: http://dx.doi.org/10.1016/j.compedu.2012.03.002

Dunleavy, M., Dede, C., & Mitchell, R. (2009). Affordances and limitations of immersive participatory augmented reality simulations for teaching and learning. *Journal of Science Education and Technology, 18*(1), 7-22. DOI:10.1007/s10956-008-9119-1

Feiner, S., Macintyre, B., Hollerer, T. & Webster, A. (1997). A touring machine: Prototyping 3D mobile augmented reality systems for exploring the urban environment. *Personal Technologies, 1*(4), 74–81. DOI:10.1007/BF01682023

Godwin-Jones, R. (2016). Augmented reality and language learning: From annotated vocabulary to place-based mobile games. *Language Learning and Technology, 20*(3), 9–19. DOI: 10125/44475

Greenwood, A.T. & Wang, M. (2018). Augmented reality and mobile learning: theoretical foundations and implementation. In: Crompton H, Traxler J (Eds), *Mobile Learning and Higher Education: Challenges in Context* (pp. 41-55). Routledge.

Holden, C., & Sykes, J. (2011). Leveraging mobile games for place-based language learning. *International Journal of Game-Based Learning, 1*(2), 1–18. DOI:10.4018/ijgbl.2011040101

Hsu, T. (2017). Learning English with augmented reality: Do learning styles matter? *Computers & Education*, 106, 137-149. http://dx.doi.org/10.1016/j.compedu.2016.12.007

Jalaluddin, I., Darmi, R., & Ismail, L. (2021). Application of mobile augmented visual reality (MAVR) for vocabulary learning in the ESL classroom. *Asian Journal of University Education, 17*(3), 162-173. https://doi.org/10.24191/ajue.v17i3.14507

Johnson, L., Smith, R., Willis, H., Levine, A., & Haywood, K. (2011). *The 2011 horizon report.* The New Media Consortium, Austin, Texas. Retrieved from https://waynedev.uakron.edu/dotAsset/d252d696-2a99-4102-8010- 4fc103846b0d.pdf

Klopfer, E., & Squire, K. (2008). Environmental detectives: The development of an augmented reality platform for environmental simulations. *Education Technology Research and Development, 56*(2), 203-228. DOI:10.1007/s11423-007-9037-6

Lantolf J.P., & Thorne S.L. (2006). *Sociocultural theory and the genesis of second language development*. Oxford University Press.

Lee, S., & Park, M. (2020). Reconceptualization of the context in language learning with a location-based AR app. *Computer Assisted Language Learning, 33*(8), 936-959. https://doi.org/10.1080/09588221.2019.1602545

Lin, V., Liu, G., & Chen, N. (2020). The effects of an augmented-reality ubiquitous writing application: a comparative pilot project for enhancing EFL writing. *Computer Assisted Language Learning*. https://doi.org/10.1080/09588221.2020.1770291

Liu, P. E., & Tsai, M. (2013). Using augmented-reality-based mobile learning material in EFL English composition: An exploratory case study. *British Journal of Educational Technology, 44*(1), 1–4. DOI:10.1111/j.1467-8535.2012.01302.x

Liu, T. Y. (2009). A context-aware ubiquitous learning environment for language listening and speaking. *Journal of Computer Assisted Learning, 25*(6), 515–527. http://dx.doi.org/10.1111/j.1365-2729.2009.00329.x

Majoros, A., & Neumann, U. (2001). Support of crew problem-solving and performance with augmented reality. *In Bioastronautics Investigators' Workshop*, Galveston, TX January, (pp. 17-19).

Merriam-Webster Dictionary, (n.d.). "augmented reality" in Merriam-Webster Dictionary. Retrieved from https://www.merriam-webster.com/dictionary/augmented%20reality

Núñez, M., Quirós, R., Núñez, I., Carda, J. B., & Camahort, E. (2008). Collaborative augmented reality for inorganic chemistry education. In J. L. Mauri, A. Zaharim, A. Kolyshkin, M. Hatziprokopiou, A. Lazakidou, M. Kalogiannakis, & N. Bardis (Eds.), *WSEAS International Conference Proceedings*. Mathematics and Computers in Science and Engineering (No. 5). WSEAS.

Piaget, J. (1973) *To understand is to invent: The future of education*. Grossman.

Pokémon GO [Mobile software]. (2016). San Francisco. Niantic.

Redondo, B., Cozar-Gutierrez, R., Gonzalez-Calero, J. A., & Ruiz, R. S. (2019). Integration of augmented reality in the teaching of English as a foreign language in early childhood education. *Early Childhood Education Journal,* 48, 147-155. https://doi.org/10.1007/s10643-019-00999-5

Shelton, B. E., & Hedley, N. R. (2002). Using augmented reality for teaching earth-sun relationships to undergraduate geography students. Augmented Reality Toolkit, *The First IEEE International Workshop*.

Squire, K. D., & Jan, M. (2007). Mad City Mystery: Developing scientific argumentation skills with a place-based augmented reality game on handheld computers. *Journal of Science Education and Technology, 16*(1), 5-29.

Sutherland, I.E. (1968). A head-mounted three-dimensional display. In Proc. Fall Joint Computer Conf. (pp. 757–764). Thompson Books.

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

Tsai, C. (2020). The effects of augmented reality to motivation and performance in EFL vocabulary learning. *International Journal of Instruction, 13*(4), 987-1000. https://doi.org/10.29333/iji.2020.13460a

Wang M., Callaghan V., Bernhardt J., White K., & Peña-Rios, A. (2018). Augmented reality in education and training: pedagogical approaches and illustrative case studies. *Journal of Ambient Intelligence and Humanized Computing, 9*(5), 1391–1402. https://doi.org/10.1007/s12652-017-0547-8

Wen, Y. (2020). Augmented reality enhanced cognitive engagement: Designing classroom-based collaborative learning activities for young language learners. *Education Technology Research and Development, 69*, 843-860. https://doi.org/10.1007/s11423-020-09893-z

Wu, M. (2019). The applications and effects of learning English through augmented reality: a case study of Pokémon Go. *Computer Assisted Language Learning*, https://doi.org/10.1080/09588221.2019.1642211

Yang, S., & Mei, B. (2018). Understanding learners' use of augmented reality in language learning: Insights from a case study. *Journal of Education for Teaching, 44*(4), 511-513. https://doi.org/10.1080/02607476.2018.1450937

Yeh, H., & Tseng, S. (2020). Enhancing multimodal literacy using augmented reality. *Language Learning & Technology, 24*(1), 27-37. https://doi.org/10125/44706

Yuen, S. C. Y., Yaoyuneyong, G., & Johnson, E. (2011). Augmented reality: An overview and five directions for AR in education. *Journal of Educational Technology Development and Exchange, 4*(1). https://doi.org/10.18785/jetde.0401.10

Zhang, D., Wang, M., & Wu. J.G. (2020). Design and implementation of augmented reality for English language education. In Vladimir G. (Ed.), *Augmented Reality in Education*. Springer International Publishing. DOI: 10.1007/978-3-030-42156-4_12

"6 Benefits and 5 Examples of Augmented Reality in Education". (September 26, 2019). Retrieved from https://www.viewsonic.com/library/education/6-benefits-and-5-examples-of-augmented-reality-in-education/#Requirements_for_AR_in_the_Classroom