Mobile Augmented Reality for Learning Phonetics: A Review (2012-2022)

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Abstract

The traditional methods used for learning phonetics (LP) are somehow overwhelming and lack interactivity. Therefore, researchers adapted popular technologies such as Mobile Augmented Reality (MAR). Until now, there isn't any review conducted about using MAR for LP. So, this review provides the basic knowledge needed for those interested in this field. MAR applications published between 2012 and 2022 are summarized, the technical requirements of making an LP MAR app are described and the benefits/limitations of using MAR for LP are discussed. The review showed that using MAR technology increased learners' attention and made the learning process more interactive. Even though it still suffers in some areas, such as instability of marker tracking, inflexibility of updating AR content, and inability to correct learners' pronunciation as it happens in real life by language teachers.

Keywords: Mobile Augmented Reality; MAR; phonetics; Learning phonetics.

1 Introduction

MAR is the most popular and most used Augmented Reality (AR) type (Nizam et al., 2018). It uses mobile devices - such as smartphones and tablets - to blend the information of the real world with computer-generated objects in a way that wasn't possible before (Chatzopoulos et al., 2017). Phonetics is a part of linguistics that studies the sounds of human speech (Bruhn, 2018). The phonics method focuses on the sound of symbols (Mahayuddin & Mamat, 2019). It enables the students to pronounce the words rather than memorize the word pronunciation. The phonics method is ideal for teaching reading (Engwall, 2012). (Jumi, 2018) proposed courseware for English vocabulary pronunciation using the phonic reading method in her thesis.

Many researchers have conducted studies about using MAR as an educational tool for Language Learning (Majid & Salam, 2021), (Fan et al., 2020), (Karacan, 2021), (Yilmaz et al., 2022). But only few focused on using it for learning phonetics. (Booton et al., 2021) covered in their systematic review the part of language pronunciation and how it is enhanced by using MAR applications. (Munshi & Aljojo, 2020) showed how effective the MAR multimodal input applications are in assisting the problems of learning vocabulary pronunciation/spelling. (Poompimol, 2017) explored to what

extent AR materials implementation can help improve Prathom 1 students' English pronunciation proficiency.

MAR has been used as an interactive tool for learning phonetics in the classroom. (Wu, 2019) used the famous Pokemon Go game as a learning activity in classrooms to enable the students to write and pronounce the sound 'pi', 'ka', and 'chu'. (Mei, 2021) reviewed the use of the Clips app in language classrooms and how that provides instant feedback on students' pronunciation and makes language learning more engaging. (Chen, 2018) assisted students' phonic learning and helped them to decode letters into their respective sounds, forming an essential skill to read unfamiliar words by themselves using MAR application. (Nugraha et al., 2019) described the steps and procedures of developing MAR English phonetic learning media. (Arunsirot, 2020) examined how MAR enhanced the students' abilities to produce English consonant sounds.

MAR apps are also used to help learners with disabilities and autism (Mahayuddin & Mamat, 2019), (Zaman, 2012), (Shaltout et al., 2020), (Antkowiak et al., 2016), (Bhatt et al., 2020). For example, (Wook et al., 2020) investigated the effect of using video modeling in the MAR app, on the phonics performance of first-grade students who are at risk for reading disabilities. (Anas & Mahayuddin, 2017) proposed a system that helps Autistic children to learn the Arabic alphabet. (Sidi et al., 2017) presented a prototype of MAR interactive synthetic phonics courseware for kindergarten Consonant-Vowel-Consonant (CVC) word. The courseware started with learning phonics sounds and then blended the phonics sounds to read the CVC words.

Most of the studies used a card to learn how a character/word should be pronounced (Opu et al., 2021), (Tsai, 2020), (Beder, 2012), (Fung & Wan, 2019), (Rozi et al., 2020), (Khan et al., 2019), (Ulfah et al., 2020), (Wulan & Rahma, 2020), (Florentin, 2016), (Küçük et al., 2014), (Sorrentino et al., 2015), (Martínez et al., 2017), (Wen, 2020), (Zhang et al., 2020). As (Wen, 2020) demonstrated in his Chinese character composition game with the paper interface designed and implemented in classrooms. Also, (Welbeck, 2020) discussed how audio features in MAR apps could potentially enhance pronunciation of the vocabulary in the case of using native accents. (Jalaluddin et al., 2020) the experimental study aimed to explore the effectiveness of using MAR application in vocabulary learning among LINUS students and how that helped the students grasp the meaning and the concept of how to pronounce the words.

Despite the importance of learning phonetics, only one review was found about using MAR technology in the field of Learning Phonetics. So, this review was conducted to provide a broad overview of user-based MAR research, to help researchers find example papers that contain related studies, to help identify areas where there have been few user studies conducted, and to highlight exemplary user studies that embody the use of MAR app in LP.

2 Methodology

To help the AR community improve usability, this paper provides an overview of 10 years of MAR user studies, from 2012 to 2022. Four research questions (RQ) were designed, as shown in Table 1. Then related data to these questions were collected from five interdisciplinary databases: Google Scholar, IEEE Xplore, ACMD Digital Library, Springer, and ResearchGate. The search strings are Augmented Reality for learning phonetics, Augmented reality for Phonics Learning, and Augmented Reality Language Pronunciation.

Table 1. Research Questions.

ID	Research Question
RQ1	What are the existing MAR applications for learning phonetics?
RQ2	Which languages are using MAR for learning phonetics?
RQ3	What types of activities are covered in the MAR apps for LP?
RQ4	What are the technical requirements to make MAR apps for LP?

The title and abstract of each paper are considered, and the results are cross-checked to discard any repetition. Certain inclusion and exclusion criteria are applied. These criteria are shown in Table 2. The initial search was conducted from Dec 2021 to Feb 2022. Updates have been done during the review process in March 2022 to include the latest published studies.

Table 2. The inclusion and exclusion criteria.

Inclusion Criteria
• Containing search keywords in the title or the abstract or keywords. • English research articles published from January 2012 till March 2022. • Review studies that have domain in using MAR in Language Learning. • Papers that describe MAR applications for learning phonetics.
Exclusion Criteria
• Papers focusing only on Language Learning. • Publications that didn't contain terms 'AR' and 'phonetics'. • Any study published before 2012. • Redundant publications.

3 Results

223 studies were found using search strings. After applying the inclusion and exclusion criteria, 65 topic-related studies were analyzed. The distribution of these studies over the last decade (2012-2022) has been illustrated in Figure 1. The figure gives an in-depth understanding of the current research state of the review topic.

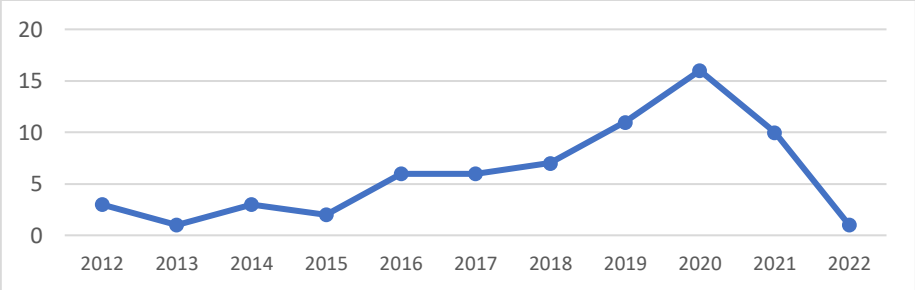

Fig. 1. Distribution of related studies over the last decade.

There are only a few studies published between 2012 and 2015. This could imply that researchers were doubted of emerging new technology tools in the educational settings at this time. Nevertheless, studies on using MAR for LP have an upward trend from 2016, reaching a peak of 16 studies in 2020.

3.1 MAR Applications for LP

Not all reviewed studies focused on making an application to be used. Only 32% of them made applications that are summarized in Table 3. The Table shows the study, application name, year of production, used for which language, and target audience.

Table 3. MAR applications for LP that are published between 2012 and 2022.

Study	App Name	Year	Language	Audience
(Sirat et al., 2021)	ReModAR	2021	-	Kindergarten with/without disabilities
(Daud et al., 2021)	ARabic-Kafa	2021	Arabic	Primary school students
(Khatoony, 2021)	ARET	2021	English	For teachers and English learners
(Piatykop et al., 2021)	Fox Alphabet AR	2021	Ukrainian	Children
(Daniel et al., 2020)	InglesAR	2020	English	Children whose native language is Portuguese
(Hasbi et al., 2020)	Lontara	2020	Buginese	Elementary school students
(Mahayuddin & Mamat, 2019)	-	2019	Malay	Children with Autism
(Nasution et al., 2019)	Translation Agent	2019	English\ Indonesian	School age children
(Dalim & Sunar, 2019)	TeachAR	2019	English	4 -6 years old

(Hadid et al., 2019)	Reader Buddy	2019	English / Arabic	English learners
(Ali & Azmi, 2019)	Azmi	2019	Malay	International students
(Hossain et al., 2019)	AR Children's Book	2019	English / Bangla	Children
(Thongchum & Charoenpit, 2018)	Kanji AR	2018	Japanese	Thai-Nichi Institute students
(Fan et al., 2018)	PhonoBlocks	2018	English	7-9 years old
(Plecher et al., 2018)	Dragon Tale	2018	Japanese	Beginners
(Hashim et al., 2017)	ARabic	2017	Arabic	7 years old
(Abd Majid et al., 2016)	AR app for pre-literacy	2016	English	4-6 years old
(Bojórquez et al., 2016)	Lotería Mayo	2016	Mayo	Undergraduate students
(Martínez et al., 2016)	Leihoa	2016	English	3-4 years old
(He et al., 2014)	MAR App	2014	English	Pre-school children
(Khaled et al., 2013)	AR AlphaBees	2013	English	Children

3.2 Languages used MAR apps for LP

Using MAR app for LP has been explored in many languages such as English, Arabic, Japanese, Chinese and Indonesian. It is also explored in uncommon languages such as Malay, Buginese, Bangla, Hijaiyah, and Makhraj. The languages available in LP MAR apps are illustrated in Figure 2, along with the number of reviewed studies for each. English stands at the top with 31 studies in total. Arabic comes next with seven studies.

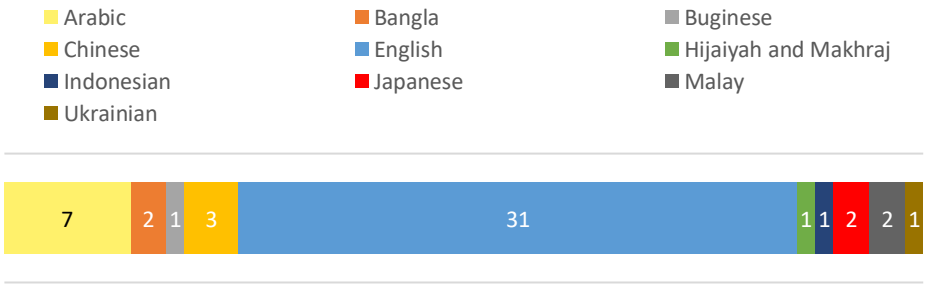

Fig. 2. The number of MAR apps collected for each language.

3.3 Types of Activities covered

According to the reviewed studies, there are three main activity types used in MAR applications for LP: (1) Learning language's letters/character/alphabets pronunciation. (2) Learning how to pronounce words/vocabulary of a specific language. (3) Pronunciation option in Translation applications. Not all the reviewed studies focused on one type of activity. Studies such as (Daud et al., 2021), (Hossain et al., 2019), and (Yilmaz et al., 2022) covered two types: letters and vocabulary learning. Most of the studies focused on learning vocabulary pronunciation, as shown in Figure 3.

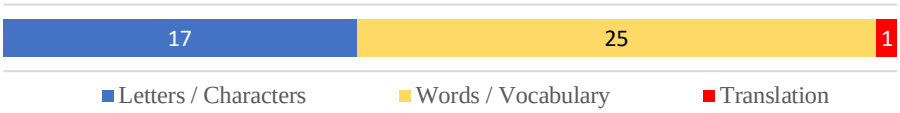

Fig. 3. Activities used in MAR for LP and number of studies found for each.

3.4 Technical Requirements of MAR applications for LP

The technical requirements to develop MAR application for LP include MAR SDK (Software Development Kit), tracking techniques, and interaction techniques.

AR SDKs

SDKs or devkits are development tools that allow developers to create apps, build virtual objects, and blend them with the real world. From the reviewed studies, the top SDKs that gained researchers' attention in making MAR applications for LP are ARcore, Android SDK, Vuforia, Aurasma, Wikitude, and Hair SDK (Zhang et al., 2020). It was found that Vuforia is the most used SDK, as shown in Figure 4. Android is the most used platform, as shown in Figure 5. The other used platforms were IOS and XML.

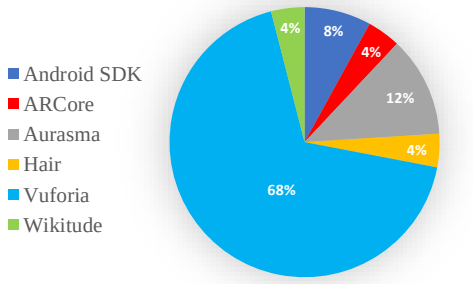

Fig. 4. Number of studies for each SDK.

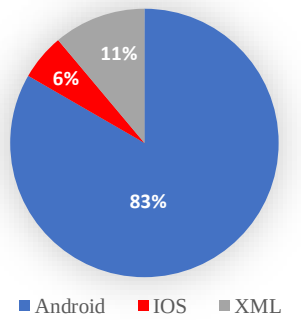

Fig. 5. Number of studies for each platform.

Tracking Techniques

To overlay the virtual content onto physical objects in the real world, objects must be tracked in the real world in real-time. Tracking anchors the virtual content in the correct position to the real world (Yu et al., 2016). MAR tracking techniques could be either Sensor-based or Vision-based tracking. Sensor-based tracking is a lightweight MAR implementation approach (Singh & Mantri, 2015). It uses mobile device sensors, such as accelerometers, gyroscopes, compasses, magnetometers, and GPS. While Vision-based tracking uses a Mobile device's camera to capture the surrounding environment. The most common Vision-based tracking types are Marker-based and Marker-less tracking (Perry, 2021). In Marker-based tracking, the virtual content is triggered by using printed flashcards or books pages. Where in Marker-less tracking, it could be triggered either by large-scale real-world scenes such as buildings or by small-scaled objects placed in the environment (e.g., table) (Karacan, 2021). Marker-based tracking is used in 70% of reviewed studies.

Interaction Techniques

Interaction techniques focused on how users interact with the virtual objects that appear in the AR environment (Tang & Young, 2014). It also offers the controls of the virtual objects, such as selection and manipulation functions (e.g., color, shape, and position) (Nizam et al., 2018). Usually, interaction technique in AR involves unimodal interaction technique that only allows user to interact with AR content by using one modality such as gesture (Bruhn, 2018), speech (Nasution et al., 2019), (Dalim & Sunar, 2019), touch (Jalaluddin et al., 2020), (Khaled et al., 2013) and click. Clicking is the most used interaction technique in 23 studies, as shown in Figure 6, because it includes pressing menus and buttons of the interface. Where Touching includes physical manipulation of the virtual object from rotating to zooming in and out, but it has a lot of issues such as fat fingers.

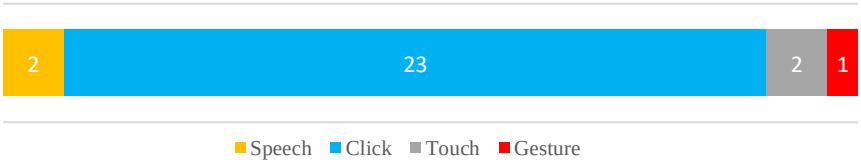

Fig. 6. The number of reviewed studies for each interaction technique.

4 Discussion

From the reviewed studies, MAR technology significantly enhanced the learning process. It overcame the dilemma of whether the pronunciation of a word is correct or not. The learners' interaction increased through the provided multimedia content. It can be easily deployed at schools or at home (Fan et al., 2020). And the provided LP activities helped improve learners' reading skills (Wook et al., 2020). Also, it transforms the abstract language symbols on physical learning materials (e.g., letters, flashcards, objects) into vivid 2D/3D augmented visual representations and auditory sounds (Fan et al., 2020). Despite the benefits of using MAR technology in LP, the number of studies in this field started to decrease in 2021. This could be due to the difficulty of providing the rich content containing all the needed rules to learn the phonetics of specific languages, such as French or Russian. It could also be due to the improvement of Mixed Reality Headsets that grabbed researchers' attention.

Yet, using MAR technology for LP still suffers from limitations such as unstable marker tracking due to inappropriate marker design or inappropriate interaction design (e.g., children's hands blocked markers during interaction) (Fan et al.,2020). The AR content is fixed in most studies and didn't have the option to be updated. Only the InglesAR app by (Daniel et al., 2020) offered an option to upload resources, to expand the vocabulary existing in the game. The commonly used interaction technique (clicking) didn't provide the interaction level offered by MAR technology. Only two reviewed studies (Jalaluddin et al., 2020) and (Khaled et al., 2013) used Touch interaction to increase interactivity level.

5 Conclusion

MAR technology increases learning outcomes by using integrated augmented visualizations as learning guidance. It is the most popular because of its ease of use, affordances, and portability. This paper discussed the use of MAR for learning phonetics. A total of 65 articles were reviewed from 2012 to 2022. Approximately two-thirds were published after 2015, and half were from the Google Scholar database. The findings revealed that the most taught foreign language is English with 31 articles. In addition, MAR has been explored for other languages such as Arabic, Chinese, and Japanese. Yet it is still not used in learning common languages such as German, French, and Italian. The most preferred development tools were Unity and Vuforia SDK. Vision-based tracking is used in all MAR applications for LP, especially the Marker-based type. Where touch and click are the most used interaction models. Although using MAR technology have great benefits, it still suffers from certain limitations such as instability of marker tracking, inflexibility of updating AR content, and inability to correct learners' pronunciation as it happens in real life by the language teacher. All these limitations are considered points of improvement for future research in this field.

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