Journal of Education and Practice
ISSN 2222-1735 (Paper) ISSN 2222-288X (Online)
Vol.14, No.33, 2023

"Mandarin AR" : An Augmented Reality Application for Mandarin Vocabulary Self-Directed Learning

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Abstract
The demand of foreign language learning such as Mandarin has increased globally. More efforts have been taken up especially in the tertiary level to further improve learning experience in line with the increasing demand and needs of students in learning. Since technology has been the key element in the journey to deal with language courses, Augmented Reality (AR) is seen as a transformative tool that has shown a promise in self-directed learning of foreign language, particularly in vocabulary acquisition. However, the potential of AR in this context is less explored in Malaysia. Therefore, this study addresses the gap by concentrating on a self-developed "Mandarin AR" application (app), used as a supplementary tool for introductory Mandarin courses. This study focused on the self-developed "Mandarin AR" app as an additional instructional tool for Introductory Mandarin courses. The aim of this study was to explore the feasibility of the "Mandarin AR" app for improving students' vocabulary with visual-verbal-auditory features, and to create a flexible, enjoyable, flipped, and self-regulated learning environment for students. This study used the quantitative method involving 238 students who enrolled in a course namely Introductory Mandarin 1. The data analysed using a descriptive analysis, revealed that the design, content, and presentation of the "Mandarin AR' app were suitable for them to learn Mandarin vocabulary in the self-directed learning environment. It is hoped that the finding of the research could be a guideline for practitioners venturing into the AR integration in language education.
Keywords: Augmented reality, Instructional tool, Mandarin, Self-directed learning, Vocabulary
DOI: 10.7176/JEP/14-33-12
Publication date: November 30th 2023

1. Introduction

The rapid advancement in educational technology has changed the education landscape from teaching and learning using the conventional methods to applying technologies such as portable document format (PDF,) gamification, virtual reality (VR), augmented reality (AR) and artificial intelligence (AI). The integration of technologies in teaching and learning may fulfil the teaching needs of instructors and learning needs of students. Therefore, this paper focuses on the AR in the teaching and learning of Mandarin as a third language.

Learning Mandarin as a third language is challenging as students may not have any vocabulary or only have limited vocabulary to use Mandarin. Thus, they need to memorise adequate vocabulary in order to use Mandarin effectively. However, memorising vocabulary is tedious, and requires a lot of effort, time and motivation. Therefore, there is a need to provide learning materials which promote fun learning, interactive, engaging and increase learning retention. Since the AR has been proven by research as shown in Table 1 to have the positive impacts on learning, the "Mandarin AR," app was designed and developed using selected multimedia.

The multimedia for the app was selected based on the Cognitive Theory of Multimedia Learning (Mayer, 2001) which emphasizes three principals. First, learners have two channels to process information which are the visual channel and the auditory channel. Second, the capacity of each channel is limited so that the multimedia must be selected carefully to avoid cognitive load in processing the information provided. Finally, learning is an active process which involves learners to filter, select, organise, and integrate information using their prior knowledge.

After the design and development of the "Mandarin AR," app was completed, it was implemented to students. Therefore, a study was conducted to investigate students' perceptions in using the Mandarin AR vocabulary application for learning Mandarin vocabulary in the self-directed learning environment. The objectives of the study are as follows:

a. To assess students' perceptions on the design of content and presentation of the Mandarin AR vocabulary application
b. To determine students' perceptions on usefulness of using the Mandarin AR in learning Mandarin vocabulary

2. Review of Related Literature

There are various definitions of augmented reality provided by dictionaries. The Cambridge Online Dictionary

(n.d.) defines it as "images produced by a computer and used together with a view of the real world". While the Oxford Learners' Dictionaries (n.d.) describes it as "a technology that combines computer-generated images on a screen with the real object or scene that you are looking at". Özcelik et al. (2022) depict that augmented reality as "the process of combining interactive digital 3D elements with the components of physical world". Therefore, in the context of teaching and learning, AR provides the real-world elements by enhancing them using digital elements such as texts, graphics, sounds, background music and audios for teaching and learning purposes.

There are various benefits of applying the AR in education. According to Özcelik et al (2022) the AR in education generally provides the advantages in terms of (1) access: the AR learning materials are accessible at any time and from anywhere, (2) affordability: the AR learning materials are less expensive, (3) portability: the AR learning materials are portable, and (4) unlimited application: it is suitable for any field and level of education. Pertaining to language learning, previous literature has demonstrated that AR has facilitated students in learning. Table 1 indicates the benefits of the AR in language learning which are promoting immersive learning, personalising learning, boosting motivation, increasing retention, promoting fun learning, increasing learning retention and reducing cognitive load.

Table 1. Benefits of the AR in language learning

		Immersive learning	Personalised learning	Boost motivation	Increase retention	Fun learning	Increase learning retention	Reduce cognitive load
1.	Belda-Medina and Marrahi-Gomez (2023)	√					√	
2.	Chang, et al. (2022)			√				
3.	Chuang, et, al. (2022)			√				
4.	Kazu and Kuvvetli (2023)	√		√		√	√	√
5.	Mozaffari and Hamidi (2023)	√					√	
6.	Shadiev and Liang (2023)	√					√	
7.	Wang, et al. (2022)			√				

3. Methodology

3.1 Method and Instrument

The research employed a quantitative method using an online survey questionnaire created with Google Forms. The questionnaire consisted of three sections: Section A (demographics), Section B (information about Mandarin learning conditions), and Section C (perceptions of using the AR application for learning Mandarin vocabulary). The items in Section C were rated based on a five-point Likert scale ranging from 1 to 5: 1=Strongly Disagree (SD), 2=Disagree (D), 3= Uncertainty (U), 4=Agree (A), and 5=Strongly Agree (SA).

3.2 Sample

The sample for the study was selected through purposive sampling. It included students from various faculties at Universiti Teknologi MARA (UiTM) Selangor and Seremban campuses who were enrolled in Mandarin classes. The sample consisted of 238 undergraduate students who volunteered to participate in the study. They were non-native speakers of Chinese/Mandarin. They were enrolled in the Introductory Mandarin 1 course at UiTM. They were drawn from three faculties located at the UiTM's Seremban satellite campus: the Faculty of Computer and Mathematical Sciences (FSKM), the Faculty of Sports Science & Recreation (FSK), the Faculty of Administrative Science & Policy Studies (FSPPP), and the Faculty of Built Environment (FSPU), and the Faculty of Civil Engineering (FK) at UiTM, Shah Alam.

3.3 Data Collection and Analysis

The data were collected after the Mandarin AR app was implemented for one months. Students used the app outside the classroom as they needed to use it in the self-directed learning environment. Then, the questionnaire in the form of Google Form was distributed to students via WhatsApp. The form was open for one week.

The data collected were analysed by using the Statistical Package for Social Science for the reliability of questionnaire items and descriptives statistics such as frequency, percentage, means score and standard deviation. Then, the results were presented in tables.

3.4 The Mandarin AR Vocabulary App

The study investigated students' perceptions in using the Mandarin AR vocabulary application for learning Mandarin vocabulary in the self-directed learning environment. The Mandarin AR vocabulary application was used as an additional instructional tool for Introductory Mandarin 1 at UiTM (Universiti Teknologi MARA).

The Mandarin AR vocabulary application is an experimental AR app. It is named as the "Mandarin AR,". It was developed using Unity and Vuforia authoring tools. The star navigational structure was applied in the development of Mandarin AR application content and design. This structural design allows users to navigate from the main page to other pages via hyperlinks. Each of the linked pages leads directly back to the main content/main page and enables users to make another selection. Therefore, users should be able to move in and out from the main page/main menu to explore different topics.

The framework of the Mandarin AR app was developed based on the Cognitive Theory of Multimedia Learning (Mayer, 2001). According to the Cognitive Theory of Multimedia Learning, 'multimedia' refers to the presentation of materials using words and pictures together, rather than words alone. 'Words' can be either printed text (words displayed on the screen for the learner to read) or spoken text (words presented as speech that the learner listens to through earphones or speakers). 'Pictures' encompass static illustrations, such as drawings, charts, graphics, maps, or photos, as well as dynamic graphics or images, such as animations or videos (Clark & Mayer, 2003). The design of the landing page and other pages on the Mandarin AR app is simple and user-friendly (refer to the screenshots in Figure 1, 2, 3 and 4). Figures 1 shows the landing page where students can click the 'START' button to access the main page, which consists of seven themes: (1) Pronoun, (2) Family, (3) Occupation, (4) Noun, (5) Place, (6) Time References and (7) Verbs, as displayed in Figure 2. The main page also provides the "Exercise" button where students can click the button to practice the lessons by using the exercises provided in the app. While Figure 3 and 4 show the sample of digital game-based exercise and content respectively.

Furthermore, the vocabulary in the 'Mandarin AR' app is based on the prescribed Introductory Mandarin I textbook. Each vocabulary entry includes a picture/image, a Chinese character, 'pinyin,' and sentence example in both the English and Malay language. The inclusion of the Malay language is beneficial because UiTM students are predominantly Bumiputra, with the Malay language as their mother tongue. This makes it easier for students to understand or master Mandarin words when they are translated into the Malay language. Additionally, each vocabulary entry includes audio pronunciation. After completing each vocabulary theme, students are provided with game-based exercises to reinforce their vocabulary knowledge (refer to Figure 3). Moreover, incorporating digital game-based exercises into vocabulary learning does not only make it enjoyable and fun but also reduces cognitive overload and motivates students to learn (Kazu & Kuvvetli, 2023).

The vocabulary items are categorized into themes to facilitate easier recognition and the memorization process for learners (Teh & Goh, 2018). For example, the 'Pronoun' vocabulary theme encompasses singular pronouns such as '我 wǒ' (I/saya), '你 nǐ' (you/Awak), and '他/她 tā' (he/she/dia), as well as plural pronouns like '我们 wǒmen' (we/kita), '你们 nǐmen' (you all/kamu semua), and '他们 tāmen' (they/mereka). This means that when using plural pronouns, one simply needs to add 'men.' Similarly, each pronoun is associated with a simple sentence. As shown in Figure 4, for instance, the pronoun '你 nǐ' corresponds to the sentence '你好吗？ Nǐ hǎo ma?' (How are you?/Apa khabar?). This content and design approach assists students in effectively engaging with and mastering all five cognitive processes: selecting, organizing, and integrating information. The outcome of this meaningful learning approach is improved performance in both retention and transfer tests (Mayer, 2001; 2008).

To access the Mandarin AR app, students must first download the APK link and the image maker link onto their phone, tablet, or laptop. They can then view the vocabulary through the downloaded image maker. Students have the option to view the vocabulary in both online and offline modes. Consequently, students can use this Mandarin AR app tool without any spatial limitations.

Fig. 1. Mandarin AR app landing page

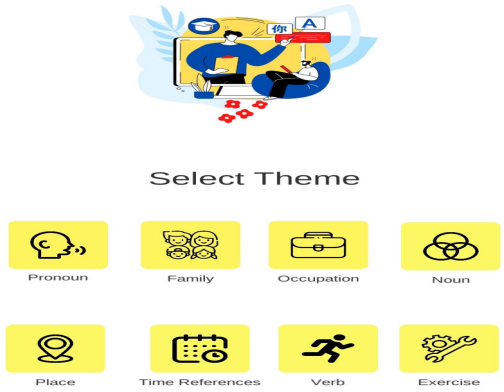

Fig. 2. Mandarin AR app main page

Fig. 3. Example of Digital game-based exercises

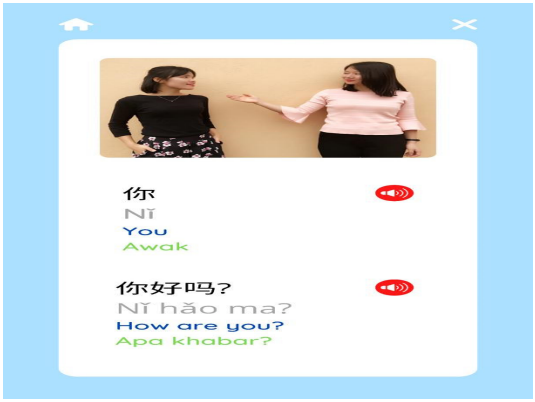

Fig. 4. Sample of Mandarin AR app contents

4. Results and Discussions

4.1 Reliability of Questionnaire Items

Table 2 indicates that the Cronbach' Alpha for design of content and presentation of Mandarin AR was 0.943, usefulness of using Mandarin AR was 0.966 and overall was 0.954. According to Gliem & Gliem (2003) the results indicate that the reliability of the items was excellent. Thus, the instrument possesses acceptable internal consistency.

Table 2. Constructs and Items

		Cronbach's Alpha	Number of items
Perceptions towards using AR app in learning Mandarin vocabulary			
	Design of content and presentation of Mandarin AR vocabulary Application	0.943	10
	Usefulness of using Mandarin AR in learning Mandarin vocabulary	0.966	13
	Overall	0.954	23

4.2 Demographic Profile of Participants

The distribution of respondents' demography such as gender, faculty and age is described in Table 3.

Table 3. Demographic of respondents

Item	Category	Frequency	Percentage (%)
Gender	Male	53	22.3
	Female	185	77.7
Faculty	FSKM	65	27.3
	FSPPP	111	46.6
	FSR	21	8.8
	FSPU (Shah Alam)	23	9.7
	FSPU (Puncak Alam)	9	3.8
	FK	9	3.8

Item	Category	Frequency	Percentage (%)
Age	20	1	0.4
	21	32	13.4
	22	160	67.2
	23	31	13
	24	12	5.0
	25	2	0.8

Table 3 indicates that there were 53 male students (22.3%) and 185 female students (77.7%). The respondents were from UiTM Shah Alam, UiTM Puncak Alam and a satellite campus of UiTM Seremban. The majority of the respondents were from FSPPP with 111 students (46.6%), followed by FSKM with 65 students (27.3%), 23 students (9.7%) from FSPU UiTM Shah Alam, 21 students (8.8%) from FSR, 9 students (3.8%) from FSPU UiTM Puncak Alam and 9 students (3.8%) from FK.

In terms of age, 67.2% or 160 respondents were 22 years old, 13.4% (32) were 21 years old, 31 (13%) were 23 years old, 12 (5%) were 24 years old, 2 students were 25 years old (0.8%) and the remaining 1 (0.4%) was 20 years old.

4.3 Perceptions in using AR application in learning Mandarin Vocabulary

Students' perceptions on the design of contents and presentation of the Mandarin AR app were assessed by using a five-point Likert's scale was used ranging from 1 to 5 (1=Strongly Disagree (SD), 2=Disagree (D), 3= Uncertainty (U), 4=Agree (A), and 5=Strongly Agree (SA). Scores on the design of contents and presentation of the Mandarin AR app related to frequency, percentage, mean and standard deviation (SD) were tabulated Table 4.

Table 4. Design of content and presentation of Mandarin AR vocabulary application

No	Item	SD	D	U	A	SA	M	SD
1	The size and type of font used in the app should be suitable.	0 (0.0)	2 (0.8)	42 (17.6)	135 (56.7)	59 (24.8)	4.05	0.676
2	The virtual graphics / images used in the apps should be suitable.	0 (0.0)	5 (2.1)	37 (15.5)	136 (57.1)	60 (25.2)	4.05	0.7
3	Informative virtual graphics or images are necessary to make me understand the lesson better.	1 (0.4)	4 (1.7)	29 (12.2)	123 (51.7)	81 (34)	4.17	0.735
4	Sample sentences should be provided to illustrate the use of each vocabulary item in the lesson will help to increase my vocabulary.	1 (0.4)	1 (0.4)	31 (13.0)	132 (55.5)	73 (30.7)	4.16	0.685
5	The audio quality of the app should be good.	1 (0.4)	2 (0.8)	42 (17.6)	126 (52.9)	67 (28.2)	4.08	0.725
6	The layout and interface design should be systematic.	0 (0.0)	5 (2.1)	59 (24.8)	123 (51.7)	51 (21.4)	3.92	0.737
7	The layout and interface design should be friendly.	2 (0.8)	4 (1.7)	53 (22.3)	126 (52.9)	53 (22.3)	3.94	0.766
8	Navigation of Mandarin AR is user friendly.	1 (0.4)	8 (3.4)	55 (23.1)	123 (51.7)	51 (21.4)	3.9	0.782
9	Instruction of using Mandarin AR should be easy to understand	1 (0.4)	5 (2.1)	43 (18.1)	121 (50.8)	68 (28.6)	4.05	0.767
10	Distribution of vocabulary items into different themes will made learning process easy.	0 (0.0)	3 (1.3)	36 (15.1)	131 (55.0)	68 (28.6)	4.11	0.691
	Overall						4.04	0.726

M: mean, **SD**: standard deviation

SD: Strongly Disagree **D**: Disagree **U**: Uncertainty **A**: Agree **SA**: Strongly AgreeQuestion 1 to 10 in Table 2 were used to assess students' perceptions on the design of content and presentation elements of Mandarin AR vocabulary application. A total of 238 students from five different faculties participated in the survey to evaluate their experiences of using the Mandarin AR vocabulary application.

The analysis of the data reveals positive feedback from the respondents. Based on the collected data, 194 students (81.5%) agreed that the size and type of font used in the app were suitable. Additionally, 196 students

(82.3%) agreed that the virtual graphics or images used in this app were suitable, and 204 students (85.7%) agreed that these virtual graphics were informative. Students also agreed that graphics were essential for learning Mandarin because graphics helped them better understand the lessons.

Referring to the analysis of the data, most of students (86.5%) agreed that the sample sentences provided to illustrate the use of vocabulary increased their vocabulary. Furthermore, 83.6% of the respondents (199 students) agreed that the distribution of vocabulary according to different themes made the learning process easier. Most students (81.1%) were pleased with the audio quality of the app, finding it to be of good quality and expressing satisfaction with its inclusion. Regarding the layout and interface design, most of students agreed that the design was systematic (73.1%) and user-friendly (75.2%). Students also provided positive feedback on the navigation and instructions within the Mandarin AR vocabulary application. The results demonstrated that 174 students (73.1%) agreed that the navigation was user-friendly, while 79.4% of them found the instructions were clear and easy to understand. While the Mandarin AR vocabulary application received positive feedback from the majority of students in this research, approximately 1.7% of students did not agree with the design and presentation of the app due to its limitations.

Based on the data collected, the aspect of design of content and presentation of the Mandarin AR app was at high level, with the average mean score of 4.04 and the average standard deviation of .726. The highest mean scores were recorded by two items: "Informative virtual graphics or images are necessary to make *me understand the lesson better." (M = 4.17, SD = .735) and "Sample sentences should be provided to* illustrate the use of each vocabulary item in the lesson will help to increase my vocabulary. (M = 4.16, SD = .685).

The results suggest that the Mandarin AR app is easy to use and user-friendly due to the interface promote easy navigation and instructions are easy to understand. The multimedia used to design the app also are also suitable to facilitate the learning of Mandarin by using appropriate graphics, text and audios. The design and development of the app applies the Cognitive Theory of Multimedia Learning (Mayer, 2001, Clark & Mayer, 2003) that provide the contents by cautiously combining words in the form of text, graphics and audios (words presented in the form of speech) in order to promote active learning and avoid cognitive load.

4.4 Usefulness of using Mandarin AR in learning Mandarin vocabulary

Students' perceptions on the usefulness of using the Mandarin AR app in learning Mandarin vocabulary were assessed by using a five-point Likert's scale was used ranging from 1 to 5 (1=Strongly Disagree (SD), 2=Disagree (D), 3= Uncertainty (U), 4=Agree (A), and 5=Strongly Agree (SA). Scores on the usefulness of using the Mandarin AR app in learning Mandarin vocabulary related to frequency, percentage, mean and standard deviation (SD) were tabulated Table 4.

Table 5. Usefulness of using Mandarin AR in learning Mandarin vocabulary

No	Item	SD	D	U	A	SA	M	SD
1	Using Mandarin AR can make interaction more flexible.	1 (0.4)	3 (1.3)	43 (18.1)	137 (57.6)	54 (22.7)	4.01	0.706
2	I think I can be in control when dealing with AR experience	0 (0.0)	6 (2.5)	59 (24.8)	124 (52.1)	49 (20.6)	3.91	0.741
3	I believe that using AR Mandarin helps to make information easier to understand	2 (0.8)	3 (1.3)	41 (17.2)	129 (54.2)	63 (26.5)	4.04	0.751
4	Using AR in learning Mandarin can make learning more focused and faster.	1 (0.4)	4 (1.7)	47 (19.7)	136 (57.1)	50 (21.0)	3.97	0.717
5	Using Mandarin AR increases my productivity in learning Mandarin.	1 (0.4)	7 (2.9)	43 (18.1)	125 (52.5)	62 (26.1)	4.01	0.774
6	I find Mandarin AR useful in learning Mandarin vocabulary.	1 (0.4)	4 (1.7)	36 (15.1)	135 (56.7)	62 (26.1)	4.06	0.718
7	Using Mandarin AR improves my listening skills.	2 (0.8)	3 (1.3)	39 (16.4)	119 (50.0)	75 (31.5)	4.10	0.773
8	Using Mandarin AR improves my grammar skills.	1 (0.4)	2 (0.8)	48 (20.2)	128 (53.8)	59 (24.8)	4.02	.0723
9	Using Mandarin AR improves my speaking skills.	1 (0.4)	3 (1.3)	41 (17.2)	125 (52.5)	68 (28.6)	4.08	0.737
10	Using Mandarin AR improves my writing skills	2 (0.8)	5 (2.1)	62 (26.1)	120 (50.4)	49 (20.6)	3.88	0.783
11	Using Mandarin AR improves my vocabulary.	1 (0.4)	3 (1.3)	42 (17.6)	128 (53.8)	64 (26.9)	4.05	0.730

No	Item	SD	D	U	A	SA	M	SD
12	Using AR in learning Mandarin can motivate me to learn Mandarin.	0 (0.0)	4 (1.7)	41 (17.2)	127 (53.4)	66 (27.7)	4.07	0.717
13	Distribution of vocabulary into themes via AR can help me to memorize the vocabulary.	0 (0.0)	7 (2.9)	40 (16.8)	139 (58.4)	52 (21.8)	3.99	0.712
	Overall						4.01	0.737

M: mean, **SD**: standard deviation
SD: Strongly Disagree **D**: Disagree **U**: Uncertainty **A**: Agree **SA**: Strongly Agree

Table 5 shows the respondents' perceptions on the usefulness of using Mandarin AR in learning Mandarin vocabulary. 82.8% students gave positive feedback about using AR app was useful in learning Mandarin vocabulary. 80.3% of them agreed that AR app could make interaction more flexible. In addition, the AR app would make information easier to understand (80.7%), made learning more focus and faster (78.1%). The vocabulary was distributed according to the theme would increase learner to memorize vocabulary (80.2%). Respondents were generally positive about using AR app would motivate them to learn Mandarin (81.1%). This finding is in line with many researchers (Chang, et al., 2022; Chuang, et, al., 2022; Wang, et al., 2022; Kazu & Kuvvetli, 2023) indicated that AR apps motivate students in learning language.

Table 5 also indicates that the average mean score and standard deviation for the usefulness of using Mandarin AR in learning Mandarin vocabulary (M=4.01, SD=.737). This showed that AR Mandarin is useful for learning Mandarin. Items with the highest mean values were "Using Mandarin AR improves my listening skills." (M = 4.10, SD = .773). It is followed by "Using Mandarin AR improves my speaking skills." (M = 4.08, SD = .737) and "AR in learning Mandarin can motivate me to learn Mandarin." (M = 4.07, SP = .717).

The results suggest that the app is useful for learning Mandarin. The features provided in the app is useful for engaging students in learning Mandarin, motivate them to learn Mandarin and facilitate them to improve the Mandarin language skills namely grammar, vocabulary, writing, listening and speaking.

5. Conclusion

This study confirms that the "Mandarin AR" app is highly beneficial in enhancing non-native speakers' Mandarin vocabulary development. This is consistent with previous studies which demonstrated that the AR technology has positive impacts on language learning by creating immersive and personalized language learning experiences, boosting students' motivation and increasing learning retention in the mind (Belda-Medina & Marrahi-Gomez 2023; Kazu & Kuvvetli, 2023; Mozaffari & Hamidi 2023; Shadiev & Liang 2023). Several reasons may be accounted for the significant achievement in this study. Students agreed that the design and contents used in this AR app make learning vocabulary more organized, efficient and attractive. The results obtained from the questionnaire also confirmed that students were confident in using the Mandarin AR app and believed that the app increased their motivation and made learning more effective and enjoyable.

The significant achievements in this study can be attributed to several reasons. Students agreed that the design and content used in this AR app made learning vocabulary more organized, efficient, and attractive. The results obtained from the questionnaire also confirmed that students were confident in using this Mandarin AR app and believed that it increased their motivation, making learning more effective and enjoyable.

In addition, the Mandarin AR app provides an immersive environment by allowing students to interact with objects or scenes related to the target vocabulary, introduce new words according to students' level and pace and incorporate gamification elements to boost students' interest, motivation and retention. Students' interest and motivation play a critical role in self-directed learning (Lai et al., 2023). Self-directed learning is a valuable skill especially for language learning because it empowers students to take control of their learning, fosters critical thinking skills, broader knowledge based and self-regulation skills. These skills can maximize students' learning potential and achieve more effective education goals. It is hoped that the finding of the research could be a reference or guideline for practitioners in developing AR technology apps in language education. Students' feedback will be taken into consideration when upgrading and improving the application in future.

6. Recommendations

The following recommendations for further related study are summarised. The "Mandarin AR" app is an image-based AR technology that relies on recognizing and interacting with specific images. There are certain reports on technical problems such as navigation, recognition accuracy, app size and performance. Future studies should explore the integration of marker less AR technologies that offer more flexibility and address some of the limitations.

Another recommendation is that to further confirm the effectiveness of applying AR app in learning vocabulary among non-native speakers, it would be necessary to carry out a study with subjects from various

levels. In addition, exploring students' factors, such as previous experience with augmented reality (AR) apps, frequency of use, and teachers' attitudes toward AR apps, are crucial for understanding the effectiveness and potential challenges of integrating AR technology into language education.

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