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Exploring Augmented Reality for Chinese as a Foreign Language Learners' Reading Comprehension

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Abstract. Augmented reality (AR) has emerged as a promising tool in various disciplines, including language education. While previous studies have unpacked the potential and benefits of AR with regard to students' language gains, most of them focused on the domain of English language learning. Yet, little is known about the role of AR in Chinese as a Foreign Language (CFL) contexts. In this short paper study, we explored the impacts of AR on CFL learners' reading comprehension by using a quasi-experimental design in an online Chinese reading course with 54 undergraduate students. Quantitative results showed that students in the experimental group who adopted the AR tool scored higher than their pretest scores. Moreover, we also found that learners who used AR in their reading activities outperformed those who used conventional reading approaches. We concluded that AR is an efficacious tool and could be adopted to support CFL learners' reading comprehension. Implications were discussed as follows.

Keywords: Augmented Reality, Immersive Learning, CFL, Reading Comprehension.

1 Introduction

In language education, reading is regarded as one of the essential skills yet a challenge to learners in academia. Previous research has revealed that students reading comprehension is highly correlated with their academic success in other subjects [1]. Therefore, academic and professional success tends to be enhanced for students with high levels of reading comprehension [2]. Nevertheless, it is challenging for those who read that is different from their native language, such as Chinese as a Foreign Language (CFL) Learners. This is given the fact that the orthographic systems between Chinese and English are completely different [3]. In other words, transferring from L1 experience to performing the Chinese reading tasks in L2 remains difficult. It is, therefore, crucial for instructors and educators to investigate how to effectively support CFL learners in their reading comprehension.

In the advancement of technology, Augmented reality (AR) has been adopted across disciplines, including mathematics, engineering, and language education, to name but a few [4]. According to [5], AR is an intriguing technology given its unique traits that can make the intangible tangible in order to support learners in understanding concepts that are otherwise unobservable. In other words, learners can use AR to learn more complex concepts in an interactive, immersive approach [6]. In the study of [7], they conducted a meta-analysis to investigate the impacts of AR on language education. This study concluded that AR was most effective in improving learners' gains and had a small to medium effect on motivation, indicating its merits and potential as a learning tool in the domain of language field. Moreover, [8] indicated that language learning will likely benefit significantly from AR technologies in the near future. In light of this, it is worthwhile to examine full-scale the role of AR technologies in enhancing language learning [7].

While previous researchers have exerted great efforts in exploring AR to facilitate language learners and yield insightful outcomes (e.g., [9, 10, 11]), their focuses were predominantly targeted at English, leaving a notable gap in studies on non-alphabetic languages like Chinese (e.g., [12]). We argue that more empirical studies should be explored to understand the impacts of AR on other language sources. Therefore, the objectives of this study are twofold. First, it aims to contribute to the scarce body of knowledge on the application of AR in Chinese language learning, particularly focusing on reading comprehension among Chinese as a Foreign Language learners. Second, it seeks to provide some implications for practitioners, educators, and instructors to integrate AR into the classroom settings, and hence support CFL students' reading comprehension.

2 Literature Review

2.1 AR and Language Learning

Previous studies have unpacked the benefits of emerging technologies, such as AR, in the field of language education (e.g., [13, 22]). For example, in reviewing studies from 2014 to 2019, [13] conducted a systematic study and indicated that AR is beneficial for language learning not only with regard to learning performance improvement, but also learners' affects, such as motivation, satisfaction, attention, engagement, and enjoyment. However, [13] also reported that the most target language explored in the domain of AR is English, with 63% of studies included in the literature, while only 14% of the studies have explored Chinese as either in L1 or L2. In a further meta-analysis study conducted by [7], they specifically explored how AR could influence students' language learning gains and motivation. Results showed a large positive effect of AR on language improvement and yielded a small to medium effect on motivation. [7] thus concluded that using AR can facilitate language learning by creating the right context for learners, which would enhance their motivation and result in better language proficiency. Aligned to [6], they posited that AR applications can present multiple representations in the same time and space, and in the physical context where they are most relevant to the learner. Therefore, AR can support students' conceptual understanding.

There are ample positive outcomes reported on the impacts of AR on students' different language skills. In vocabulary, for instance, [14] explored the impacts of AR flashcards on improving 98 kindergarten children's English vocabulary learning. Their results showed that AR flashcards were effective and children held positive attitudes regarding AR learning activities. Concerning speaking, [15] employed a quasi-experimental case study to evaluate impacts of AR within a situational scenario on EFL junior high schoolers' language achievement. Quantitative results in this study revealed that learners could focus more on the spoken English practice and qualitative findings showed the enhancement of their confidence in English learning. Similar positive results were also found in the aspect of writing. [16] employed a pilot study exploring the impacts of AR ubiquitous writing tools on EFL undergraduate students' writing performance. They concluded that this AR tool was conducive to developing task schema in writing with regard to long-term memory and motivation.

In summary, previous literature has unveiled the advantages of AR in language education. However, echoing [7], compared to other disciplines, more empirical studies have to explore the impacts of AR in language education.

2.2 AR and Reading Comprehension

Several studies have also investigated the impacts of AR on learners' reading comprehension when compared to conventional teaching methods. In the study by [17], they explored the incremental impact of AR-integrated materials on ADHD children's reading capabilities along with their engagement in a pilot study. Their insightful results indicated that AR can improve ADHD learners' reading and spelling abilities. At the secondary educational level, [2] employed a mixed-method study to measure the effectiveness of AR on fifth graders' reading comprehension, where results revealed that the AR group students outperformed the conventional group students who learned without AR-based reading activities. Moreover, their study also reported low anxiety levels within the AR group and suggested that instructors could embed AR into reading-related classes given the benefits of AR. [18], likewise, concluded that AR could be employed as a scaffolding approach when it comes to English reading comprehension among undergraduate students in a two-group posttest design study. Taken together, AR can be a suitable alternative to support learner's reading comprehension based on previous research.

Nevertheless, previous studies have predominantly put emphasis on English language reading comprehension, and thus, little is known about the impacts of AR on other language sources, such as Chinese reading comprehension. Moreover, most of the aforementioned studies focused on varying from early childhood to secondary level, with only a few studies exploring in tertiary level (e.g., [18]). In addition, the study of [18] only

used a posttest design, which may limit the robustness of the result generalization of the impact of AR on reading comprehension.

Thus, it is important for different stakeholders to understand the role of AR in higher education through robust empirical evidence, specifically in CFL learners' reading comprehension. This study hopes to shed some light on exploring how AR can affect CFL students' reading comprehension and to provide some implications for instructors and educators who hope to embed AR into their classrooms. In light of these, we aim to answer the following research questions:

RQ1: What is the effect of AR-enhanced technology on Chinese as a Foreign language learners' reading comprehension?

RQ2: Is there any difference between AR-enhanced technology and conventional instruction on Chinese as a Foreign language learners' reading comprehension?

3 Methods

3.1 Participants and Context

Given the objectives of this study, we employed a pretest-posttest control-group design study [19], which included 54 undergraduate students (26 males, 28 females) via convenience sampling [19] from a renowned university in Northeast China at the end of the fall semester of 2023-2024 in China. All participants were non-Chinese speakers. They learned Chinese as a Foreign Language. 53.7% of the participants were from Asia, such as Vietnamese, Thai, and Korean. The other participants were African (18.52%), Turkish (14.8%), French (5.56%), American (3.7%), and Cairenes (3.7%). Consents from all participants were obtained. Students were divided into an experimental group (n=27), which used the AR tool in class, and a control group (n=27), taught without AR. None of them had prior AR experience in their previous lessons.

This study was conducted during an online Chinese reading course taught by an experienced Chinese teacher who has over 10 years of instructional experience in Chinese. The reading materials were taught under the module named "Holidays" with the implementation of a theme-based approach [23] in this study. Prior to the intervention, both groups of students completed an online pretest for standardized reading comprehension to examine whether there were any statistically significant differences between the two groups. Then, participants from the experimental group were assigned to use an AR tool, namely CoSpaces, during their reading activities. CoSpaces is an educational AR tool that enables learners to construct, code, and explore their own creations in augmented reality. In this study, students used CoSpaces through their mobiles or tablets. The intervention lasted for one week and included two two-hour reading sessions, as previous literature has shown it to be especially effective for up to one week with regard to learners' motivation [7].

In the first lesson, both group of participants learned to read an article called "My Winter Holiday" guided by the instructor. In this phase, students were taught the main idea of the article, featured vocabulary and phrases related to holiday in Chinese, and future tense in Chinese. In the second lesson, students in the experimental group were required to use the AR tool to create related reading materials under the instructors' guidance (see Fig. 1). Specifically, learners were grouped with four to five peers to construct their own expected winter holiday scenarios with detailed holiday preparations using the AR tool. After this, students were invited to orally present their winter holiday artifacts in front of the class by using either their phones or tablets to project their AR creations. Specifically, there was a blue button on students' bottom right-hand side on the CoSpaces surface. When they clicked on this button, the AR artifact will be projected entangled with the reality (See Fig. 2). On the other hand, participants from the control group adopted the conventional reading approach to finish the reading activities without AR, namely thought about their expected winter holidays and shared orally with the class. Both experimental group and control group were requested to use what they have learned from the first class to demonstrate their expected winter holidays.

Fig. 1. An AR artifact created by students who would like to travel to Hainan during their winter holiday.

Fig. 2. An AR artifact projected in real-time setting.

3.2 Instrument

HSK Standardized Exam

In this study, we used a standardized examination adapted from the HSK test, which is designed for non-native Chinese speakers. This test was administered to two groups of participants before and after an intervention to collect data on their reading comprehension skills. The HSK standardized reading exam consisted of 30 multiple-choice questions, with scores ranging from 0 to 60 (α= .86). When students choose the correct answer per question, they will be scored 2. In contrast, if not, students will be scored 0. The content of these questions was related to what participants had learned during their reading classes. For example, in Question 10, students were required to select the appropriate word to fill in the blank: 'A. 一直 [always], B. 周末 [weekends], C. 带 [pack], D. 搬 [carry], E. 声音 [voice], F. 面包 [bread]. Sentence A: 现在去北方旅游很冷，多（ ）几件衣服吧 [It's quite chilly traveling up north right now, so make sure to ( ) more clothes]. Sentence B: 我已经准备好了 [I'm all set].' In this question, we tested whether participants have mastered the action verb, namely "带" [pack], in the dialogue. This verb was also one of the key feature expressions taught in the reading class. Please note that the English translations in brackets were not shown in the actual test administered to the participants.

3.3 Data Analysis and Results

In this study, all data analyses were run by using the SPSS 27th version. We first reported the descriptive statistics, followed by independent t-tests and paired t-tests. No statistical differences were found in the pretest scores, given the p-value equals .24 is greater than 0.05 level. To answer research question 1 to seek the effect of AR-enhanced technology on CFL learners' reading comprehension, a paired t-test was used to examine the differences between the scores of pretest and posttest in the AR group (see Table 2). To answer the second research question for understanding any difference between AR-enhanced technology and conventional instruction on CFL learners' reading comprehension, an independent t-test was administered to find the difference (see Table 4).

Table 1. Group Statistics of Experimental Group.

		Mean	N	SD	Std. Error Mean
Pair 1	Pretest	47.04	27	11.68	2.25
	Posttest	53.78	27	7.63	1.47

The results from Table 1 showed that the posttest of EG (M= 53.78, SD= 7.63) was higher than in the pretest (M= 47.04, SD = 11.68).

Table 2. Paired Samples T-tests of Experimental Group.

		Mean	SD	Std. Error Mean	95% Confidence Interval		t	df	Sig (2-tailed)
					Lower	Upper			
Pair 1	post-pre	6.74	9.24	1.78	3.09	10.39	3.79	26	0.00

A paired samples t-test revealed a significant difference between pre-test and post-test scores, t(26)=3.79, p=.001 < .01, with a mean difference of 6.74, SD= 9.24. The calculated effect size indicated that the AR-enhanced experience had a high effect size (Cohen's d = .73).

Table 3. Group Statistics of EG and CG.

	Group	Mean	N	SD	Std. Error Mean
posttest	EG	53.78	27	7.63	1.47
	CG	48.15	27	12.28	2.36

The results from Table 3 indicated that the posttest of EG (M=53.78, SD=7.63) was higher than the posttest of CF (M=48.15, SD=12.28).

Table 4. Independent Sample Test of Experimental Group and Control Group.

		Levene's Test		t	df	Sig (2-tailed)	MD	SED	95% Confidence Interval	
		F	Sig.						Lower	Upper
Post-test	Equal variances assumed	4.26	0.04	2.02	52	0.048	5.63	2.78	0.05	11.21
	Equal variances not assumed			2.02	43.48	0.049	5.63	2.78	0.02	11.24

The independent samples t-test from Table 4 showed a significant difference in post-test scores between the two groups (p = .049 < .05), with the experimental group outperforming the control group by a mean difference of 5.63. The calculated effect size indicated a moderate effect size (Cohen's d = .55).

4 Discussion

The major objective of this study was to investigate the influences of AR on Chinese as a Foreign Language learner's reading comprehension. From the quantitative results' perspective, there was a significant difference between students' posttest and pretest in the experimental group. This indicated that AR can improve participants' reading comprehension and showed that AR was efficacious in CFL students' reading comprehension. Such a positive result may be attributed to that AR can offer multiple representations that could reduce the cognitive loads of learners, which leads to deeper understanding [6]. This finding echoes [14, 15, 16] that AR was an efficacious tool in supporting learners' language achievement. Moreover, the moderate effect size found in the effect of AR on learners' learning outcomes, specifically in reading comprehension echoes the study conducted by [20], while the only difference is that [20] focused on writing achievement.

Regarding the comparison of the AR-enhanced approach and conventional methods, our study indicated that there was a significant statistical difference between the experimental group and the control group. Specifically, the posttest of the experimental group outperformed the control group, which indicated that the AR tool was more effective than the conventional method concerning reading comprehension. This result aligned with [2, 18], which both showed that AR was more effective than the traditional method reading approach. Similar to [21], we believe that the AR tool provided learners with a sense of ownership when they constructed their AR artifacts, which can enhance their agency and thus positive performance. Compared to the traditional methods, AR can facilitate a more student-centered approach, which empowers students to learn more effectively than the conventional teacher-centered approach.

Given the positive findings of this study, several implications could be offered to different stakeholders as follows. For instructors, they could adopt AR-enhanced tools in the reading activities when supporting CFL

students' reading comprehension. We believe that AR can empower learners' reading comprehension when they read while constructing their own artifacts. In this case, AR was used as alternative technological scaffolding to facilitate learners' reading comprehension while reducing their cognitive load. For instructional designers, it is beneficial to design an integrated AR learning environment for theme-based reading materials. In our study, the "My Winter Holiday" theme-based reading is more suitable for designing AR materials during reading activities. Similar theme-based readings, thus, can be designed using AR to create a more contextual learning environment, which enhances learners' reading comprehension.

5 Conclusion

This study aimed to explore the role of AR in Chinese as a Foreign Language learning with a specific focus on reading comprehension. Our empirical evidence revealed that AR was an efficacious tool when supporting CFL learners' reading ability. Moreover, it is noted that AR was more effective in supporting students' reading comprehension when compared to the traditional approach. This study not only enriches the literature on the impacts of AR in language education by addressing the void lie in the CFL contexts but also offers actionable insights for different stakeholders to support CFL learners' reading comprehension. It is, however, needed to mention there were limitations of the current study. First, the sample size in this study was relatively small, which could affect the robust generalization of the impacts of AR on the CFL setting. Second, our study only focused on learners' reading comprehension in the online setting. Thus, the findings might not be applied to the offline situations. Future work could focus on addressing the aforementioned limitations to enhance our understanding of the impacts of AR on CFL learning settings and to confirm the generalization of research findings.

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