Using Augmented Reality to Support CFL Students' Reading Emotions and Engagement

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Abstract

Augmented Reality (AR) has been proven to have potential and benefits in language education, given its unique features of contextual visualization and interactive learning environments. However, no previous studies have been conducted to understand its application in teaching Chinese as a Foreign Language (CFL) university learners' reading comprehension. Thus, this study aims to examine the effects of AR in supporting CFL learners' reading comprehension, in particular in the aspects of reading engagement and emotions. Through a quasi-experimental design, this study included 54 undergraduate students in China. Quantitative results showed that there was a significant difference between students in the experimental group and the control group with regard to their overall reading engagement and emotions, which indicated the effectiveness of teaching CFL students with AR tools. However, no significant differences were found in the subscales of reading boredom and reading anxiety. The presented findings can contribute to the future development of AR and shed some light on implications for educators and instructors.

Keywords

Augmented Reality, Reading, Engagement, Emotions, Chinese as Foreign Language

1. Introduction

The emergence of Augmented Reality (AR) has marked a significant advancement in educational fields, including the realm of language education. AR offers interactive and immersive learning experiences that significantly support learners in understanding complex concepts (Cai et al., 2022). In addition, research

has found that AR can not only enhance students' engagement and motivation, but also improve their academic achievements (Chiang et al., 2014). With its benefits and the unique features, AR provides educators with alternatives for the development of fundamental skills, such as reading. Reading is considered vital for academic achievement and personal growth (Kerr & Frese, 2017). In particular, in the context of learning a foreign language, reading becomes a key tool for acquiring and expanding knowledge of language patterns, structures, and vocabulary. Moreover, reading also plays a significant role in reinforcing the learner's comprehension of the target language (Alderson & Urquhart, 1984). Hence, enhancing reading skills is a critical aspect in foreign language education.

Prior research on AR in language education has mainly focused on English (Fan et al., 2020), leaving a significant gap in studies on non-alphabetic languages such as Chinese. Although AR has shown promise in improving reading comprehension and vocabulary acquisition (Cai et al., 2022; Parmaxi & Demetriou, 2020), its impact on teaching the Chinese language to tertiary-level students who are foreign language learners has yet to be explored. Given this research gap and the critical importance of reading skills, the overarching objectives of this study are twofold. First, we aim to address the lack of research on the use of AR in Chinese language education, with a special focus on reading comprehension for those studying Chinese as a Foreign Language at tertiary institutions. Second, we hope to offer valuable insights and approaches for educators in the field of Chinese as a Foreign Language (CFL).

2. Literature Review

2.1. Augmented Reality in Language Education

Schneider and Radu (2022) defined AR as a technology that is composed of digitally generated 3D content with real-world objects that users are looking at. Such an computer-generated 3D content is overlaid on a view of the real world via a specialized display. Thus, in this sense, AR could enable the invisible visible (Akçayır & Akçayır, 2017). This is especially conducive to support learners to understand complex concepts, which are not directly observable. Moreover, differentiating from virtual reality, AR contains real-world aspects, which make the learners' experience always situated in the physical environment.

AR has been witnessed an accelerated growth since 2010 and it has been proved its the potential for enhancing students' learning performance, given its features in providing contextual visualization and interactive learning experiences (Cai et al., 2022). In the realm of language education, AR has brought benefits for both first and second language learners (Qiu et al., 2021). For instance, in the study of (Cai et al., 2022), they presented a meta-analysis of AR in language education for both L1 and L2 settings for the past eighteen years, with the main focus on the influences of AR on learning gains as well as motivation of learners. While current AR applications in language learning predominantly address alphabetic languages like English (Fan et al., 2020), the exploration in

non-alphabetic languages, especially Chinese, is relatively underdeveloped. Research has predominantly demonstrated AR's effectiveness in English language learning, particularly in reading and vocabulary (Cai et al., 2022; Parmaxi & Demetriou, 2020; Xie & Huang, 2023). However, its influence on Chinese reading comprehension has not been thoroughly investigated. Echoing Garzón and Acevedo (2019), the effectiveness of AR varies across subjects, but in language learning, it shows promises in aiding younger learners in alphabetic languages (e.g., Cai et al., 2022; Chen & Chan, 2019; Lantavou & Fesakis, 2018). Nonetheless, the specific impact of AR on Chinese as a Foreign Language (CFL), especially in reading comprehension, remains to be discovered.

2.2. Reading, Emotions, Engagement, and Augmented Reality

Reading engagement involves the reader's ability to interact with the text in a strategic and motivated way (Guthrie & Wigfield, 2000). This concept has been defined by Fredricks et al. (2004) as encompassing three dimensions, i.e., behavioral, emotional, and cognitive. The impact of reading engagement is significant, affecting knowledge acquisition (Guthrie & Wigfield, 2000), learner performance (Guthrie et al., 2013), and various other cognitive, affective, and behavioral outcomes. Consequently, reading engagement plays a crucial role in the learning process related to reading. Similarly, reading emotion is another vital element influencing reading comprehension (Hyland & Jiang, 2016). Research shows that emotions like boredom, enjoyment, and anxiety significantly affect language learners' capacity to comprehend and process text (Hyland & Jiang, 2016). Positive emotions, such as enjoyment, are seen as beneficial for reading and enhancing academic performance (Goetz et al., 2007), while negative emotions, like anxiety, are associated with poorer academic outcomes. Additionally, boredom is found to have a negative relationship with motivation, cognitive engagement, self-regulation, and academic success (Rowe & Fitness, 2018).

Collectively, these studies suggest that reading comprehension is shaped by the dual factors of reading emotions and engagement. Addressing these aspects effectively could lead to improved teaching methods and better learning outcomes in reading comprehension. For instance, a study by Kamarainen et al. (2013) revealed that the use of AR could enhance learners' positive perceptions towards science and boost content comprehension. This was supported by Schneider and Radu (2022), who noted that participants using AR tools developed more favorable attitudes towards physics learning.

2.3. Theoretical Framework

Smagorinsky and Smith (1992) defined that literacy scholars have centered on three kinds of literacy in a broader sense, namely general, task-specific, and community-specific. In general literacy, from the cognitive perspective, reading comprehension has been long recognized as a creative act of structure building (Bartlett, 1932) where learners selects related information, mentally organizes it

into a coherent structure, and itegrates it with relevant prior knowledge activated from long-term memory (Mayer, 2011). Skilled readers effectively leverage their pre-existing knowledge to optimize how they select, organize, and assimilate new information (Smagorinsky & Mayer, 2022). Research indicates that learners with relevant prior knowledge typically outperform those without in reading comprehension tests (Bransford & Johnson, 1972; Pearson et al., 1979). Furthermore, learners are more likely to retain information that aligns with what they already know (Lipson, 1983; Pichert & Anderson, 1977). Furthermore, task-specific literacy refers to the differences of declarative and procedural knowledge employed between learning to read different genres, such as argumentation and narration (Smagorinsky & Mayer, 2022). Akin to Smagorinsky and Mayer (2022), we acknowledge that general literacy is necessary, yet there remains insufficiency as people grow mature and begin to read an increasing variety of genre texts. Moreover, the cognitive variation existed in reading diverse types of genre articles (Smagorinsky & Mayer, 2022). Thus, task-specific literacy is needed to acquire as they grow academically.

Taken together, in this paper, we take from both perspectives of general and task-specific literacy to ground our research design. Reading in Chinese, a logographic system, poses unique cognitive processing challenges compared to phonetic systems, especially for foreign language learners aiming for reading proficiency. In learning sciences field, scholars have explored the role of AR on learning mainly using three perspectives, namely conceptual, socio-contextual, and affective (Schneider & Radu, 2022). From the perspective of cognition, learning is defined as the procedure of individual information processing, and knowledge was regarded as the representation of information within an individual mind. In viewing this lens, AR could be designed to contain different traits that may benefit learning. Interactive 3D visualizations offered by AR technologies enable representations of educational content that are unattainable with conventional 2D screens or textbooks. The use of AR in teaching reading comprehension is drawing increasing interest from researchers, such as Parmaxi and Demetriou (2020). This is because AR creates an engaging and interactive environment beneficial for both general reading comprehension and specific literacy tasks. Drawing on the schema theory, AR can help learners establish and access prior knowledge, enhancing their comprehension abilities (Dai, 2003). Additionally, from an affective perspective, studies have examined AR's impact on learner engagement, emotions, and motivation. For example, Schneider and Radu (2022) observed that AR could present timely information within authentic settings and present content in an engaging, playful manner, thereby boosting engagement, personal agency, and self-efficacy.

In summary, previous research has highlighted the potential of AR in language education, yet its effectiveness in aiding CSL learners in reading comprehension is still an unknown area. Moreover, given the importance of reading engagement and emotions in reading comprehension, this study aims to address the following research questions to achieve the objectives of this study:

1) What is the effect of AR-enhanced technology on Chinese as a Foreign language learners' reading emotions?

2) To what extent does AR-enhanced technology influence Chinese as a Foreign language learners' reading engagement?

3. Methodology

3.1. Context and Participants

This research was carried out in part of the research project named ARCL (see Xie et al., 2024) during an online Chinese Reading course in the latter part of the Fall 2023 semester. The course was led by a proficient Chinese language instructor with over 10 years' teaching experience in instructing Chinese as a Foreign Language learners. The study involved 54 undergraduate students, with a gender distribution of 26 males and 28 females, and the mean age of participants is 23.6. All participants were non-native Chinese speakers and they were selected based on convenience sampling (Johnson & Christensen, 2019). All participants were learning CFL at a university in Northeast China. Each Chinese reading class lasted for 120 minutes and the intervention period was one week. None of them had exposed to AR in their previous classrooms. Moreover, all participants passed their HSK Level 4 examination. Each student provided consent to participate, and they received 30 RMB and a certificate of participation upon completion of the study.

3.2. Research Design

For answering the research questions above mentioned, this study employed a pretest-posttest control-group design (see **Figure 1**) (Johnson & Christensen, 2019). In this paper, our main focuses were only on learners' reading emotions and engagement. Thus, for centering the objectives of the study (see Xie et al., 2024), we illustrated the process as follows. First, the instructional materials in this investigation were delivered via a thematic approach, with "vacation" designated as the core theme. Prior to the classes, all participants underwent a pretest using the HSK examination (i.e., a standardized test) with and completed a questionnaire containing demographics, reading emotions, and reading engagement. The pretest results revealed no significant disparities in reading comprehension ($p = 0.24$), overall Chinese proficiency ($p = 0.48$), reading engagement ($p = 0.38$), and reading emotions ($p = 0.44$) between the two groups. The experimental group then engaged in reading tasks employing an educational AR tool known as CoSpaces, which facilitates the construction, programming, and exploration of user-generated content in AR. Throughout the study, students accessed CoSpaces on their mobile devices or tablets.

During the initial lesson, both student groups analyzed an expository article titled "My Winter Holiday," guided by the instructor (see Xie et al., 2024). This phase focused on understanding the principal learning objectives of the class, mastering relevant vocabulary and phrases pertaining to the vacation theme, and learning the future tense in Chinese. In the subsequent lesson, participants
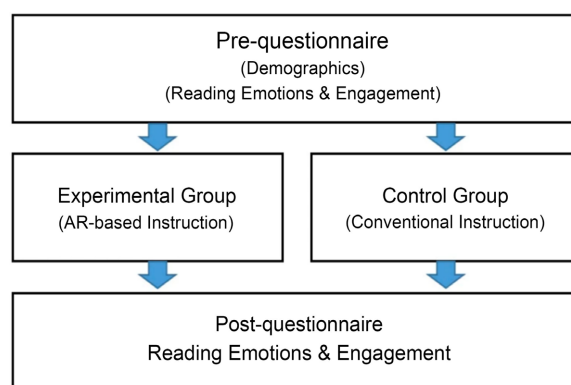
Figure 1. Design of the study.

in the experimental group were tasked with developing content linked to the reading materials using the AR tool under the instructor's supervision. The students were organized into groups of four to five to design scenarios depicting their anticipated winter vacations and elaborate on their preparatory activities. Subsequently, they were required to orally present their winter vacation projects in class with their mobile devices or tablets. Conversely, the control group adopted a traditional reading approach, where they conceptualized their ideal winter vacations and discussed them orally with their peers. Students from both groups were instructed to apply the insights gained from the first lesson to effectively present their envisioned winter vacations. After the intervention, we administered a post-test HSK reading exam and an online survey for both groups of participants. Please note that the Figure 2 shown below did not display the pre-and-post test of HSK exam. This is due to the fact that it is not our main data focus of this study (see Xie et al., 2024).

3.3. Instruments

In order to address research questions 1 and 2, the study deployed a questionnaire for both groups before and after the AR intervention. This survey collected data on the demographic information, emotional responses to reading, and engagement levels in reading among participants. We utilized two reliable and validated measures, which were adapted from Hamedi et al. (2020). This instrument included the English Language Learners' Reading Emotions Scale (ELL-RES) and the English Language Learners' Reading Engagement Inventory (ELL-REI). The ELL-RES scale is divided into three subscales, namely "Reading Boredom", "Reading Anxiety", and "Reading Enjoyment". Please note that in the subscales of Reading boredom and Reading anxiety, the higher the score, the lower the boredom and anxiety. The ELL-REI scale is composed of three subscales, which are "Behavioral Engagement", "Cognitive Engagement", and "Emotional Engagement". Both scales utilized a five-point Likert scale for participants' responses, ranging from 1 (strongly disagree) to 5 (strongly agree), to measure the participants' attitudes and experiences regarding their reading emotions and engagement levels.

Figure 2. Students' created artifacts using AR.

4. Data Analysis

The table shows the results of group samples tests that were conducted to compare the scores of two groups, namely EG and CG, on different scales, which included reading boredom, reading anxiety, reading enjoyment, reading emotions (overall), cognitive engagement, behavioral engagement, emotional engagement, and reading engagement (overall). For each aspect, the group statistics table provides the mean and standard deviation of the scores for both groups. The independent samples test table provides the results of Levene's test for equality of variances and the t-test for equality of means (see Table 1).

From the Levene's Test table, regarding participants' reading emotions, the results showed that there was a significant difference between the scores of the two groups on reading enjoyment, reading emotions (overall), with a mean difference of 1.07 ($p = 0.00 < 0.05$) and 0.62 ($p = 0.01 < 0.05$) respectively. However, no significant difference were found regarding their reading boredom and reading anxiety. Additionally, in terms of participants' reading engagement, results showed that there was a significant difference between students' behavioral engagement ($p = 0.00 < 0.05$), emotional engagement ($p = 0.01 < 0.05$), and reading engagement (overall) ($p = 0.02 < 0.05$).

Overall, the results of the independent samples tests suggest that there were significant differences between the scores of the two groups on various aspects of

reading engagement, with the EG having higher scores on average compared to the CG (see Table 2). The effect sizes of the variables were calculated using Cohen's d and were found to be as follows: RE (1.2), REO1 (0.7), BE (0.9), EE (0.7), REO2 (0.7). According to Cohen's criteria, REO1, EE, and REO2 were considered to have a moderate effect size. Furthermore, RE and BE were considered to have a large effect size, indicating the practical implications within.

Table 1. Group samples tests of reading emotions and engagement.

	Group	N	Mean	SD	SEM
RB	EG	27	3.98	1.22	0.23
	CG	27	3.65	1.10	0.21
RA	EG	27	4.01	1.28	0.25
	CG	27	3.56	1.06	0.20
RE	EG	27	4.52	0.64	0.12
	CG	27	3.44	1.06	0.20
REO1	EG	27	4.17	0.86	0.17
	CG	27	3.55	0.82	0.16
CE	EG	27	3.23	0.81	0.16
	CG	27	3.27	0.49	0.09
BE	EG	27	4.25	0.63	0.12
	CG	27	3.57	0.94	0.18
EE	EG	27	4.28	0.74	0.14
	CG	27	3.66	0.96	0.19
REO2	EG	27	3.92	0.58	0.11
	CG	27	3.50	0.68	0.13

Note: RB = Reading Boredom; RA = Reading Anxiety; RE = Reading Enjoyment; REO1 = Reading Emotions Overall; CE = Cognitive Engagement; BE = Behavioral Engagement; EE = Emotional Engagement; REO2 = Reading Engagement Overall.

Table 2. Independent t-tests of reading emotions and reading engagement

	Levene's Test t-test							95% Confidence Interval	
		F	Sig.	t	df	Sig.	MD	SED	Lower	Upper
RB	Equal variances assumed	0.08	0.78	1.05	52.00	0.30	0.33	0.32	−0.30	0.97
RA	Equal variances assumed	2.13	0.15	1.43	52.00	0.16	0.46	0.32	−0.18	1.10
RE	Equal variances not assumed			4.52	42.87	0.00	1.07	0.24	0.59	1.55
REO1	Equal variances assumed	0.01	0.94	2.71	52.00	0.01	0.62	0.23	0.16	1.08
CE	Equal variances assumed	2.80	0.10	−0.17	52.00	0.87	−0.03	0.18	−0.39	0.33
BE	Equal variances assumed	2.50	0.12	3.13	52.00	0.00	0.68	0.22	0.24	1.11
EE	Equal variances assumed	2.35	0.13	2.67	52.00	0.01	0.62	0.23	0.16	1.09
REO2	Equal variances assumed	0.41	0.52	2.46	52.00	0.02	0.42	0.17	0.08	0.77

Note: RB = Reading Boredom; RA = Reading Anxiety; RE = Reading Enjoyment; REO1 = Reading Emotions Overall; CE = Cognitive Engagement; BE = Behavioral Engagement; EE = Emotional Engagement; REO2 = Reading Engagement Overall.

5. Discussion

In this paper, we expanded upon the current understanding of AR in CFL contexts, where limited studies have specifically explored its impact. We explored the effect of AR-enhanced technology on Chinese as a Foreign Language reading comprehension, specifically in the aspects of learners' reading emotions and engagement. Our findings revealed that AR has a overall positive effect on students' reading emotions and engagement. Specifically, the findings indicated that students who used AR technology scored in higher levels of reading enjoyment, behavioral engagement, and emotional engagement when compared to those in the traditional learning environment. This aligns with Wang and Smith (2013), who observed improved engagement in foreign language reading tasks using multimedia annotations. This suggests that AR's immersive and interactive features contribute to a more engaging and uplifting reading experience, which is beneficial for effective reading learning. Such findings are aligned with Kamarainen et al. (2013) and Radu and Schneider (2019), who also found the positive attitudes when learners adopted AR in their studies. The difference between this study and these two is that they focused on the topic of science rather than the reading ones. Moreover, similar to Schneider and Radu (2022), we also believe that AR embedded in this reading activities could provide in-time information to the authentic settings (i.e., winter vacation display in AR) and make the original invisible reading materials visible for learners in a playful way. This could make the enhancement of the learners' reading enjoyment and emotional engagement.

However, the experimental group does not show obvious differences in students' reading boredom, reading anxiety and cognitive engagement. Generally speaking, we believe these could potentially be attributed to the novelty of the AR experience overshadowing the specific content-related engagement. Akin to Liu and Chu (2010), they suggested the initial novelty of technology in educational settings may temporarily elevate engagement metrics, which may not necessarily pertain to the content itself. Specifically, for the reading boredom, we assume that this could be attributed to the topic chosen for learners to study. Specifically, since the topic is related to holiday, which perhaps is the topic itself is related to learners' daily life compared to other topics, such as history. Regarding the reading anxiety and cognitive engagement, we assume that it was due to the very first time that learners were exposed to AR tool along with the arrangements of learning in the online context that led to the results. A more rigorous exploration of these aspects could involve longitudinal studies to assess how these factors evolve with increased familiarity with AR tools. In future studies, there is still room to investigate whether similar outcome will yield in offline learning settings, given that previous studies have indicated differences between these two modalities concerning reading comprehension (e.g. Xie & Huang, 2024). We believe that more studies should be conducted to explore the differences of AR used in both online and offline learning environments.

This study also hopes to she some light on the practical implications for educators and instructional designers. Given the findings, we suggest that integrat-

ing AR technology in reading comprehension, in particular in expository genre texts, could significantly enhance student engagement and emotional response to reading. For educators, they might consider incorporating AR tools in their teaching strategies to create a more dynamic and enjoyable learning experience, particularly for complex languages like Chinese. Moreover, since we have not found any significant differences between both group regarding their reading boredom, we suggest educators should pay more attention to the genre text chosen to integrate AR in the reading activities. For instructional designers, they could focus on creating AR content that is not only engaging but also supportive of the emotional aspects of reading comprehension. Nevertheless, similar to reading boredom, instructional designers should also pay attention to deal with learners' reading anxiety and cognitive engagement. Like what we have argued previously, the differences between learners using AR to learn to read in an online setting could be different from those who use AR in the offline scenarios. Thus, we suggest that instructional designers should take this into consideration when designing an AR-enhanced reading activities in the online settings.

6. Conclusion

In summary, we explored how AR could be leveraged to support learners' reading, in particular in the facets of emotions and engagement. Our findings suggest that AR could be adopted to enhance learners' reading emotions and engagement, specifically in reading enjoyment, behavioral engagement, and emotional engagement. In contrast, there is no significant difference found in both groups regarding their reading boredom, anxiety, and cognitive engagement. Despite of these insights, we acknowledge there are some limitations in this study. First, the rather small sample size could influence the generalization of the results. Second, further research could explore the longitudinal effects of AR, resonating with Schneider and Radu (2022), on reading engagement and emotions and its potential applications in other language learning contexts. Investigating the specific elements of AR that most significantly impact reading comprehension and emotional engagement would also be beneficial. In conclusion, this study demonstrated the effectiveness of AR technology in enhancing reading emotions and engagement among Chinese as a Foreign Language university students. The findings have important implications for the future of educational strategies and technology integration in language education.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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