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Improving international students' acculturation and Chinese vocabulary through problem-based learning with augmented reality

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ABSTRACT

The integration of problem-based learning (PBL) and augmented reality (AR) has emerged as a promising approach to improve language learning and acculturation. This study aimed to develop and evaluate a problem-based learning and augmented reality (PBLAR) instructional model to enhance international students' acculturation and Chinese vocabulary. The study used a quasi-experimental design with 70 first-year international students randomly assigned to an experimental group (EG) (PBLAR, n=35) or a control group (CG) (traditional teaching method, n=35). The intervention lasted two weeks, and both groups completed a pre-test to ensure baseline comparability. The EG achieved significantly higher post-test scores in Chinese vocabulary ($F=296.65$, $p<0.001$) and acculturation ($F=840.62$, $p<0.001$). In this context, PBLAR demonstrated stronger short-term outcomes in Chinese vocabulary and acculturation; it should be viewed as a complementary pedagogy that highlights the value of integrating PBL and AR. Findings highlight PBLAR's potential for immersive, problem-driven language instruction that bridges technology and pedagogy in multicultural contexts.

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1. INTRODUCTION

Acculturation and Chinese vocabulary are crucial for international students' academic and social integration [1]. Successful acculturation relies on language proficiency, and learning Chinese vocabulary not only facilitates academic communication but also fulfills daily socialization needs [2]. Language proficiency is an important predictor of academic and social competence, as well as helping to understand cultural context [3]. However, acculturation and vocabulary acquisition can be particularly difficult for international students. Challenges of acculturation can lead to psychological distress and academic problems, while the tonal and ideographic properties of Chinese characters further complicate language acquisition [4]. The language barrier is seen as a major obstacle to integration into the host society, and this dual challenge may increase stress and decrease academic performance.

In recent years, the combination of language learning and technology has significantly changed instructional practices, with a variety of technologies—including computer-assisted language learning (CALL), mobile-assisted language learning (MALL), multimedia, and virtual reality (VR)—being used to

support language acquisition and acculturation [5]. Combined with strategies such as communicative language teaching (CLT) and content-based instruction (CBI), technology enhances international students' Chinese vocabulary and acculturation. Problem-based learning (PBL) fosters critical thinking by solving real-world problems, while augmented reality (AR) combines the virtual with the physical to enhance the interactivity and utility of learning [6]. The immersive teaching tools combining AR and PBL deepen vocabulary comprehension and promote long-term memorization, which significantly improves learning outcomes and engagement [7].

The problem-based learning and augmented reality (PBLAR) model, which combines AR and PBL, benefits students, teachers, schools, and policymakers by improving acculturation and Chinese vocabulary. PBLAR makes classrooms more interactive and interesting, increasing student motivation and achievement [8]. At the same time, the integration of AR and PBL promotes teachers' professional growth, stimulates innovative teaching methods, and promotes inclusive and collaborative learning environments in schools, which in turn increases student satisfaction and achievement. Facing the challenges of international students in acculturation and Chinese vocabulary learning, traditional teaching methods (TTM) have limited effectiveness; therefore, this study is dedicated to developing a PBLAR model to address these issues and explore its effectiveness compared to TTM. The study was directed by two main research questions (RQ):

i) What are the key components and processes involved in developing an effective PBLAR instructional model for improving acculturation and Chinese vocabulary? (RQ1)
ii) Is using PBLAR more effective in improving acculturation and Chinese vocabulary than TTM? (RQ2)

2. LITERATURE REVIEW

2.1. Problem-based learning

PBL is a pedagogy that enhances learning by solving real-world problems [8]. It is centered on the idea that students are faced with complex problems and need to investigate, collaborate, and apply what they have learned to find a solution [9]. PBL promotes critical thinking and self-directed learning skills, fosters the ability to analyze a problem and independently formulate a response, and supports lifelong learning. However, the design and implementation of PBL requires a great deal of time and effort [10]. Teachers need to shift from traditional lecturers to facilitators, which may require additional training [11].

2.2. Augmented reality

AR enhances real-world user experiences by overlaying digital information (videos and images) and has been widely used in education to enhance interactivity and immersive learning [12]. AR visualizes abstract concepts and promotes comprehension and memory [13], but its application in education is still limited by challenges such as device compatibility and software stability [14]. To advance AR education, platforms such as ARIS and Metaverse provide tools to support teachers in creating interactive learning experiences [13], [15].

2.3. Acculturation

Acculturation is defined as a skill that encompasses both psychological adaptation (well-being and satisfaction) and sociocultural adaptation (the ability to integrate and interact with the host culture) [16]. The process involves learning and adopting the norms of the host culture, including language acquisition and behavioral adjustment. Acculturation encompasses culture maintenance, contact participation, and cultural identity and is influenced by factors such as age, length of stay, and social support [17]. International students who are well acculturated tend to perform better academically as they are better able to assimilate into the host country's culture and social norms [18]. However, there are also challenges to acculturation, with culture shock being a major obstacle, which can lead to anxiety, depression, and identity confusion [19], and factors such as cultural differences, language barriers, and discrimination exacerbating the stress of acculturation.

2.4. Chinese vocabulary

Chinese vocabulary, which includes words and phrases in spoken and written language, is a core part of language learning, especially important in Chinese learning due to the uniqueness and tonal nature of Chinese characters [20]. Vocabulary learning involves not only word meaning, pronunciation, and cognition of Chinese characters, but also understanding their contextual use [21]. Mastery of Chinese vocabulary can improve communication skills of international students in academic and social settings, and enhance learning confidence and acculturation [22]. However, the complexity, polysemy and polyphony of Chinese characters increase the difficulty of learning. Based on the HSK standard course 1, this study focuses on the teaching of vocabulary related to "self-presentation" to help international students express themselves confidently when communicating with native Chinese vocabulary speakers for the first time, and to lay the foundation for daily communication and acculturation [23].

2.5. Positioning problem-based learning and augmented reality relative to CALL/MALL

While CALL and MALL have achieved substantial progress in vocabulary learning, their predominant designs are often transactional, tool-centric, or game-based, emphasizing content delivery, drill-and-practice, or seamless access across devices [24]. For example, mobile-enabled seamless learning effectively supported knowledge building and vocabulary growth among international students, yet the learning flow largely remained transactional rather than problem-driven [25]. By contrast, PBLAR embeds vocabulary and cultural understanding within authentic, ill-structured problems and leverages AR's situated, interactive affordances to prompt inquiry, collaboration, and reflection. In other words, PBLAR extends CALL/MALL by coupling problem-based immersion with augmented contextualization, thereby shifting from "delivery of lexical items" to "construction of meaning in context". This theoretical positioning clarifies how PBLAR contributes beyond established CALL/MALL practices and motivates our empirical test of its differential effects on Chinese vocabulary and acculturation.

3. METHOD

This study is divided into two phases. The first phase is the development of a PBLAR instructional model. The model aims to improve international students' Chinese vocabulary and acculturation through qualitative and quantitative assessments by experts. Secondly, a quasi-experimental study of the PBLAR learning activities as an integrated Chinese language program for international students.

3.1. Participants

The participants in the first phase were five experts in relevant professional fields. Backgrounds and experiences varied among each expert with at least five years of experience in their field. These experts were assessed through a combination of quantitative and qualitative methods.

In the second phase, the study participants were first-year international students at Kunming University of Science and Technology in Yunnan Province. The study used whole cluster random sampling to randomly select two classes of students. Due to the limited size of international students at Kunming University of Science and Technology, the sample size of this study was objectively limited by the research environment. In order to ensure the operability of the experiment and the controllability of the study, 70 students who met the conditions of the study were selected as participants of the study. They were randomly divided into two groups: the experimental group (EG) and the control group (CG), with 35 students in each group [26]. The EG was taught using the PBLAR instructional model, while the CG was taught using TTM.

3.2. Research procedures

The experimental activities of this study are shown in Figure 1. The study was conducted over two weeks of instruction, with four lessons per week comprising 360 minutes of experimentation. The participants international students were divided into two groups: experimental and control. Students in the EG were taught using PBLAR and students in the CG were taught using TTM. The same teacher taught the experimental and CGs and used the same learning materials. Figure 2 shows the activity design in this study. In the first course, self-assessments and questionnaires were administered by adapting Zhang and Zeng [27] and Alfadil [28]. The teacher administered a pretest on Chinese vocabulary and acculturation to measure their mastery of Chinese vocabulary. In the second course, the teacher introduced the learning activities to the students in the traditional group. Figure 3 shows some examples of AR Chinese vocabulary cards. The students in the PBLAR group were also introduced to the AR platform and learning activities that would be used later in their teaching. The two groups used different instructional strategies from the third to the seventh course to guide the students in learning the content. Figure 4 shows students' participation in PBLAR activities. The students in the PBLAR group, adhered to Santharooban and Premadasa [29] PBL instructional steps in their teaching procedures for instruction and used AR for the learning activities. Figure 5 shows students presenting solution questions. In the 8th course, students were given post-test self-assessments and questionnaires on Chinese vocabulary and acculturation. Table 1 gives specific information about the PBLAR learning activities, the tools used, and the schedule.

3.3. Research instrument and data collection

The first phase of this study adapted Fidan and Tuncel [8] assessment tool to validate the PBLAR model, which was quantitatively assessed by experts using a five-point Likert scale and thematically analyzed with qualitative comments. The second phase assessed the self-assessment and questionnaire using scales revised by Zhang and Zeng [27] and Alfadil [28] to assess students' Chinese vocabulary and acculturation. The mean and standard deviation (SD) of the item-objective congruence index (IOC) revealed that the IOC values for the Chinese vocabulary and acculturation sections ranged from 0.6 to 1, and all questions were greater than 0.5, so indicating good validity of the self-assessment and questionnaire design.

Second, demonstrating modest to high degrees of internal consistency, Cronbach's alpha coefficients for every dimension were more than 0.7. Ultimately, for student use the self-assessment and questionnaire design are valid and reliable. As part of the experimental procedures, students were asked to complete a pre-test and a post-test under the guidance of the researcher and the tests were provided to the students in paper form. Students were required to ensure that they completed them within the designated time frame.

3.4. Data analysis

The first phase of the study completed the expert assessment by analyzing quantitative data (mean and SD) through statistical quantitative analysis and qualitative data through thematic analysis. In the second phase, descriptive statistics were used to analyze pre-test and post-test scores and to assess the effects of PBLAR in the EG and TTM in the CG on students' Chinese vocabulary and acculturation by multivariate analysis of variance (MANOVA) with a significance level of 0.05.

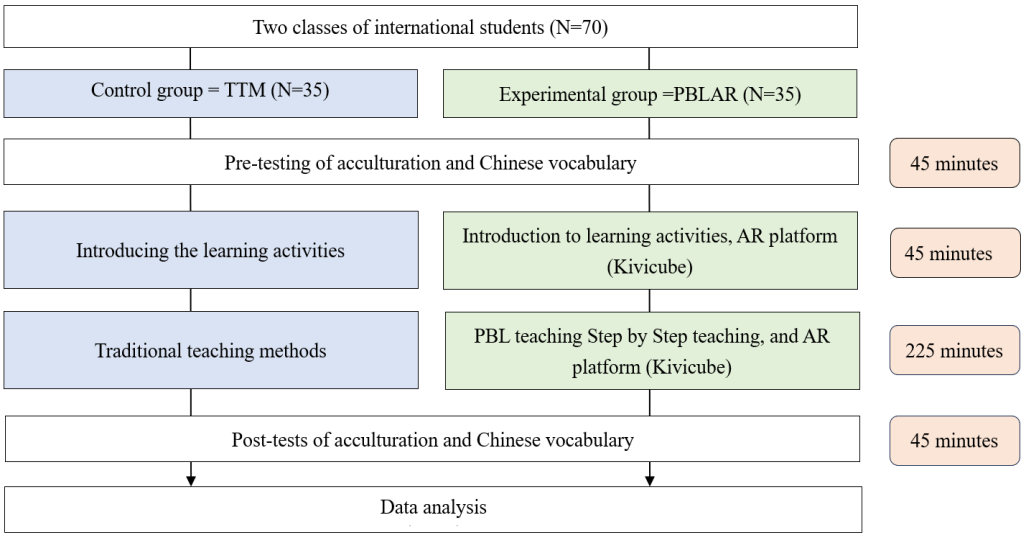

Figure 1. Experiment activities

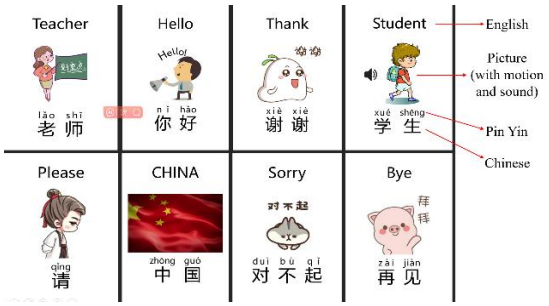

Figure 2. Activity design

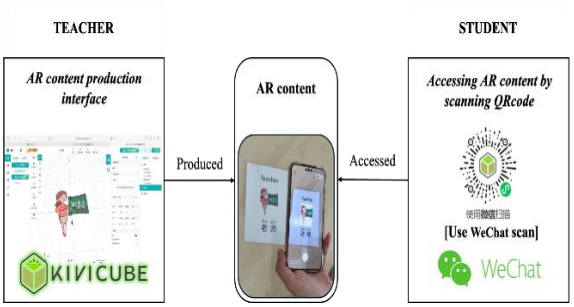

Figure 3. Example of AR Chinese vocabulary card

Figure 4. Students engaging in PBLAR activities

Figure 5. Students present solution questions

Table 1. PBLAR stages, activities, tools, and timelines

Stages	Activities	Tools used	Timelines
Course description and pre-test	- Introduce course objectives and structure. - Conduct a pre-test on acculturation and Chinese vocabulary.	Presentation software	Lesson 1 (Week 1)
Introduction to the AR platform and learning activities	- Demonstrate the use of the AR platform (Kivicube). - Explain how to integrate AR into learning activities.	Presentation software and AR Platform (Kivicube)	Lesson 2 (Week 1)
Introduction of the problem	- Teachers design role-play activities. - Guides students to observe and discover the problems in the activity.	Presentation software	Lesson 3 (Week 1)
Discussion on problem	- Students work in groups to learn about AR animations on the Kivicube. - Discuss the problems in the role-play scenarios	AR Platform (Kivicube)	Lesson 4 (Week 1)
Independent study	- Students independently explore AR animations on the Kivicube.	AR Platform (Kivicube)	Lesson 5 (Week 2)
Formulation of the solution	- Analyze the cause of the problem and propose an initial solution through an animation of the vocabulary on Kivicube.	AR Platform (Kivicube)	Lesson 6 (Week 2)
Presenting the solution	- Students present debriefing solutions. - Receive feedback from peers and teachers in class.	Presentation software	Lesson 7 (Week 2)
Course summary, review, and post-test	- Summaries key learning and course content. - Post-tests were administered to assess students' acculturation and Chinese vocabulary progress.	Presentation software	Lesson 8 (Week 2)

4. RESULTS AND DISCUSSION

4.1. Results

4.1.1. What are the key components and processes involved in developing an effective PBLAR instructional model for improving acculturation and Chinese vocabulary?

This study developed an instructional model of PBLAR that combines PBL and AR with the aim of improving the Chinese vocabulary and acculturation of international students. Six teaching steps were identified based on relevant research on teaching models, experiences, and literature: i) introduction of problem; ii) discussion on problem; iii) independent study; iv) formulation of the solution; v) presenting the solution; and vi) present review. After the initial development of the model, five experts were invited to evaluate it, using a quantitative assessment on a five-point Likert scale with a mean score of 3.8-5.0 (SD=0.00-0.89), who affirmed the effectiveness of the model in promoting Chinese vocabulary and acculturation and provided qualitative feedback. Relevant themes were summarized through thematic analysis, as presented in Table 2.

Table 2. Thematic analysis results

Themes	Aspects	Relevant quote examples
Engagement and enjoyment	Increased enjoyment in learning	"Learning is no longer boring by just reading textbooks, it is engaging and fun."
Personalized learning	Addresses different learning styles	"Some students prefer visual learning, others kinesthetic. AR caters to all types."
Interactivity	Interactive learning process	"Students can interact with the content in AR, enhancing their engagement."
Efficiency and effectiveness	Improves learning efficiency	"It can significantly improve learning efficiency by focusing on practical problems."
Positive classroom atmosphere	Creates a relaxed and enjoyable environment	"Icebreakers create a relaxed and joyful classroom atmosphere for learning."

After that, the researcher designed the PBLAR instructional model (final version) by combining experts' opinions, as shown in Figure 6. The improved model emphasizes the key elements of participation and fun, personalized learning, interactivity, efficiency and effectiveness, and a positive classroom climate. These elements are integrated into every step of the instructional process, from the introduction of a problem to the final stage of revision. The improved PBLAR model continues to follow the PBL six-step framework but now places greater emphasis on the role of AR in reinforcing these key areas. In addition, feedback loops between students and teachers have been improved to ensure that students can apply the language and cultural skills they are learning more effectively. In conclusion, the PBLAR teaching model successfully improved international students' learning experience by combining the immersion experience of AR with the problem-solving approach of PBL. Positive evaluations and thematic analyses by experts provided important insights into the optimization of the model. The improved model effectively promoted student engagement, personalized learning, and interaction, improved Chinese vocabulary learning, and acculturation, and became a powerful tool to address international students' Chinese language learning and adaptation to new cultures.

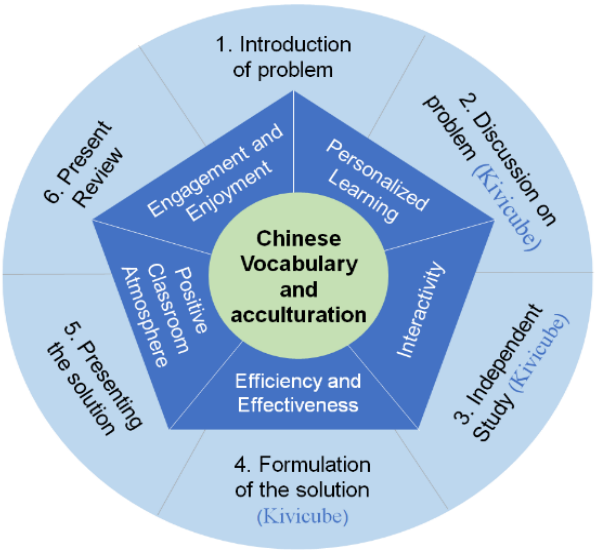

Figure 6. PBLAR model final version

4.1.2. Is using PBLAR more effective in improving acculturation and Chinese vocabulary than traditional teaching methods?

The results of the pre-test showed that the Chinese vocabulary and acculturation data of both the EG and CG met the assumption of normality (Shapiro–Wilk, $p>0.05$) and could be analyzed parametrically. MANOVA showed that there was no difference between the EG and the CG in pre-test scores on Chinese vocabulary and acculturation (all $p>0.05$). The EG and CG had similar scores in Chinese vocabulary (EG: mean=30.57, CG: mean=30.17) and acculturation (EG: mean=34.00, CG: mean=33.03), and the F-value and p-value did not reach the significant level. The results of the post-test showed that the data of the EG and CG on Chinese vocabulary and acculturation variables conformed to a normal distribution (Shapiro–Wilk, $p>0.05$,) and satisfied the assumption of normality, as seen in Table 3. The results of the multivariate test showed that there was a significant effect on Chinese vocabulary and acculturation of the two groups of students (Wilks' Lambda=0.052, $F(2, 67)=612.07$, $p<0.001$), as shown in Table 4.

The MANOVA test examined Chinese vocabulary and acculturation between the two groups of students, yielding significant differences. In terms of Chinese vocabulary, CG's mean score was 66.20 (SD=1.83), while EG's mean score was 73.54 (SD=1.74). In terms of acculturation, the mean score for CG was 62.43 (SD=2.52), while the mean score for EG was 76.83 (SD=1.50). The ANOVA results showed that the intervention had a significant effect on Chinese vocabulary and acculturation (Chinese vocabulary: $F=296.65$, $p<0.001$; acculturation: $F=840.62$, $p<0.001$). Compared with the CG, the EG performed significantly better than the CG on both Chinese vocabulary and acculturation variables. These findings suggest that the PBLAR intervention had a positive impact on international students' Chinese vocabulary and acculturation. The PBLAR instructional intervention significantly improved international students' Chinese vocabulary and acculturation. This suggests that the intervention is effective in improving international students' academic performance, as seen in Table 5.

Table 3. Normality test results of post-test

Variable	Group	Shapiro-Wilk		
		Statistic	df	Sig.
Chinese vocabulary	CG	0.945	35	0.081
	EG	0.961	35	0.246
Acculturation	CG	0.977	35	0.666
	EG	0.952	35	0.131

Table 4. Multivariate test results of post-test

Effect		Value	F	Sig.
Group	Wilks' Lambda	0.052	612.073	<0.001

Table 5. MANOVA results of post-test

Dependent variable	Group	N	Mean	SD	ANOVA F	ANOVA Sig.	Results
Chinese vocabulary	CG	35	66.20	1.83	296.65	<0.001	CG<EG
	EG	35	73.54	1.74			
	Total	70	69.87	4.10			
Acculturation	CG	35	62.43	2.52	840.62	<0.001	CG<EG
	EG	35	76.83	1.50			
	Total	70	69.63	7.54			

4.2. Discussion

This study reveals that the PBLAR approach offers solid proof of its efficiency in improving international students. On assessments of Chinese vocabulary and acculturation in particular, the EG under the PBLAR teaching approach showed notably superior performance than the CG under the conventional teaching approach. These findings line up with earlier research showing how well immersive learning technologies (AR) mix with student-centered learning approaches (PBL) [30], [31]. From this study, both quantitative and qualitative data point to PBLAR as a potential method of instruction for language and culture. We accordingly position PBLAR as a complementary pedagogy—adding value when problem-driven inquiry is paired with situated AR under adequate technical stability and structured facilitation—rather than a wholesale replacement for traditional methods. Future comparisons should examine where PBLAR adds value or combines with these approaches across learner profiles and settings.

4.2.1. PBLAR role in improving acculturation and Chinese vocabulary

PBL fosters critical thinking and self-directed learning through problem-solving functions while enhancing language skills and acculturation through realistic tasks [9]. However, the effectiveness of PBLAR may vary according to individual differences and learning styles, with students who are more self-directed learners usually performing better [32], while those who are accustomed to passively receiving knowledge may face difficulties in adapting. The immersive learning experience of AR enhances the contextualization of language and culture acquisition and supports deeper cognitive processing and memory [14]. Although contextualized learning in AR improves the learning experience, the influx of multimodal information can elevate cognitive load—though study by Elford *et al*. [33] indicate this does not necessarily reduce learning effectiveness. Also, the enhancement of acculturation may be influenced by a variety of factors, such as an individual's socialization experience and psychological adjustment [34], rather than being exclusively facilitated by PBLAR. Combined with collaboration and reflection in PBL, AR's multisensory experience with immediate feedback helps students internalize vocabulary and cultural knowledge through extensive engagement, thus optimizing language acquisition and cultural adaptation [35].

Beyond the aforementioned limitations, incidental factors during implementation may also affect the results. In this study, we intermittently encountered device-compatibility issues and network latency [36], which led to brief tracking losses and rendering pauses. These interruptions disrupted the inquiry flow, reduced time-on-task, and temporarily increased cognitive load as students reoriented to the task. Because AR was used only in the EG, such events would attenuate rather than inflate the observed effects (i.e., bias results toward the null). Nevertheless, the EG still showed significant advantages over the CG in both vocabulary and acculturation, indicating that the direction of the effects is robust. To consolidate these gains, optimization should target rendering responsiveness and connection stability, thereby improving the instructional effectiveness of PBLAR.

4.2.2. PBLAR vs TTM in Chinese language learning

PBLAR is more important in improving learning outcomes than TTM since it provides the benefits of tailored learning, instantaneous feedback, and multimodal experiences [34]. However, that does not mean it is a full replacement for traditional teaching models. While traditional classrooms are teacher-centered and students passively absorb knowledge, PBLAR enables students to explore knowledge at their own pace through tailored learning paths [37], instant feedback, and multimodal experiences [38]. PBLAR relies on students' self-directed learning skills, and students who are not comfortable with this type of learning may struggle to learn optimally [39]. PBLAR improves students' memory, comprehension, interest, and engagement [40] through a multimodal experience that combines visual and auditory senses, as well as gamification and task-driven learning strategies, which leads to improved language acquisition and acculturation outcomes. Overall, PBLAR optimizes language acquisition and cultural adaptation with interactivity and task-driven strategies that are significantly better than TTM.

5. CONCLUSION

This study investigates the role of the PBLAR model in enhancing Chinese vocabulary and acculturation of international students. The results of this study show that the PBLAR model can effectively improve students' language learning and cultural integration, which is more advantageous than TTM. The innovation of this study is the integration of the interactivity and immersion of AR and the inquiry and problem solving ability of PBL to improve students' learning experience and knowledge construction. The experimental results showed that after the PBLAR instructional intervention, the Chinese vocabulary and acculturation of the students in the EG significantly improved, which verified the effectiveness of the instructional model.

The findings are reliable within the present design and measurement framework, and the statistical procedures and implementation consistency support their validity. Several bounded conditions indicate directions for optimization rather than threats to the conclusions. First, the sample comprised 70 international students from a single university, which limits generalizability, and future work should use larger, multi-site cohorts with more diverse learner profiles. Second, the two-week intervention does not permit claims about long-term durability, and delayed post-tests and longitudinal tracking are therefore warranted. Third, routine AR operational factors such as device heterogeneity, network latency, Internet instability, and occasional image-recognition errors were observed during implementation, indicating the need for lightweight assets, offline buffers, and cross-device compatibility testing. These steps outline a path to extend the applicability of the present reliable findings to broader contexts and longer time frames.

The findings, particularly in the areas of acculturation and Chinese vocabulary for international students, the results have significant ramifications for educators, language educators, policymakers, and researchers in the disciplines of educational technology and language acquisition. For educators, the integration of AR and PBL can optimize the language learning environment and make abstract concepts more intuitive, thus improving students' learning and classroom participation. For language educators, the PBLAR model bridges the gap between theory and practice, helps students experience language through authentic contexts, and improves language proficiency and acculturation. Policymakers can rely on the findings of this study to use PBLAR as a basis for investing in educational technology to promote more inclusive and flexible pedagogical approaches. For researchers, this study provides direction for future longitudinal studies, such as exploring the scalability of PBLAR across cultural contexts and educational levels to further validate its long-term impact and universal applicability.

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AUTHOR CONTRIBUTIONS STATEMENT

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

ETHICAL APPROVAL

All procedures in this study were conducted in accordance with the Research Ethics Committee of Kunming University of Science and Technology, China. The approval reference number is 24082901.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author, [TR-O], upon reasonable request.

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