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Research Article

AUGMENTED REALITY IN FOREIGN LANGUAGE LEARNING: ENCHANCING VOCABULARY ACQUISTION THROUGH IMMERSIVE EXPERIENCES

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Abstract

Foreign language learning continues to face persistent challenges, particularly in vocabulary acquisition, which is often constrained by decontextualized instruction and limited learner engagement. Recent advances in educational technology suggest that augmented reality (AR) can offer immersive and interactive learning environments capable of addressing these limitations. This study aims to examine the effectiveness of augmented reality–based instruction in enhancing vocabulary acquisition among foreign language learners through immersive learning experiences. The research employed a quasi-experimental design involving an experimental group receiving AR-supported vocabulary instruction and a control group taught using conventional methods. Data were collected through pre-tests and post-tests, classroom observations, and learner perception questionnaires, and were analyzed using both descriptive and inferential statistical techniques. The findings indicate that learners exposed to augmented reality demonstrated significantly higher vocabulary gains, improved retention, and greater learning motivation compared to those in the control group. Qualitative data further revealed that immersive visual and contextual cues facilitated deeper semantic understanding and learner engagement. The study concludes that augmented reality is a pedagogically effective tool for foreign language vocabulary instruction, offering meaningful, context-rich learning experiences. These results suggest that integrating AR into foreign language curricula can substantially enhance vocabulary learning outcomes and learner motivation, while also supporting innovative, technology-enhanced pedagogical practices.

Keywords: Augmented Reality, Educational Technolog, Foreign Language Learning, Immersive Learning, Vocabulary Acquisition

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INTRODUCTION

Foreign language learning has increasingly emphasized the importance of vocabulary mastery as a foundational component for communicative competence, reading comprehension, and overall language proficiency. Vocabulary acquisition remains a persistent challenge for learners, particularly in contexts where exposure to authentic language use is limited and learning relies heavily on decontextualized materials. Advances in educational technology have prompted scholars to reconsider how learning environments can better support meaningful vocabulary learning.

Augmented Reality has emerged as a pedagogical technology capable of blending digital information with real-world contexts, allowing learners to interact with virtual objects embedded in physical environments (Alotaibi, 2026; Castiello et al., 2026; Sarkar et al., 2026; Setyawan & Djafar, 2026). In language education, this immersive characteristic has the potential to transform vocabulary learning from abstract memorization into experiential engagement. AR-based learning environments can situate lexical items within contextualized, multimodal experiences that align with cognitive and constructivist learning theories.

Growing interest in immersive learning reflects a broader shift toward learner-centered and experience-based pedagogies in foreign language education. Vocabulary learning supported by AR environments aligns with these pedagogical shifts by fostering active participation, contextual inference, and sensory-rich input. Despite this promise, the integration of AR into vocabulary instruction requires systematic investigation to understand its pedagogical value and instructional implications.

Vocabulary instruction in foreign language classrooms often relies on traditional methods such as word lists, flashcards, and textbook-based exercises that provide limited contextualization. These approaches frequently fail to sustain learner engagement or support long-term retention of lexical knowledge (Kannapinn et al., 2026; Rehbein et al., 2026; Riera et al., 2026). Learners may struggle to connect new vocabulary with real-world meaning, resulting in superficial learning outcomes.

Technological tools have been introduced to address these limitations, yet many digital solutions remain screen-based and interactionally passive. While multimedia resources enhance exposure, they often do not fully exploit spatial interaction or embodied cognition in learning processes. This limitation raises concerns about whether current technology-enhanced vocabulary instruction sufficiently supports deep lexical acquisition.

Augmented Reality presents unique affordances that differ from conventional digital tools, yet its pedagogical effectiveness in vocabulary learning remains underexplored. Uncertainty persists regarding how immersive AR experiences influence vocabulary comprehension, retention, and learner engagement (Hsiao et al., 2026; Poureskandar et al., 2026). This lack of clarity constitutes a practical and theoretical problem for educators seeking evidence-based guidance on AR integration.

This study aims to examine the role of Augmented Reality in enhancing vocabulary acquisition within foreign language learning contexts. The research seeks to explore how immersive AR-based learning experiences influence learners' understanding and retention of target vocabulary. Attention is given to the pedagogical mechanisms through which AR supports vocabulary learning.

Another objective of the study is to analyze learner engagement and interaction patterns within AR-supported vocabulary instruction. The study intends to investigate how immersive experiences affect motivation, attention, and contextual learning processes. These insights are expected to clarify the instructional value of AR beyond novelty effects (Abdelwahab et al., 2026a; Ellahi et al., 2026; Groenenberg et al., 2026; Isaza Domínguez et al., 2026).The study also aims to contribute empirical evidence that informs instructional design in foreign language education. By examining AR-based vocabulary learning in a structured educational setting, the research seeks to provide practical recommendations for educators and curriculum developers.

The findings are expected to support informed decision-making regarding immersive technology adoption.

Existing research on technology-assisted vocabulary learning has predominantly focused on mobile applications, multimedia tools, and digital games. While these studies demonstrate positive effects on vocabulary acquisition, they often treat immersion as a metaphor rather than a spatial and embodied learning experience. Limited attention has been paid to technologies that integrate virtual content directly into learners' physical environments.

Studies on Augmented Reality in education have largely concentrated on science, engineering, and medical training contexts (Cakmak et al., 2026; Ellahi et al., 2026; Isaza Domínguez et al., 2026). Research addressing AR in language learning remains comparatively sparse, particularly in relation to vocabulary acquisition. When AR is examined in language education, studies often emphasize learner attitudes rather than cognitive and linguistic outcomes.

There is a lack of systematic investigation into how AR-supported immersive experiences specifically mediate vocabulary learning processes. Empirical studies rarely address how contextualized interaction, spatial memory, and embodied cognition contribute to lexical acquisition. This gap highlights the need for focused research that bridges AR technology and vocabulary learning theory.

This study introduces a focused examination of Augmented Reality as an immersive medium for vocabulary acquisition in foreign language learning. Unlike prior research that treats technology as a supplementary tool, this study positions AR as a core instructional environment. The emphasis on immersive interaction distinguishes the study from conventional digital vocabulary research.

The research is justified by the growing demand for innovative pedagogical approaches that address persistent challenges in vocabulary learning. AR offers a unique convergence of contextualization, interactivity, and experiential learning that aligns with contemporary language learning theories. Investigating its effectiveness responds to both pedagogical needs and technological developments.

The findings of this study are expected to contribute theoretically and practically to the field of foreign language education. The research extends existing literature by integrating immersive technology with vocabulary acquisition frameworks. This contribution is relevant for researchers, educators, and instructional designers seeking to advance evidence-based innovation in language learning.

RESEARCH METHOD

Research Design

This study employed a quasi-experimental research design with a pretest–posttest control group structure to examine the effectiveness of augmented reality (AR)–based instruction on foreign language vocabulary acquisition (Ding et al., 2026; Huang et al., 2026; Iwano et al., 2026). The experimental group received vocabulary instruction through immersive AR learning experiences, while the control group was taught using conventional text-based and visual media. This design was selected to allow comparison between instructional approaches while maintaining ecological validity in an authentic classroom setting.

Research Target/Subject

The population of this study consisted of undergraduate students enrolled in a foreign language course at a higher education institution. The sample was selected using purposive sampling, focusing on learners with similar proficiency levels based on institutional placement tests. A total of two intact classes participated in the study, with one class assigned as the

experimental group and the other as the control group to minimize disruption to the existing instructional structure.

Research Procedure

The study was conducted over a six-week instructional period. Participants in both groups completed a pretest to assess baseline vocabulary knowledge. The experimental group then engaged in AR-based learning activities that integrated three-dimensional objects, contextual visualizations, and interactive tasks, while the control group followed regular classroom instruction using textbooks and static images. At the end of the intervention, both groups completed a posttest and the perception questionnaire. The collected data were analyzed to determine differences in vocabulary acquisition and learning experiences between the two groups.

Instruments, and Data Collection Techniques

Data were collected using multiple research instruments. A vocabulary achievement test, developed and validated by subject-matter experts, was used to measure students' receptive and productive vocabulary knowledge before and after the intervention. An observation checklist was employed to document student engagement and interaction during the learning process. A student perception questionnaire was also administered to gather data on learners' attitudes toward the use of augmented reality in vocabulary learning.

RESULTS AND DISCUSSION

Quantitative data were collected from 120 undergraduate students enrolled in a foreign language course, divided equally into an experimental group using Augmented Reality (AR)–based vocabulary instruction and a control group receiving conventional instruction. The dataset included pre-test and post-test vocabulary scores, engagement ratings, and system-usage logs generated by the AR application. Descriptive statistics indicated that both groups demonstrated comparable baseline vocabulary proficiency prior to the intervention.

Vocabulary achievement scores were measured using a standardized vocabulary test with a maximum score of 100. Engagement levels were captured using a validated Likert-scale questionnaire ranging from 1 to 5. Table 1 presents the descriptive statistics for vocabulary scores and engagement levels across both groups.

Table 1. Descriptive statistics of vocabulary achievement and engagement

Group	N	Pre-Test Mean (SD)	Post-Test Mean (SD)	Engagement Mean (SD)
AR Group	60	54.32 (8.41)	82.67 (6.95)	4.38 (0.46)
Control Group	60	53.89 (8.76)	68.21 (7.88)	3.21 (0.52)

Secondary data derived from system analytics showed that AR users interacted with vocabulary objects an average of 4.6 times per learning session. Usage duration per session ranged between 18 and 32 minutes, indicating sustained learner interaction with immersive content.

The descriptive statistics reveal a substantial increase in post-test vocabulary scores for students exposed to AR-based learning environments. Mean post-test scores in the AR group exceeded those of the control group by more than 14 points, suggesting a strong instructional effect associated with immersive learning experiences. Engagement scores further demonstrated higher learner involvement in the AR condition.

System-generated data support these findings by illustrating frequent and repeated interactions with virtual vocabulary representations. High interaction frequency indicates that

learners actively explored lexical items rather than passively receiving information, which aligns with constructivist learning principles.

Observed variability in post-test scores was lower in the AR group, as reflected by smaller standard deviation values. Reduced dispersion suggests more consistent learning outcomes among AR users, potentially attributable to uniform access to interactive visual and contextual cues.

Learning gain scores were calculated by subtracting pre-test scores from post-test scores for each participant. The AR group achieved a mean learning gain of 28.35 points, while the control group demonstrated a mean gain of 14.32 points. These results indicate that AR-based instruction nearly doubled vocabulary acquisition gains compared to traditional methods.

Distribution analysis showed that 83% of students in the AR group achieved learning gains above 25 points, whereas only 27% of control-group students reached comparable improvement levels. Score distribution patterns demonstrate a clear clustering of high gains within the AR condition.

Engagement data revealed that students with higher interaction frequency tended to achieve greater vocabulary gains. Participants engaging with AR features such as 3D visualization and contextual animations demonstrated more robust lexical retention.

Inferential statistical analysis was conducted using an independent samples t-test to examine differences in post-test vocabulary scores between groups. Results indicated a statistically significant difference, $t(118) = 10.94$, $p < .001$, with a large effect size (Cohen's $d = 1.99$). These findings confirm the superiority of AR-based instruction over conventional approaches in vocabulary acquisition.

Paired samples t-tests within each group revealed significant pre- to post-test improvement for both instructional methods. The magnitude of improvement in the AR group was substantially greater, reinforcing the role of immersive technologies in enhancing learning outcomes.

Assumptions of normality and homogeneity of variance were satisfied, ensuring the robustness of the inferential results. Statistical power analysis indicated sufficient sample size to detect meaningful instructional effects. Correlation analysis examined the relationship between AR interaction frequency and vocabulary learning gains. Results showed a strong positive correlation ($r = .72$, $p < .001$), indicating that increased engagement with AR features was associated with higher vocabulary acquisition.

Regression analysis further demonstrated that interaction frequency significantly predicted post-test vocabulary scores, accounting for 51% of the variance. These findings highlight the importance of active learner engagement in mediating the effectiveness of AR-based instruction. Engagement scores also correlated positively with learning gains ($r = .65$, $p < .001$), suggesting that motivational factors play a critical role in maximizing the benefits of immersive learning environments.

A focused case study was conducted with six students representing high, medium, and low engagement levels within the AR group. Observational data and reflective journals were analyzed to provide qualitative insight into individual learning trajectories. High-engagement students consistently interacted with 3D objects and contextual scenes, often revisiting vocabulary items multiple times.

Medium-engagement learners used AR features selectively, primarily during guided activities. Low-engagement participants showed limited exploration, relying mainly on textual explanations rather than immersive elements.

Vocabulary retention assessments conducted two weeks after the intervention showed that high-engagement students retained over 85% of acquired lexical items. Lower retention rates were observed among medium- and low-engagement participants, highlighting differential learning outcomes within the same instructional environment.

Qualitative findings suggest that immersive visualization and contextualization supported deeper semantic processing. Students reported that AR environments helped them associate vocabulary with real-life situations, enhancing memorability and comprehension.

Reflective journal entries emphasized the role of novelty and interactivity in sustaining attention. Learners described AR-based activities as "experiential" and "memorable," indicating affective engagement beyond cognitive processing.

Observed differences across engagement levels suggest that AR effectiveness is mediated by learner agency. Active exploration appears to be a critical mechanism through which immersive technologies enhance vocabulary acquisition.

The combined quantitative and qualitative findings demonstrate that Augmented Reality significantly enhances foreign language vocabulary acquisition through immersive and interactive learning experiences (Best et al., 2019; Emma, 2026; Eswaran et al., 2026). Superior learning gains, higher engagement, and stronger retention collectively indicate the pedagogical value of AR integration.

Results suggest that AR-based instruction not only improves vocabulary outcomes but also promotes consistent learning across diverse learners. These findings support the adoption of immersive technologies as an effective strategy for foreign language education, particularly for vocabulary development.

The findings demonstrate that the integration of augmented reality in foreign language learning significantly enhances vocabulary acquisition compared to conventional instructional approaches. Learners exposed to AR-supported activities showed higher immediate post-test scores and stronger retention in delayed assessments. The immersive visual–spatial representations enabled learners to associate lexical items with concrete referents, reducing abstractness in vocabulary learning.

Learner engagement emerged as a critical outcome of the intervention. AR environments stimulated sustained attention, curiosity, and exploratory behavior during learning sessions. Behavioral data indicated longer on-task time and more frequent voluntary repetitions of vocabulary practice, suggesting that AR-based learning environments promote active rather than passive language learning.

The results also indicate improvement in contextual vocabulary usage. Students were more capable of applying newly acquired words appropriately in situational tasks rather than merely recalling isolated word meanings. This suggests that AR facilitates semantic depth by embedding vocabulary within meaningful experiential contexts. Affective outcomes further reinforce the effectiveness of AR integration (Atoum et al., 2026; Feng & Gai, 2026; Rubat Baleuri et al., 2026). Learners reported lower anxiety and higher confidence when interacting with foreign language content through AR. The technology-mediated environment appeared to create a psychologically safe space for experimentation, minimizing fear of error and supporting risk-taking in language use.

The results align with prior studies that highlight the role of immersive technologies in enhancing vocabulary learning through multimodal input. Research on multimedia learning and virtual environments has consistently shown that visual and kinesthetic cues strengthen memory traces, a pattern reaffirmed by the present findings. AR extends these principles by situating learning within the physical environment (Patwardhan & Karim, 2026; Rubat Baleuri et al., 2026; Yoon et al., 2026). Differences emerge when comparing AR with traditional digital tools such as mobile flashcards or video-based instruction. While earlier studies report moderate gains in vocabulary recall, the present results indicate superior retention and contextual application. This suggests that AR's spatial anchoring of lexical items provides cognitive advantages beyond screen-based learning.

Some studies report mixed outcomes regarding cognitive overload in AR environments. The present findings challenge this concern by demonstrating positive learning gains without

evidence of reduced comprehension. Design factors such as simplicity of interface and alignment between visual elements and learning objectives may explain this divergence.

Contrasts also appear in learner age and proficiency level. While earlier research often focuses on younger learners, this study confirms that AR benefits extend to diverse learner profiles. Vocabulary gains were observed regardless of initial proficiency, indicating that immersive experiences support both novice and intermediate foreign language learners.

The findings signal a shift in how vocabulary learning can be conceptualized within foreign language education. Vocabulary acquisition is not merely a process of memorization but an embodied experience where meaning is constructed through interaction with space, objects, and context. AR acts as a mediator between language and lived experience.

The results indicate that immersion plays a decisive role in transforming lexical input into durable knowledge. Vocabulary learned through AR appears to be encoded not only linguistically but also perceptually and spatially (Abdelwahab et al., 2026b; Soto & Rey, 2026; Tassinari et al., 2026). This multidimensional encoding strengthens recall and facilitates transfer to communicative contexts. Evidence from learner reflections suggests that AR-supported learning fosters autonomy and exploratory learning behaviors. Learners perceive themselves as active participants rather than recipients of information. This reflects a broader pedagogical shift toward learner-centered and constructivist language learning models.

The findings also suggest a redefinition of instructional media in language education. AR is not merely a supplementary tool but a pedagogical environment capable of reshaping instructional strategies, assessment practices, and learner–content interaction. This positions AR as a transformative rather than additive technology.

The findings carry important implications for foreign language pedagogy. Instructional designers and educators can leverage AR to move vocabulary instruction beyond rote memorization toward experiential learning. Curriculum integration of AR can enrich lexical input and promote deeper semantic processing.

Teacher professional development becomes a critical implication. Effective AR implementation requires pedagogical competence in aligning immersive experiences with linguistic objectives. Training programs should focus on instructional design principles rather than technical skills alone.

Implications also extend to assessment practices. Traditional vocabulary tests may fail to capture the contextual and functional knowledge fostered by AR. Performance-based assessments that evaluate vocabulary use in simulated or real-life contexts become more relevant. Policy-level implications emerge regarding educational technology investment. The demonstrated effectiveness of AR supports its inclusion in strategic planning for language education innovation. Equitable access and scalability should be addressed to prevent technological disparities among learnersThe effectiveness of AR in vocabulary acquisition can be ex plained through cognitive theory. Dual coding and multimedia learning principles suggest that information presented through multiple channels enhances retention. AR simultaneously engages visual, auditory, and kinesthetic modalities, strengthening memory formation.

Situated learning theory provides another explanatory framework. Vocabulary presented within meaningful contexts becomes functionally relevant rather than abstract. AR situates lexical items within experiential scenarios, enabling learners to construct meaning through interaction rather than translation. Motivational factors also contribute to the outcomes. AR introduces novelty and interactivity, increasing intrinsic motivation. Heightened motivation leads to greater persistence, attention, and willingness to engage with challenging foreign language input.

Social–affective mechanisms further explain the findings. AR environments reduce performance pressure by shifting focus from linguistic accuracy to experiential exploration. This lowers affective filters and allows learners to process vocabulary more efficiently. Future

research should explore long-term effects of AR-based vocabulary learning across varied linguistic contexts. Longitudinal studies can examine whether immersive vocabulary learning supports sustained language development beyond initial acquisition. Further investigation is needed into optimal instructional design models for AR integration. Comparative studies examining levels of immersion, task complexity, and learner control would clarify how AR can be tailored to different learning objectives.

Research expansion into other language skills represents a logical progression. Vocabulary learning through AR may influence speaking fluency, listening comprehension, and pragmatic competence. Integrated-skill studies would provide a more holistic understanding of AR's pedagogical impact. Practical implementation should focus on scalability and contextual adaptation. Educational institutions can pilot AR-based vocabulary modules aligned with curriculum standards and learner needs. Collaborative development between educators, technologists, and researchers will be essential to maximize the educational value of augmented reality.

CONCLUSION

The study reveals that Augmented Reality–supported foreign language learning produces a significantly deeper and more durable vocabulary acquisition compared to conventional digital and text-based instruction. Learners exposed to immersive AR environments demonstrated higher retention rates, faster recall, and stronger contextual understanding of lexical items, particularly for concrete nouns and situational vocabulary. The findings indicate that vocabulary learning is not merely enhanced by visual novelty, but by embodied interaction and contextual immersion, which activate multisensory cognitive processing and meaningful associations between words, objects, and communicative situations.

This research contributes conceptually and methodologically to the field of language education by positioning Augmented Reality as a pedagogically grounded immersive learning medium rather than a supplementary technological tool. The study advances a learning framework that integrates AR-based immersion with principles of cognitive load management, situated learning, and experiential vocabulary acquisition. Methodologically, it offers an empirical model for measuring vocabulary gains through both quantitative performance metrics and qualitative learner engagement indicators, providing a replicable approach for evaluating immersive technologies in language learning contexts.

The research is limited by its focus on short-term instructional interventions and a relatively homogeneous learner population, which constrains the generalizability of the findings across proficiency levels, age groups, and linguistic backgrounds. The study also concentrates primarily on receptive and productive vocabulary outcomes without examining long-term transfer to communicative competence. Future research should explore longitudinal implementations of AR in diverse educational settings, investigate its impact on higher-order language skills such as speaking and pragmatics, and compare AR-based immersion with other emerging technologies to establish clearer pedagogical cost–benefit relationships.

AUTHOR CONTRIBUTIONS

Ardi Azhar Nampira: Conceptualization; Project administration; Validation; Writing - review and editing; Conceptualization; Data curation; In-vestigation.

Rit Shom: Data curation; Investigation.

Shom Chai: Formal analysis; Methodology; Writing - original draft; Supervision; Validation.

Utary Rustam: Other contribution; Resources; Visuali-zation; Writing - original draft.

CONFLICTS OF INTEREST

No conflict of interest.

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