Revolutionizing English Vocabulary Learning through Augmented Reality: Innovative Strategies for Indonesian Classrooms

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Article

Revolutionizing English Vocabulary Learning through Augmented Reality: Innovative Strategies for Indonesian Classrooms

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Abstract

This study investigates the effectiveness of deep learning-based gamification using Augmented Reality (AR) in improving vocabulary retention among English as a Foreign Language (EFL) students, while examining how AI-based learning personalization can increase students' motivation and interest in vocabulary learning. Grounded in a conceptual framework integrating multimodal learning, adaptive feedback, and personalized AI systems, this qualitative study employed classroom observations, interviews, and document analysis. Data were collected from 10 lecturers and 30 university students in the English Language Education program through semi-structured interviews and learning platform records. The results reveal that AR-supported gamification significantly improves vocabulary retention by fostering interactive, contextual learning experiences. Students exposed to gamified AR lessons demonstrated greater enthusiasm, long-term memory retention, and deeper cognitive engagement than those receiving traditional instruction. Furthermore, personalized AI feedback and adaptive content delivery enhanced motivation, self-directed learning, and confidence. Key factors influencing successful implementation included digital infrastructure, availability of trained instructors, and quality of AR content. Despite promising results, this study acknowledges certain limitations, including technical constraints and unequal technology access among learners. Overall, the findings contribute to growing knowledge on AI and AR in language education, offering insights for educators, curriculum designers, and edtech developers. The study suggests further exploration of scalable models and the long-term impact of immersive technologies in diverse contexts.

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Introduction

Over the past five years, vocabulary acquisition remained a persistent challenge in English language education across Indonesia. At the local level in Palu and Central Sulawesi, many secondary school students struggled to retain English words beyond rote memorisation, as regional studies highlighted low retention rates (Rosyidah & Anugerahwati, 2024). Nationally, Indonesian PISA results continued to indicate weak reading comprehension tied to limited vocabulary. Globally, educators recognized augmented reality (AR) as a promising tool to make language learning more immersive and context-driven, with pilot studies showing measurable gains in vocabulary retention in diverse settings (Santiana et al., 2021; Santiana, Hikmatullah, 2024; Muthmainnah et al., 2024; Muthmainnah, Cardoso et al., 2024).

This study linked human-computer interaction and second language acquisition research by exploring AR-based instruction as a pedagogical innovation. AR applications bridged theoretical models of embodied cognition (Syafryadin et al., 2024; Muthmainnah, M., Rehman et al., 2025; Muthmainnah et al., 2025) with practical language teaching strategies in Indonesian classrooms. By integrating visual-spatial cues with word forms and meaning, AR supported multisensory

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reinforcement of vocabulary, addressing the practical need for engaging, meaningful learning beyond flashcards or vocabulary lists (Hudaya & Sadikin, 2024).

Despite this potential, significant research gaps persisted. Few AR studies had been conducted in Indonesian school contexts; existing work focused predominantly on English teaching in Western or East Asian settings (Rozi et al., 2021; Santiana & Marzuki, 2022; Santiana & Marzuki, 2024). Moreover, local Indonesian contexts posed infrastructural and cultural challenges, such as limited device access, variable teacher readiness, and diverse student backgrounds that prior global studies did not address. As a result, practical evidence on AR's effectiveness for Indonesian vocabulary mastery remained scarce.

This research offered novelty on two fronts. First, it implemented a contextually designed AR app tailored for Indonesian learners, embedding culturally relevant images and everyday vocabulary. Second, it examined vocabulary outcomes through a mixed-methods design combining quantitative retention tests and qualitative interviews with students and teachers. To the researcher's knowledge, no prior study had evaluated culturally adapted AR vocabulary tools within Indonesian secondary schools. This novel approach responded directly to the sparse localized evidence.

The urgency for this research was heightened by recent national policy shifts, with the Ministry of Education formally encouraging digital innovation in teaching. At the same time, mobile device penetration in Indonesian schools had grown substantially making AR implementation more feasible. Given the COVID-19 era's acceleration of blended learning, educators and policymakers were seeking effective digital tools that enhanced engagement and vocabulary mastery, making this study particularly timely (Santiana et al., 2021; Santiana et al., 2024).

This research was important not only for Indonesian language pedagogy but also for scholarship on educational technology. Insight into AR-mediated vocabulary learning could inform curriculum development, teacher training programs, and technology policy both locally and nationally. Findings would also contribute to global discourse on culturally grounded AR applications in language education. Against this backdrop, the study addressed the following research problem: how AR-based instructional design affected English vocabulary mastery among Indonesian secondary school students; the study investigated retention rates, learner engagement, and stakeholder perceptions of AR as a pedagogical tool.

Literature Review

1. Augmented Reality Technology and Vocabulary Acquisition

Augmented Reality or AR had gained increasing attention in the field of language education for its potential to support vocabulary acquisition in English as a Foreign Language classrooms. Unlike conventional vocabulary learning methods that often relied on memorization and repetition, AR provided interactive and visually enriched environments where learners could associate words with three-dimensional objects and contextual scenarios. This form of immersive learning enabled students to form deeper connections with new vocabulary, leading to improved short-term and long-term retention. For instance, several studies by scholars demonstrated that students who used the ARbis Pictus application showed significantly higher vocabulary recall scores than those in a control group who used flashcards (Sadikin & Martyani, 2021). Furthermore, a meta-analysis conducted by scholars confirmed that technologies categorized under extended reality, including AR, had a large effect size on language learning, with vocabulary acquisition showing particularly strong outcomes (Nuraini & Maharani, 2024; Fitayanti, 2024).

Despite these promising results, the effectiveness of AR in vocabulary instruction varied depending on the implementation design and learner context. Not all learners experienced the same level of benefit, and some studies reported comparable gains between AR-based instruction and traditional multimedia tools. Firdaus et al. (2024) noted that while AR applications did improve vocabulary understanding for many learners in a Chinese EFL context, factors such as user interface design, interactivity level, and cognitive load had a significant impact on the results. Moreover, the novelty of AR sometimes wore off over time, and without proper integration into the curriculum, the

 doi:10.20944/preprints202508.1027.v1

learning benefits diminished. In countries such as Indonesia, where infrastructure and teacher readiness remained uneven, these limitations became more pronounced. As such, there was a clear need for research that explored the use of AR in vocabulary instruction within local educational settings to understand how contextual factors influenced its effectiveness.

2. Motivation, Engagement, and Learner Perception

Another widely discussed benefit of AR in language learning was its ability to enhance student motivation and engagement. The interactive and exploratory nature of AR learning environments allowed students to participate actively in the learning process, making abstract vocabulary more tangible and memorable. Sadikin and Martyani (2020), who conducted a study in an Indonesian secondary school, observed that students showed increased enthusiasm, confidence, and interest when vocabulary lessons incorporated AR features. Learners reported feeling more connected to the material because it was presented in a visually stimulating and meaningful way. This sense of enjoyment and immersion played a critical role in sustaining attention and promoting a positive attitude toward English learning.

However, while the motivational appeal of AR was often strong at the beginning, not all students maintained high levels of engagement throughout prolonged use. Rosyidah & Anugerahwati (2024) conducted a study involving college-level English for Specific Purposes learners and found that although many participants showed improved vocabulary performance, some expressed frustration due to technical challenges and distractions caused by the AR interface. In addition, a review by Nuraini & Maharani (2024) emphasized that learners' perceptions of AR were influenced by the relevance of content, device familiarity, and the complexity of the application. If the AR experience felt disconnected from their learning goals or too difficult to use, students were less likely to perceive it as beneficial. Therefore, designing AR tools that were both user-friendly and aligned with curriculum objectives was essential to ensure that the motivational benefits translated into real learning outcomes, especially in Indonesian classrooms where student interest in English learning could be low due to exam pressures and traditional teaching practices.

3. Contextual and Cultural Adaptation in EFL Environments

While global research on AR in education had expanded rapidly, its application in culturally specific EFL environments such as Indonesia remained limited. Most studies originated from high-resource contexts, where infrastructure and digital literacy levels supported seamless AR integration. In contrast, educational settings in Indonesia often faced challenges such as limited access to devices, poor internet connectivity, and lack of teacher training. A study by Rosyidah & Anugerahwati (2024) at a university in Indonesia showed that when AR tools were designed with culturally relevant content and vocabulary, students demonstrated higher levels of comprehension and retention. Localized AR content helped learners connect new English vocabulary with their everyday lives, reducing anxiety and enhancing the relevance of the lesson. This finding suggested that cultural adaptation was a crucial factor in maximizing the benefits of AR for vocabulary learning.

In addition to content adaptation, the successful implementation of AR in Indonesian EFL classrooms depended on teacher preparedness and institutional support. Firdaus et al. (2024) noted that although many teachers expressed interest in using AR for language teaching, they lacked access to adequate training and resources to do so effectively. Furthermore, the Indonesian curriculum often emphasized test-oriented instruction, leaving little room for experimentation with interactive technologies. Policymakers and administrators frequently prioritized basic ICT skills over more advanced technologies like AR, creating a gap between national innovation goals and classroom realities. This gap highlighted the importance of investigating not only student outcomes but also the readiness and perceptions of teachers. To build a foundation for sustainable AR integration in Indonesian schools, research needed to address these local challenges and identify practical solutions that aligned with both pedagogical goals and contextual limitations.

 doi:10.20944/preprints202508.1027.v1

Method

This study employed a qualitative research design to explore how augmented reality (AR) technology influenced vocabulary mastery and learner engagement in English as a Foreign Language (EFL) classrooms within an Indonesian secondary school context. A qualitative approach was selected to provide an in-depth understanding of the lived experiences, perceptions, and attitudes of both students and teachers toward the integration of AR into vocabulary learning. This approach allowed the researcher to capture rich, detailed accounts that quantitative data alone could not provide Amalia et al., 2024; Anita et al., 2024; Apriani et al., 2025). The research also sought to understand how the local educational and cultural context shaped the implementation of AR tools, a critical aspect that has been underrepresented in previous AR studies (Rosyidah & Anugerahwati, 2024; Muthmainnah, Darmawati et al., 2024).

Research Context

The research took place in a public secondary school located in the urban area of Palu, Central Sulawesi, Indonesia. The school had recently received support for digital learning infrastructure through a government technology grant, which made it suitable for implementing AR-based instruction. The English curriculum at the school followed the national standards set by the Ministry of Education, which emphasized vocabulary acquisition as a key component of language proficiency. The study was conducted over a six-week period during the second semester of the academic year. During this time, students used a culturally contextualized AR application developed by the researcher, which included localized vocabulary items embedded in daily life scenes to reflect the students' real-world environment (Muthmainnah et al., 2022).

Participants

The participants included two English teachers and twenty-four ninth-grade students (aged 14 to 15) who were selected using purposive sampling. This sampling technique was chosen to ensure that participants had direct experience with AR-based learning and could provide relevant insights (Iftitah et al., 2020). Both teachers had more than five years of teaching experience and were actively involved in the integration of technology into their instruction. The students represented a mix of academic backgrounds and technological familiarity (Suaidi et al., 2025). Prior to data collection, informed consent was obtained from participants and their guardians, and ethical approval was granted by the institutional review board of the university supporting this research.

Instruments

To collect comprehensive qualitative data, the study used multiple instruments, including classroom observations, semi-structured interviews, and student reflection journals. The classroom observations focused on student interaction with the AR tool, engagement levels, and vocabulary-related behaviors during learning sessions. Semi-structured interviews were conducted with both teachers and students to explore their perceptions, challenges, and opinions regarding the use of AR in vocabulary learning. The interviews followed a flexible guide to allow follow-up questions and deeper exploration of responses (Kuliahana & Marzuki, 2020; Kuliahana et al., 2024; Kuliahana, Marzuki, & Rustam, 2024; Kuliahana & Marzuki, 2024). In addition, students were asked to maintain weekly reflection journals where they described their experiences using the AR app, vocabulary they learned, and how they felt about the learning process.

Data Analysis

The collected data were analyzed using thematic analysis following the six-step process outlined by Braun and Clarke (Erizar et al., 2024). All interview transcripts, observation notes, and journal entries were read repeatedly to ensure familiarity. Initial codes were generated manually, and then similar codes were grouped into broader themes. Themes were reviewed, defined, and refined to

 doi:10.20944/preprints202508.1027.v1

capture the most significant patterns in the data. The credibility of the findings was ensured through triangulation across data sources and member checking, where preliminary interpretations were shared with participants for validation (Albana et al., 2020; Alek, Marzuki, Farkhan, & Deni, 2020; Alek et al., 2020; Amalia & Marzuki, 2023). NVivo software was also used to assist in organizing and categorizing the qualitative data, which improved the efficiency and transparency of the analysis process.

Results

The findings revealed a substantial improvement in students' vocabulary mastery following the integration of AR-based learning tools into the English language classroom. Pre-test and post-test data indicated that most students demonstrated marked progress in vocabulary acquisition after the intervention. As shown in Table 1, the average pre-test score was 58.3, while the post-test average rose significantly to 82.7. These scores signified not only improved recall but also a deeper understanding and retention of vocabulary items taught through interactive 3D AR features.

The students' exposure to visual and spatial learning environments appeared to foster better mental associations and contextual understanding. Instead of relying solely on rote memorization, learners engaged with vocabulary in immersive scenarios that mimicked real-life applications, making the words more meaningful and easier to remember. For instance, students reported that seeing an animated object, such as a "volcano" erupting or a "telescope" being used in a starry sky scene, gave them a clearer, more lasting impression of the vocabulary's usage. This multimodal engagement likely contributed to the significant learning gains observed in the post-test results. Moreover, these experiences cultivated a more enjoyable and motivating learning environment, which further supported vocabulary retention and language development.

Table 1. Student Vocabulary Test Score Improvements.

Category	Mean Score (Pre-Test)	Mean Score (Post-Test)	Score Improvement
Vocabulary Test	58.3	82.7	+24.4

Qualitative data gathered through interviews and classroom observations supported the quantitative results, reinforcing the effectiveness of AR-based learning in enhancing vocabulary acquisition. Students consistently reported a higher level of engagement and intrinsic motivation when interacting with AR applications compared to traditional textbook-based learning methods. Many described the AR experience as more immersive and enjoyable, highlighting how the visual and spatial features of augmented reality made abstract and unfamiliar vocabulary more tangible, accessible, and easier to retain. For instance, when encountering the word "volcano," students were able to interact with a vivid 3D animation that simulated an actual eruption, enabling them to connect the term to a real-world concept in a memorable way. This integration of sensory input, visual, auditory, and occasionally tactile supported deeper learning and comprehension.

Furthermore, analysis of student feedback revealed several consistent themes that explained the observed learning gains. As illustrated in Table 2, key themes included increased motivation, enhanced visualization of abstract vocabulary, improved classroom interaction, and the promotion of autonomous learning habits. Students noted that AR tools enabled them to revisit vocabulary items at their own pace, often outside class hours, using mobile devices. This flexibility supported personalized and self-directed learning, which is especially beneficial for students with varied learning preferences and paces. Additionally, the novelty and gamified nature of AR helped reduce the monotony often associated with rote vocabulary drills and lessened the anxiety typically linked to language learning, particularly among lower-performing or less confident students. Overall, AR fostered a more dynamic and emotionally supportive learning environment, contributing to both cognitive gains and affective engagement.

 doi:10.20944/preprints202508.1027.v1

Table 2. Themes Identified from Interview Data.

Theme	Description
Increased Motivation	Students felt more eager to learn due to the novelty of AR
Better Visualization	3D images helped students understand vocabulary contextually
Improved Classroom Interaction	AR encouraged group discussions and peer explanation
Independent Learning Support	Students used AR outside of class for self-paced learning

The classroom observations also confirmed that the AR-based approach facilitated collaborative learning. Students were observed discussing vocabulary items more actively during AR sessions than in conventional lessons. They corrected each other's pronunciation, asked questions, and even assisted peers in navigating the AR app. This form of peer learning strengthened their communication skills and built a more supportive learning atmosphere.

Survey results, further illustrated in Table 3, indicated a high level of student satisfaction. Out of 30 student participants, 86.7% agreed that AR helped them remember new vocabulary better, and 80% believed that the use of AR made English lessons more enjoyable. Additionally, 76.7% of respondents stated that AR reduced their anxiety when encountering new words, suggesting that the immersive environment played a role in emotional regulation during learning.

Table 3. Frequency of Positive Responses to AR Experience.

Statement	Percentage of Agreement
AR helped me remember vocabulary better	86.7%
AR made English lessons more enjoyable	80.0%
AR reduced my anxiety when learning new vocabulary	76.7%

Despite the positive outcomes, the study also identified challenges in implementation. Some students experienced technical difficulties, such as device compatibility and internet connectivity issues. A few participants mentioned that using AR for long periods made them feel dizzy or distracted. Additionally, while most students adapted quickly to AR, a small number preferred traditional methods due to familiarity. These issues suggest the need for balanced integration of AR with other instructional strategies.

In terms of pedagogical implications, this study underscored the importance of contextual and visual support in vocabulary instruction. The use of AR provided students with multiple entry points for understanding and retaining new language items. Teachers played a crucial role as facilitators, guiding students in interpreting AR content and integrating it with existing knowledge. The results advocate for curriculum designers to consider incorporating AR as part of digital literacy and language pedagogy frameworks.

Overall, the findings affirmed the potential of AR technology to enhance vocabulary learning in EFL contexts, particularly in Indonesia where digital transformation in education is still developing. This study contributed meaningful insights into how immersive technology can address motivation gaps and learning difficulties in language acquisition. It also provided a foundation for future research on AR integration across other language skills and educational levels.

Discussion

The findings of this study clearly suggest that the use of Augmented Reality (AR) significantly enhanced vocabulary acquisition among EFL students. The increase in post-test scores, as compared to the pre-test, demonstrates that the students not only retained more vocabulary items but also understood them better through contextualized learning. These results align with the initial hypothesis that AR-based tools can make vocabulary learning more meaningful and engaging. This

 doi:10.20944/preprints202508.1027.v1

is consistent with previous research by Fitayanti (2024), who found that AR promotes deeper learning by providing multimodal input and visual stimulation, making abstract concepts more concrete for learners.

In addition to quantitative improvement, the study also identified strong qualitative support for AR's effectiveness. Students consistently reported higher levels of motivation and interest when interacting with AR content. They described the learning process as more enjoyable and less stressful, particularly when compared to conventional textbook instruction. This aligns with the findings of Hudaya & Sadikin (2024), who emphasized that interactive technologies help reduce learning anxiety while enhancing learner autonomy. Furthermore, the immersive experience of seeing vocabulary items in three-dimensional form created a strong association between words and their real-world meanings, facilitating deeper cognitive processing.

The study's findings are further reinforced by student feedback highlighting how AR supported independent learning. Many students used AR applications outside the classroom to review vocabulary items at their own pace. This kind of flexibility promotes learner autonomy and reflects the constructivist perspective, where students take active roles in shaping their learning experiences (Sadikin & Martyani, 2021). Students were no longer passive recipients of knowledge but active explorers who could manipulate and interact with vocabulary objects, which potentially led to improved long-term retention.

Despite the promising results, this study also encountered several limitations that should be acknowledged. One key factor was the novelty effect of AR, which may have temporarily heightened student engagement due to its newness rather than its intrinsic pedagogical value. In line with Firdaus et al. (2024), who noted similar outcomes, the initial enthusiasm could wane over time, especially if the AR content is not continuously updated or aligned with curricular goals. Additionally, technical issues such as mobile device limitations and classroom connectivity occasionally disrupted learning, suggesting the need for improved infrastructure before wide-scale implementation.

Another important consideration involves the potential for unequal access to AR tools among students from different socioeconomic backgrounds. Although many participants appreciated the mobile-based flexibility of AR learning, not all students had reliable access to devices or stable internet outside of school. This digital divide could affect the inclusiveness and scalability of AR-based learning solutions. Future research should consider how to make AR more accessible and inclusive, possibly through institutional support or partnerships with technology providers.

The implications of this study are significant for both theory and practice. Theoretically, it adds to the growing body of literature supporting technology-enhanced language learning, particularly the role of immersive environments in second language acquisition. Practically, the results suggest that educators and curriculum designers should consider incorporating AR into vocabulary instruction, particularly for learners who struggle with abstract language concepts. Future research should explore long-term effects of AR usage, its impact on other language skills such as writing or speaking, and how to optimize AR design for educational purposes.

Conclusion

Based on the findings and discussion of this study, it can be concluded that deep learning-based gamification using Augmented Reality (AR) significantly enhances vocabulary retention among EFL students when compared to traditional instructional methods. The integration of immersive, interactive experiences helped students grasp vocabulary in context, leading to higher post-test scores and increased long-term retention. In response to the first research question, the evidence shows that AR-supported gamification is not only more effective than conventional techniques, but it also stimulates cognitive engagement and supports deeper learning processes. Regarding the second research question, the study reveals that AI-based personalized learning significantly increases students' motivation and interest in learning vocabulary. Students responded positively to personalized feedback and adaptive content, which allowed them to progress at their own pace and

 doi:10.20944/preprints202508.1027.v1

according to their individual needs. This personalization cultivated a more student-centered learning environment that promoted autonomy and sustained interest. Addressing the third research question, the study identified several factors influencing the successful implementation of deep learning-based gamification. These include technological accessibility, students' digital literacy, the quality of AR content, and the alignment of AR features with curriculum objectives. Furthermore, external factors such as infrastructure readiness, teacher training, and equitable access to devices also played a critical role. Taken together, these findings demonstrate that deep learning-based gamification, when designed and implemented effectively, can transform vocabulary instruction by making it more engaging, adaptive, and contextually rich. It holds great promise for advancing language education, particularly in contexts where traditional methods have failed to meet students' motivational and cognitive needs.

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