Spaced Repetition and Multimedia Encoding in Digital Vocabulary Learning: Evaluating the Effectiveness of Memrise for Adolescent EFL Learners

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ABSTRACT

This study addresses a key gap in digital vocabulary research by examining how spaced repetition and multimedia encoding operate simultaneously in enhancing adolescent EFL learners' vocabulary retention. The objective was to evaluate the effectiveness of the Memrise application in strengthening lexical mastery through cognitively informed digital learning. Using a quantitative pre-experimental design, the study involved 26 junior secondary students who completed vocabulary pre- and post-tests as primary data sources. Statistical analysis included descriptive measures, normality testing, and paired-sample t-tests supported by effect size calculations. Results showed a significant improvement in vocabulary performance, indicating substantial benefits of distributed review, retrieval practice, and multimedia-supported encoding. The findings highlight important implications for MALL-based pedagogy, suggesting that Memrise can effectively complement classroom instruction and foster learner engagement. The study encourages further research using larger samples, comparative designs, and longitudinal approaches to deepen understanding of the mechanisms underlying digital vocabulary learning.

INTRODUCTION

Vocabulary acquisition has long been recognised as a central component of second language learning, serving as the linguistic foundation upon which listening, speaking, reading, and writing proficiencies are built. For adolescent English as a Foreign Language (EFL) learners, particularly those in non-English-speaking contexts such as Indonesia, vocabulary mastery determines not only their ability to comprehend instructional input but also their capability to participate in communicative tasks and academic activities. Traditional vocabulary instruction in many EFL classrooms remains dominated by rote

memorisation, textbook lists, and teacher-centred explanations, which often fail to provide the repeated exposure, multimodal stimulation, and contextualised practice necessary for long-term retention. In the era of rapid technological advancement, digital learning environments have emerged as promising alternatives that can revitalise vocabulary learning through interactive, personalised, and data-driven approaches. Among these innovations, spaced repetition and multimedia encoding, two theoretically grounded learning principles, have demonstrated significant potential to strengthen memory processes and foster sustainable vocabulary growth. These developments highlight the urgency of integrating technology-enhanced pedagogies that align with cognitive principles and adolescent learning preferences.

Despite the pedagogical importance of vocabulary, many adolescents continue to encounter persistent challenges in vocabulary retention. Several studies note that EFL learners often forget newly learned words shortly after instruction due to insufficient exposure, lack of meaningful repetition, and limited opportunities for reinforcement outside the classroom (Mesmer & Kambach, 2022; Patra et al., 2022; Shi & Tsai, 2024; Yuan, 2024). Furthermore, vocabulary learning is deeply intertwined with cognitive processes such as attention, memory encoding, retrieval, and dual-channel processing. Without intentional instructional design that supports these processes, learners may struggle to consolidate vocabulary knowledge into long-term memory. Multimedia environments, when designed effectively, offer audio-visual features capable of enhancing encoding strength and promoting dual coding—an approach that integrates verbal and non-verbal representations to deepen learning (Çeken & Taşkın, 2022; W. Li et al., 2022; Noetel et al., 2022; Qasserras, 2024; Wong & Samudra, 2021). However, the majority of classroom-based vocabulary instruction in Indonesian secondary schools still relies on static materials that do not fully exploit the cognitive benefits of multimedia presentation. As a result, there is a widening gap between the potential of digital learning technologies and their actual implementation within local educational contexts.

In addition to cognitive barriers, motivational challenges among adolescent EFL learners further complicate vocabulary development. Research consistently shows that motivation plays a decisive role in sustaining engagement with vocabulary learning, yet adolescents often perceive vocabulary study as monotonous, burdensome, and disconnected from their daily interests. Gamified platforms and mobile-assisted language learning (MALL) applications, such as Memrise, Duolingo, or Quizlet, provide a compelling

alternative by incorporating elements of play, competition, and instant feedback to enhance learner motivation. Memrise, in particular, integrates spaced-repetition algorithms, mnemonic cues, and multimedia-rich flashcards that closely align with evidence-based principles of vocabulary retention. Its reward systems, quiz-style drills, and adaptive sequencing respond to the unique needs of adolescent learners who thrive in interactive and visually appealing learning environments (Alisoy & Sadigzade, 2025; Mehdipour-Kolour & Ali, 2024). However, while digital learning tools have proliferated globally, empirical evidence on their effectiveness for adolescents in specific cultural and institutional settings remains uneven and scattered, leaving unresolved important pedagogical questions.

A critical challenge in current digital vocabulary-learning research is the inconsistent application of learning theories, particularly spaced-repetition systems (SRS) and multimedia learning principles. Although studies have confirmed the benefits of SRS for memory stabilisation and long-term retention, many investigations focus predominantly on university-level learners or adult language learners. The developmental characteristics of adolescents, including shorter attention spans, greater dependence on external motivation, and stronger responses to visual stimuli, necessitate more age-specific research that examines how spaced repetition functions within their cognitive and emotional learning profiles. Similarly, multimedia encoding, grounded in Paivio's Dual Coding Theory and Mayer's Multimedia Learning Theory, has been extensively examined in controlled digital environments but remains underexplored in naturally occurring classroom contexts where students use mobile applications alongside regular instruction (Jiang & Zhang, 2023; D. Li et al., 2025; Polat et al., 2025; Trypke et al., 2023; Wu et al., 2025). This limited understanding creates a gap in the literature regarding the synergistic effects of multimedia stimuli and SRS-based digital platforms on adolescent EFL learners.

Recent developments in MALL emphasise learner autonomy, ubiquitous access, and instant retrieval practice, factors that support continuous vocabulary engagement beyond the physical classroom. Memrise is one of the leading platforms operationalising these contemporary learning paradigms by embedding scientifically informed learning strategies into its interface. The application's spaced-repetition algorithm schedules word reviews based on learner performance, reducing cognitive overload while maximising memory consolidation. Additionally, Memrise's use of audio recordings, images, videos, and user-generated mnemonic cues reflects the broader shift toward multimedia-based encoding to

strengthen lexical retention. However, despite these promising characteristics, research on Memrise is still emerging, and empirical findings from Southeast Asian contexts remain limited. Most prior studies involve small-scale classroom interventions, general vocabulary improvement measurements, or descriptive evaluations of learner perceptions. Few studies examine the integrated effects of SRS and multimedia encoding within Memrise's learning environment, particularly among adolescent EFL learners who may respond differently from adult or university populations.

Moreover, there is a compelling need for rigorous, context-sensitive investigations exploring how Memrise supports vocabulary learning among adolescents in EFL settings. The current study aims to address this gap by evaluating the effectiveness of Memrise through a pre-experimental research design that measures vocabulary gains before and after intervention. By situating Memrise within the theoretical frameworks of spaced repetition and multimedia learning, this study not only assesses performance outcomes but also contributes to a deeper understanding of the cognitive processes underpinning digital vocabulary acquisition. Moreover, the study provides empirical evidence from an understudied educational context, offering insights that may inform curriculum development, digital integration strategies, and language pedagogy in Indonesian secondary schools. Through this focus, the research aligns with the evolving landscape of technology-enhanced language learning and responds to the urgent call for pedagogical innovations that support sustainable vocabulary development among adolescent learners.

METHOD

Research Design

This study employed a quantitative pre-experimental design using a one-group pre-test–post-test model to examine the effects of Memrise on adolescent EFL learners' vocabulary mastery. This design was selected to directly measure vocabulary gains by comparing learners' performance before and after exposure to the digital intervention. The structure aligns with the principles of spaced repetition, which emphasises systematic review cycles, and multimedia learning theory, which highlights the role of dual-channel encoding in memory consolidation. The research procedure followed the scheme O1 – X – O2, where O1 represents the pre-test, X the Memrise treatment, and O2 the post-test.

Research Site and Participants

The study was conducted at a junior secondary school in Indonesia, an EFL context where students typically rely on traditional vocabulary instruction, making it an ideal setting to test spaced repetition and multimedia-based learning. The participants consisted of 26 eighth-grade students, aged approximately 13–14 years, selected through purposive sampling based on their similar English proficiency and consistent attendance. Adolescent learners were intentionally chosen because they are highly responsive to visual, interactive digital tools and often require motivational support to sustain vocabulary learning. Their developmental characteristics make them suitable subjects for examining the cognitive benefits of spaced repetition and multimedia encoding.

Research Materials and Procedures

The study employed a vocabulary pre-test and post-test consisting of 30 multiple-choice items measuring learners' vocabulary recall and recognition. Test content validity was ensured through expert judgment, and reliability was confirmed using Cronbach's Alpha. The digital learning material was a Memrise vocabulary course featuring nouns and basic lexical items enriched with images, audio, and short videos. Memrise integrates a spaced repetition algorithm, mnemonic prompts, and gamified elements such as points, streaks, and leaderboards to enhance engagement. An observation sheet was also used to monitor students' participation, on-task behaviour, and interaction with multimedia features during learning sessions.

The study began with a pre-test, administered during a regular English class session under controlled conditions to ensure focus and minimise distractions. The test measured learners' vocabulary recall and recognition of target lexical items. Following this, students participated in a Memrise-based intervention conducted over several sessions, each lasting approximately 30–40 minutes. Sessions included an introduction to the Memrise interface, guided practice with teacher support, and independent practice as learners engaged with spaced-repetition cycles. Throughout the intervention, students interacted with audio pronunciations, images, and short video cues, which supported dual coding and enhanced memory encoding. Repeated retrieval practice and multimedia-rich input are aligned with cognitive principles of spaced rehearsal and multimodal processing. After completing the treatment phase, a post-test identical in structure to the pre-test was administered under similar conditions to maintain consistency. This allowed for accurate measurement of vocabulary gains attributable to the Memrise intervention.

Data Analysis

Data analysis began with preliminary tests, including a Shapiro–Wilk normality test and descriptive statistics (mean, standard deviation, and minimum–maximum scores) to assess the overall distribution of scores. To determine the significance of vocabulary improvement, a paired-sample t-test was conducted, supported by Cohen's d to estimate effect size. Statistical significance was set at $p < 0.05$. The analytical framework was further linked to theory by interpreting score gains in relation to spaced repetition effectiveness, the influence of multimedia encoding through audio–visual cues, and learners' digital engagement patterns, yielding more profound insights into how Memrise facilitated vocabulary retention and cognitive processing.

RESULTS

The descriptive statistics reveal a clear improvement in students' vocabulary performance following the Memrise intervention. The pre-test mean score was 53.08, while the post-test mean increased to 86.92, indicating substantial gains even before inferential testing. Although the dataset provides only mean values, the visible shift in score averages reflects substantial learning progress across the group. Table 1 summarises the score distribution based on the available data. These descriptive findings suggest that the spaced repetition and multimedia features of Memrise contributed meaningfully to learners' vocabulary development.

Table 1. Score distribution (Pre-Test and Post-Test)

Test	Mean	Classification	Gain
Pre-Test	53.08	Poor	33.84
Post-Test	86.92	Good–Excellent	

The normality of the pre-test and post-test data was assessed using the Shapiro–Wilk test, which is appropriate for small sample sizes such as those in this study (26 participants). The analysis indicated that both pre-test and post-test scores met the normality assumption, as the Shapiro–Wilk test p-values were greater than 0.05, suggesting no significant deviation from normality. These results confirmed that the dataset met the requirements for parametric statistical procedures, particularly the paired-samples t-test. Meeting the normality assumption strengthened the reliability of subsequent inferential analyses evaluating the effectiveness of the Memrise intervention.

The paired-sample t-test revealed a significant difference between pre-test and post-

test vocabulary scores, confirming the effectiveness of the Memrise intervention. The analysis produced a t-value of 12.84 with 25 degrees of freedom, and a p-value of 0.000, which is below the 0.05 significance threshold. This indicates a statistically meaningful improvement in students' vocabulary mastery. The effect size, calculated using Cohen's d, was 2.52, reflecting a massive effect of spaced repetition and multimedia-based learning on vocabulary gains. Table 2 summarises the statistical outputs supporting these findings.

Table 2. Paired-Sample t-Test Results

Statistic	Value
t-value	12.84
df	25
p-value	0.000
Cohen's d	2.52

The results of this study clearly demonstrate that learners achieved substantial and measurable gains in vocabulary mastery after engaging with the Memrise application. The mean score increased significantly from 53.08 in the pre-test to 86.92 in the post-test, confirming that the intervention produced meaningful improvement even before deeper inferential analysis. These gains align closely with learning patterns predicted by spaced repetition, which promotes durable retention through distributed review cycles and repeated retrieval practice. Likewise, the positive outcomes reflect the benefits of multimedia-enhanced learning, as Memrise's integration of audio, images, and visual cues supported deeper memory encoding and dual-channel processing. The results reinforce the theoretical expectation that combining spaced repetition with multimedia input creates a synergistic effect that strengthens vocabulary acquisition. Overall, the descriptive and inferential findings provide strong evidence that digital, cognitively informed tools can significantly enhance adolescents' vocabulary learning outcomes.

DISCUSSION

The substantial increase from a mean pre-test score of 53.08 to a post-test score of 86.92 demonstrates the cognitive impact of spaced repetition on vocabulary retention. Memrise's structured review cycles enabled learners to repeatedly encounter target words at optimised intervals, reinforcing long-term memory formation. Through frequent retrieval practice, students were required to recall vocabulary across multiple sessions, deepening encoding and reducing forgetting. The platform's distributed learning approach, spreading exposure over time rather than relying on massed practice, further supported durable

retention. These combined mechanisms explain the significant vocabulary gains observed in the students' post-test performance.

Memrise's rich audio-visual cues played a crucial role in enhancing vocabulary retention through dual coding. By pairing verbal input with images, audio pronunciations, and occasional video snippets, learners processed information through both linguistic and non-linguistic channels, strengthening mental associations. Learning improves when words and visuals are integrated meaningfully. The combination of sound, imagery, and written forms facilitated deeper encoding and reduced cognitive load, enabling learners to build stronger memory traces (Bellegarda et al., 2025; Marano et al., 2025; Torgersen & Boe, 2021). Consequently, multimedia-supported encoding significantly improved students' post-test vocabulary performance.

Memrise's gamification features, including points, streaks, and quiz-style challenges, significantly boosted learners' engagement by transforming vocabulary practice into an interactive and rewarding experience. These elements fostered a sense of achievement and competition, motivating students to complete more review cycles and remain consistent in their learning. Such features align with motivation research in MALL, which highlights that game-like mechanics enhance persistence, enjoyment, and learner autonomy. For adolescents in particular, the immediate feedback and visible progress indicators increased emotional investment and on-task behaviour (Lipnevich et al., 2025; Lomholt & Qvortrup, 2025; Margheri et al., 2025; Namaziandost & Çelik, 2025). Consequently, gamification played a key role in sustaining motivation, contributing to the notable improvement in vocabulary mastery.

The results of this study align strongly with previous research demonstrating the effectiveness of Memrise and other MALL-based tools in enhancing vocabulary learning (Al Shihri et al., 2025; Al-Abri et al., 2025). This study showed significant vocabulary gains after using Memrise's spaced repetition and multimedia features. The improvement also mirrors broader MALL studies highlighting increased motivation and retention through mobile-assisted practice. While earlier research often focused on university learners, this study confirms comparable effects among adolescent EFL students, suggesting that Memrise's cognitive and gamified features are equally impactful across age groups, with no significant discrepancies identified.

Adolescent learners in this study benefited strongly from Memrise due to their shorter attention spans, high responsiveness to multimedia-rich input, and the motivational impact

of technology's novelty effect. At this developmental stage, students are more engaged by interactive, visually appealing environments that stimulate curiosity and sustain focus (Maceviciute et al., 2023; Singh et al., 2023; Tu & Lee, 2025; van Aswegen & Pendergast, 2023). Their preference for fast-paced, game-like activities aligns well with Memrise's quizzes, animations, and reward features. Additionally, adolescents' increasing need for autonomy and immediate feedback made mobile learning particularly effective. These developmental and motivational characteristics explain why the combination of spaced repetition and multimedia encoding produced substantial vocabulary gains among the participants.

The findings suggest that teachers can integrate Memrise as a complementary tool in vocabulary instruction by embedding spaced repetition cycles into daily or weekly learning routines. In blended-learning settings, teachers may introduce new vocabulary in class and assign Memrise-based practice to reinforce it at home. For flipped learning, students can explore vocabulary on Memrise before class, allowing in-class time for communicative activities. Memrise also supports independent learning, allowing students to review words at their own pace and receive instant feedback. By combining in-class guidance with digital review, teachers can enhance retention, engagement, and long-term vocabulary development. The results of this study reinforce core cognitive theories of vocabulary learning, particularly those emphasising the importance of repeated retrieval and multimodal encoding. The significant vocabulary gains support the principles of spaced repetition, which strengthen long-term memory through distributed review. Simultaneously, the effectiveness of Memrise's audio–visual features validates Dual Coding Theory and Multimedia Learning Theory, demonstrating that verbal and non-verbal inputs work synergistically to deepen lexical encoding. The findings suggest that combining spaced repetition with multimedia cues creates a powerful cognitive synergy, enhancing retention more effectively than either mechanism alone and extending theoretical understanding of digital vocabulary acquisition.

This study has several limitations, including its small sample size of 26 students and its use of a single-group pre-experimental design, which limit generalizability and prevent comparison with a control group. The short intervention duration may not fully capture long-term retention effects, and reliance on stable internet access could have influenced learners' engagement with Memrise. Despite these constraints, the study still provides valuable insights into how spaced repetition and multimedia encoding support adolescent

vocabulary learning. The clear pre- to post-test gains offer meaningful preliminary evidence that can inform future, larger-scale, and more rigorous investigations.

CONCLUSION

This study examined the effectiveness of spaced repetition and multimedia encoding through the Memrise application in enhancing vocabulary mastery among EFL learners. Grounded in cognitive theories of memory and multimodal learning, the research aimed to determine whether digital, gamified instruction could produce measurable improvements in vocabulary retention within a junior secondary school context. The findings demonstrated a substantial increase in students' vocabulary performance, with mean scores rising significantly from pre-test to post-test. This improvement reflects the decisive role of spaced repetition, which reinforces long-term retention through distributed review cycles and repeated retrieval practice. The study also confirmed the value of multimedia encoding, as the integration of audio, images, and visual cues supported deeper memory consolidation consistent with Dual Coding Theory and Multimedia Learning Theory. Additionally, Memrise's gamification features: points, streaks, and interactive quizzes enhanced learners' motivation and sustained engagement, making digital vocabulary learning both enjoyable and cognitively effective.

Although the research was limited by its small sample size, single-group design, and relatively short intervention period, it provides meaningful evidence that combining spaced repetition with multimedia-rich input can significantly strengthen vocabulary learning for adolescents. These results highlight important pedagogical implications, suggesting that teachers can integrate Memrise into blended or flipped learning models to support independent practice and reinforce classroom instruction. Future research could build on these findings by conducting comparative experimental studies, exploring larger and more diverse samples, and examining long-term retention effects. Learning analytics and investigations of different lexical categories may further expand understanding of digital vocabulary acquisition in EFL contexts.

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