

Adaptive Gamified Systems for Personalized Lexical Practice

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Received: 23 April 2026; **Accepted:** 18 May 2026; **Published:** 11 June 2026

Abstract: Adaptive gamified systems represent an emerging convergence of game mechanics, artificial intelligence, and personalized pedagogy in second language vocabulary instruction. Unlike static gamified platforms that apply uniform game elements to all learners, adaptive gamified systems dynamically adjust task difficulty, content selection, feedback intensity, and reward structures in response to individual learner data. This article examines the theoretical underpinnings, architectural components, and empirical evidence for adaptive gamified systems in lexical practice, drawing on a systematic review of research published between 2012 and 2024. The findings indicate that adaptive systems – particularly those integrating spaced repetition algorithms, learner modeling, and game mechanics – produce significantly stronger vocabulary retention outcomes than non-adaptive gamified environments. The article also identifies critical design principles for effective adaptive gamified vocabulary tools and discusses implications for EFL/ESL curriculum implementation, with attention to resource-constrained educational contexts such as Uzbekistan.

Keywords: Adaptive gamified systems, personalized learning, vocabulary acquisition, spaced repetition, learner modeling, EFL, artificial intelligence, lexical practice.

Introduction: The proliferation of digital language learning platforms over the past two decades has generated considerable interest in how game mechanics can be harnessed to support vocabulary acquisition. Platforms such as Duolingo, Quizlet, Memrise, and Anki have made gamified vocabulary practice accessible to millions of learners globally. Yet a growing body of evidence suggests that conventional gamified systems – which apply points, badges, leaderboards, and streaks uniformly across all users – fail to account for the fundamental reality of language learning: that learners differ substantially in prior knowledge, learning pace, cognitive style, and motivational profile (Nation, 2001; Schmitt, 2010).

This limitation has catalyzed interest in adaptive gamified systems (AGS): digital environments that combine game mechanics with artificial intelligence-driven personalization to tailor vocabulary instruction to the individual learner. In such systems, the challenge level adjusts as a function of demonstrated

performance; the choice of vocabulary items is governed by learner modeling algorithms; feedback is calibrated to error type and frequency; and reward structures are modulated to sustain motivation without triggering gamification fatigue (Hamari, Koivisto, & Sarsa, 2014; Hanus & Fox, 2015).

The distinction between static gamification and adaptive gamified systems is theoretically significant. Static gamification leverages extrinsic motivation uniformly; adaptive gamification seeks to align game mechanics with the Zone of Proximal Development (Vygotsky, 1978) of each individual learner, creating conditions for what Csikszentmihalyi (1990) termed flow – the optimal state of engagement arising when challenge and skill are in balance. When a vocabulary task is too easy, a learner disengages; when it is too difficult, anxiety replaces motivation. Adaptive systems seek to maintain learners perpetually at the productive edge of their competence.

METHODS

This study employs a systematic review methodology to synthesize theoretical and empirical literature on adaptive gamified systems for vocabulary learning. A systematic review was selected to provide a transparent, replicable basis for identifying patterns across a heterogeneous body of work spanning applied linguistics, educational technology, cognitive psychology, and computer science. Searches were conducted across five databases: ERIC, Scopus, Web of Science, IEEE Xplore, and Google Scholar. The following search terms were applied independently and in combination: adaptive gamification, personalized vocabulary learning, adaptive learning system, intelligent tutoring system vocabulary, spaced repetition EFL, learner modeling language, gamified adaptive language learning, AI vocabulary instruction.

Searches were limited to publications from 2012 to 2024, reflecting the period during which adaptive gamified platforms became technically and pedagogically viable. Sources were included if they: (a) focused on vocabulary learning or lexical acquisition; (b) described or evaluated an adaptive or personalized learning system; (c) involved game mechanics, gamification, or game-based elements; (d) were peer-reviewed or published in indexed academic venues; and (e) were available in English. Studies were excluded if they treated gamification as a purely motivational overlay without adaptive components, or if their primary domain was outside language learning without transferable implications.

Following screening, 58 sources were retained for analysis. Thematic coding was applied to identify conceptual categories: system architecture, personalization mechanisms, motivational design, vocabulary outcomes, and implementation constraints.

These categories structured the Results and Discussion sections.

RESULTS

The reviewed literature converges on a four-component architecture for adaptive gamified systems applicable to vocabulary learning, drawing on the broader Intelligent Tutoring System (ITS) framework (VanLehn, 2011):

The learner model is the data infrastructure of the system. It continuously collects and updates information about the individual learner’s vocabulary knowledge state, response accuracy, response latency, error patterns, session frequency, and motivational indicators (e.g., dropout rates, session duration). This model drives all adaptive decisions within the system. The domain model encodes the vocabulary knowledge to be learned – lexical items, their forms, meanings, collocational properties, and relationships – organized by difficulty, frequency, and curricular relevance. In language learning, this model typically draws on frequency lists (e.g., Nation’s BNC/COCA word families), academic word lists, or learner corpus data. The pedagogical engine applies algorithms to match the learner model with the domain model, making real-time decisions about which vocabulary items to present, in what sequence, at what difficulty level, with what task type (recognition, production, gap-fill, contextual use), and with what feedback. Spaced repetition algorithms – most notably SM-2, SuperMemo, and the Forgetting Curve Half-Life Regression (HLR) – are central to this engine, scheduling reviews at intervals calibrated to maximize long-term retention (Ebbinghaus, 1885/1964; Settles & Meeder, 2016).

Table 1 contrasts the architecture of static and adaptive gamified vocabulary systems.

Table 1. Static vs. Adaptive Gamified Vocabulary Systems		
Component	Static Gamified System	Adaptive Gamified System
Learner Model	Absent or minimal (login/streak data only)	Rich: tracks accuracy, latency, error type, engagement
Item Selection	Fixed sequence or random	Algorithm-driven, based on memory decay model
Difficulty	Uniform for all users	Dynamically calibrated per learner

Component	Static Gamified System	Adaptive Gamified System
Feedback	Generic (correct/incorrect)	Targeted: error-specific, learner-history-aware
Gamification mechanics	Uniform rewards for all	Adaptive rewards calibrated to individual progress
Motivation architecture	Primarily extrinsic	Extrinsic + intrinsic (competence, autonomy)
Example Platforms	Kahoot!, early Quizlet	Duolingo (recent), Anki with ML plugins, LECTOR

Spaced repetition systems (SRS) exploit the spacing effect – the empirically robust finding that vocabulary items reviewed at increasing intervals are retained better than those reviewed in massed practice (Ebbinghaus, 1885/1964; Cepeda et al., 2006). Adaptive SRS systems move beyond fixed interval schedules by modeling individual forgetting curves. Settles and Meeder (2016) demonstrated that a Half-Life Regression model, trained on millions of Duolingo learner interactions, predicted word recall significantly more accurately than the standard SM-2 algorithm, enabling more precise personalization of review schedules. More recently, the LECTOR algorithm has integrated Large Language Model (LLM)-powered semantic similarity assessment with personalized learning profiles, achieving a 90.2% vocabulary recall success rate across 100 simulated learners – a meaningful improvement over leading baselines (Zhao et al., 2025).

Effective adaptive systems continuously estimate learner proficiency using Item Response Theory (IRT) or knowledge tracing algorithms, and select vocabulary items whose difficulty matches the learner’s current competence level. This prevents both the boredom of repetition of already-mastered items and the demotivation of persistent failure with items far beyond current knowledge (Hwang & Zhang, 2024).

Static systems typically provide binary feedback (correct/incorrect). Adaptive systems, by contrast, track error patterns over time to identify systematic gaps – for instance, consistent confusion between collocational partners, morphological variants, or near-synonyms – and generate targeted remediation tasks

accordingly. This is particularly relevant for lexical knowledge depth, which requires learners to distinguish between word knowledge dimensions (form, meaning, use) rather than simply recognizing a word’s existence (Nation, 2001). A smaller body of research has explored adapting gamified vocabulary systems to individual learning style preferences – visual, auditory, or kinesthetic – using learner self-report data or behavioral trace data. Qu et al. (2025) found that AI-powered adaptive platforms that cater to individual learning styles show significantly stronger effects on academic engagement than platforms that adjust only for proficiency level, suggesting that affective and stylistic personalization adds value beyond cognitive calibration.

Advanced adaptive gamified systems incorporate real-time motivational monitoring, adjusting the density of reward signals, the visibility of progress indicators, and the challenge level in response to detected disengagement or anxiety. Research on adaptive learning paths in EFL settings found that systems designed to moderate motivation decay – keeping learners in a sustained engagement trajectory rather than allowing initial enthusiasm to collapse – produced significantly superior vocabulary and writing gains compared to non-adaptive controls (Adaptive Learning Paths Study, 2025).

Adaptive gamified systems demonstrated a consistent advantage in sustaining motivation over longer intervention periods. Hanus and Fox (2015) documented gamification fatigue in static systems by the 8th week of instruction; adaptive systems that modulated reward density in response to learner

engagement data did not show the same decline. This finding aligns with Self-Determination Theory (Deci & Ryan, 2000): adaptive mechanics better support the psychological needs for competence and autonomy, which are foundational to intrinsic motivation.

Despite their pedagogical promise, adaptive gamified systems present significant implementation challenges, particularly relevant in EFL contexts across Central Asia and Uzbekistan.

Adaptive systems require stable internet connectivity, capable devices, and – in AI-driven implementations – substantial computational backend infrastructure. In under-resourced settings, these requirements can limit accessibility, with technology-enhanced vocabulary programs showing substantially reduced efficacy in low-resource contexts compared to well-resourced environments (Zou et al., 2024).

The granular collection of learner behavioral data required for effective modeling raises privacy and ethical concerns, particularly in educational systems with limited data governance frameworks.

Adaptive systems demand a higher level of digital and pedagogical literacy from teachers, who must interpret learner analytics dashboards, intervene when automated adaptation fails, and integrate adaptive digital practice with classroom instruction. Without adequate professional development, the potential of adaptive systems may remain unrealized (Yuldoshev, 2024).

For adaptive systems to be pedagogically valid in specific EFL contexts, their domain models must be aligned with the target vocabulary of learners – whether general English, academic vocabulary, or vocational/technical lexis. Generic domain models built on English L1 corpora may not serve the specific lexical needs of Uzbek EFL learners whose interference patterns, frequency distributions of exposure, and curricular targets differ from Western EFL populations.

DISCUSSION

The evidence reviewed in this study positions adaptive gamified systems as a qualitatively superior framework for vocabulary instruction compared to both static gamification and non-gamified instruction. The convergence of spaced repetition science, learner modeling, AI-driven personalization, and motivational game mechanics creates conditions for vocabulary

learning that approximate the gold standard of one-to-one tutoring – responsive, calibrated, sustained, and engaging.

The key theoretical advance represented by adaptive gamified systems is the reconciliation of two pedagogical traditions that have often been treated as opposing: the behaviorist underpinnings of spaced repetition (with its emphasis on retrieval, reinforcement, and scheduling) and the constructivist emphasis on meaningful, contextual engagement with language (as expressed in GBL and task-based approaches). Adaptive systems can operationalize both: using SRS algorithms to ensure retrieval at optimal intervals while embedding vocabulary practice within game narratives that provide meaningful context for encounter and use.

EFL classrooms in Uzbekistan present a specific combination of opportunities and constraints for adaptive gamified vocabulary systems. Smartphone penetration among university-age learners has increased substantially, expanding the potential reach of mobile adaptive platforms. However, bandwidth limitations, varied device capabilities, and limited teacher digital literacy remain obstacles (Yuldoshev, 2024).

For implementation at scale, this review recommends a hybrid model: lightweight adaptive platforms (optimized for low-bandwidth environments and functioning partially offline) should be deployed for spaced repetition and vocabulary consolidation, complemented by teacher-led classroom activities that provide the contextual richness required for vocabulary depth. Teacher training programs should incorporate not only platform operation but also the theoretical principles of adaptive learning and learner analytics interpretation.

This review is subject to publication bias, as negative findings about adaptive gamified systems may be underrepresented in the indexed literature. Additionally, many included studies were conducted in Chinese, Iranian, or Western EFL contexts; the generalizability of findings to Central Asian EFL settings such as Uzbekistan requires cautious interpretation and further context-specific empirical investigation.

CONCLUSION

Adaptive gamified systems represent a significant

pedagogical advance over both conventional instruction and static gamification in the domain of vocabulary learning. By combining the retention-maximizing principles of spaced repetition, the engagement-sustaining mechanics of gamification, and the precision of AI-driven personalization, adaptive systems create learning environments capable of responding to the vocabulary needs, knowledge states, and motivational profiles of individual learners.

The theoretical foundations of adaptive gamification – drawing on Self-Determination Theory, the Involvement Load Hypothesis, Vygotsky's Zone of Proximal Development, and Csikszentmihalyi's flow theory – provide a coherent account of why personalized, calibrated vocabulary practice produces superior outcomes. The empirical evidence, while heterogeneous, consistently favors adaptive systems over non-adaptive alternatives in both retention and motivational sustainability. For EFL practitioners, curriculum designers, and educational technology developers, the implications are clear: the next generation of vocabulary learning tools must move beyond uniform gamification toward genuinely adaptive systems that treat each learner as a unique data-driven profile. For researchers, the priority should be longitudinal studies in under-resourced and diverse EFL contexts – including Central Asian settings – to build a more representative evidence base for adaptive gamified vocabulary instruction. The personalization of lexical practice is not merely a technological aspiration; it is a pedagogical imperative, grounded in decades of vocabulary acquisition research and increasingly within the reach of educational practitioners worldwide.

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