Journal of English Language Teaching and Applied Linguistics
ISSN: 2707-756X
DOI: 10.32996/jeltal
Journal Homepage: www.al-kindipublisher.com/index.php/jeltal

JELTAL
AL-KINDI CENTER FOR RESEARCH AND DEVELOPMENT

| RESEARCH ARTICLE

AI-Supported Vocabulary Learning in Saudi EFL Higher Education: A Bloom's Taxonomy–Based Application

Jehan A. Alherabi[1] and Saad Aljebreen[2]
[12]*Department of English Language and Literature, College of Languages and Humanities, Qassim University, Saudi Arabia*
Corresponding Author: Jehan A. Alherabi **E-mail**: 431213839@qu.edu.sa

| ABSTRACT

This study investigates the effectiveness of an AI-based vocabulary learning app, designed by the research supervisor and grounded in Bloom's Taxonomy, in enhancing English as a Foreign Language (EFL) vocabulary acquisition among Saudi university students. Vocabulary development remains a major challenge for EFL learners, and adaptive, personalized technologies may help address individual learning needs. A quasi-experimental design is employed, comparing an experimental group using the AI-based app with a control group receiving traditional instruction. Vocabulary proficiency is measured through pretests and posttests to evaluate the impact of the intervention and identify differences between the two groups. The AI app applies a scaffolded approach aligned with Bloom's cognitive levels, progressing from basic recall to higher order thinking skills to support comprehensive vocabulary mastery. Data collection includes quantitative test scores and a feedback survey to capture students' perceptions of usability and effectiveness. Statistical analyses assess differences in vocabulary gains, while thematic analysis examines learners' experiences. The study aims to contribute to EFL pedagogy by demonstrating the role of AI-driven tools in supporting vocabulary acquisition, learner engagement, and personalized learning.

| KEYWORDS

Vocabulary learning, EFL, Artificial Intelligence, Bloom's Taxonomy, Saudi students

| ARTICLE INFORMATION

ACCEPTED: 15 December 2025 **PUBLISHED:** 29 December 2025 **DOI:** 10.32996/jeltal.2025.7.8.9

1. Introduction

Learning English as a Foreign Language (EFL) poses considerable challenges, as learners are often required to achieve multiple language goals within limited timeframes. Effective language development, however, depends on progress across interconnected skills rather than isolated components, with vocabulary knowledge playing a central role (Senjahari et al., 2021). Advances in internet-based resources have made vocabulary learning more accessible and engaging, enhancing learner motivation and outcomes (Lai & Wang, 2025). Vocabulary acquisition extends beyond memorizing word lists to include multiple layers of lexical knowledge. Lexical knowledge has been conceptualized as a continuum ranging from basic word familiarity to accurate and spontaneous use in communication (Laufer & Goldstein, 2004), encompassing vocabulary items, lexemes, and their contextualized use (Caro & Mendinueta, 2017).

Contemporary research characterizes vocabulary knowledge as a multidimensional construct involving how words are understood, organized, and used meaningfully across contexts (Schmitt, 2014; Nation, 2013). Models of lexical competence distinguish between receptive and productive dimensions and emphasize the importance of both vocabulary size and depth, referring respectively to the number of words known and the quality of word knowledge (Laufer & Goldstein, 2004; Yilmaz &

Kavanoz, 2025). Empirical studies indicate that deeper lexical knowledge develops through semantic relationships, contextualized use, and repeated meaningful exposure rather than rote memorization, leading to more efficient language processing and higher proficiency, particularly in academic contexts (Nation, 2013; Schmitt, 2014). Multimedia and interactive digital tasks further support vocabulary retention and motivation by reinforcing meaning through visual and contextual cues (Li, 2022). Within this technological landscape, artificial intelligence (AI) has emerged as a promising tool for supporting EFL vocabulary learning. AI-based systems are designed to simulate aspects of human cognition and provide adaptive, personalized learning experiences by tailoring instruction and feedback to learners' proficiency levels and learning behaviors (Polyzi & Moussiades, 2023). Such systems can function as personalized tutors, reflecting aspects of teacher guidance and adaptive support (Sangkala & Mardonovna, 2024; Li & Hafner, 2022). While global research increasingly highlights the potential of AI to promote personalized vocabulary learning (Huang et al., 2023), studies in the Saudi EFL context have largely focused on mobile applications and game-based learning. Only a limited number of recent investigations have examined AI-based approaches, highlighting the need for further context-specific empirical research (Alqaed, 2024; Aldowsari & Aljebreen, 2024; Alyami et al., 2025).

2. Statement of the Problem

Traditional language teaching methods often prioritize memorization and exam preparation, limiting learners' critical engagement with language and their ability to apply knowledge in authentic contexts. Although such approaches may support short-term recall, they do not foster higher-order cognitive skills and frequently overlook individual learner differences, particularly in mixed-proficiency classrooms. To address these limitations, technology-enhanced approaches have increasingly been adopted to support vocabulary learning and learner engagement. Digital tools offer interactive and contextualized opportunities for lexical development, and research in the Saudi EFL context indicates that technology integration enhances learner motivation, retention, and autonomy through continuous practice and immediate feedback (Al-Jarf, 2021). As educational technologies advance, artificial intelligence (AI) has emerged as a transformative tool by enabling data-driven personalization and real-time feedback. When pedagogically integrated, AI-supported vocabulary applications provide adaptive learning experiences that enhance retention and sustained engagement, supporting more effective, inclusive, and personalized EFL vocabulary instruction (Huang et al., 2023; Loewen et al., 2019; Polyzi & Moussiades, 2023; Xiao & Wu, 2024; Zawacki-Richter et al., 2019).

3. Research Questions

1. How does the use of an AI-based vocabulary learning application inspired by Bloom's Taxonomy affect Saudi university students' EFL vocabulary acquisition?
2. What are Saudi university students' perceptions of the effectiveness of using an AI-based vocabulary learning application inspired by Bloom's Taxonomy?

4. Methodology

4.1 Research Design

This study employed a quasi-experimental pretest–posttest control group design to examine the effect of an AI-based vocabulary learning application grounded in Bloom's Taxonomy on Saudi EFL students' vocabulary acquisition. Random assignment was not possible due to the use of intact class sections. The design compared an experimental group using the AI-based application with a control group receiving traditional vocabulary instruction.

4.2 Participants

The participants were 26 undergraduate female EFL students enrolled in *Reading and Vocabulary Building I* at Qassim University. Two intact classes were assigned to the experimental group (n = 13) and the control group (n = 13) using convenience sampling. The experimental group used an AI-based vocabulary application designed for this study and aligned with Bloom's Taxonomy, while the control group received traditional instruction through lectures, textbook-based activities, and vocabulary drills. All participants completed a university placement test confirming intermediate proficiency and a vocabulary pretest to establish baseline equivalence. Ethical procedures were followed, and informed consent was obtained from all participants.

4.3 Data Collection

Data were collected in three stages following ethical approval. First, a researcher-developed 40-item multiple-choice vocabulary pretest aligned with Bloom's Taxonomy was administered to both groups. During the intervention, the experimental group used the AI-based application, while the control group received traditional instruction. After the intervention, an equivalent posttest

was administered to measure vocabulary gains. The experimental group also completed a feedback questionnaire to gather quantitative and qualitative data on the app's effectiveness and usability. All data were anonymized and securely stored.

4.4 Data Analysis

Data were analyzed using Microsoft Excel 365 and IBM SPSS Statistics 26. Responses collected via Google Forms were exported in CSV format, cleaned in Excel by checking completeness, coding variables, and removing invalid entries, and then imported into SPSS for statistical analysis. Descriptive statistics were calculated to summarize pretest and posttest scores, Bloom's Taxonomy subscale performance, and participants' perceptions of the app. Internal consistency reliability for the tests and survey was examined using Cronbach's alpha. Intervention effectiveness was evaluated using a paired-samples t test, with normality assumptions checked and effect size calculated using Cohen's d. Qualitative responses from the open-ended survey item were analyzed thematically through coding and theme development, with Excel used for organization and frequency tracking. Quantitative and qualitative findings were integrated to triangulate results and provide a comprehensive understanding of learners' vocabulary gains and experiences with the AI-based application.

5. Test Validity

The content of the test was developed by the researcher and reviewed by content experts to ensure validity. It included 40 multiple-choice items aligned with Bloom's Taxonomy levels, assessing a range of cognitive skills from simple recall to application and analysis.

6. Test Reliability

Table 3.1 presents the internal consistency reliability of the vocabulary tests. The pre-test (40 items) yielded a Cronbach's α of .937, and the post-test (40 items) yielded a Cronbach's α of .955. Both values exceed the recommended threshold of .70 (Nunnally & Bernstein, 1994), indicating excellent internal consistency. The slightly higher reliability coefficient for the post-test suggests improved item consistency following the intervention.
Table 3.2 reports the internal consistency reliability of the feedback survey scales. All five scales demonstrated acceptable to excellent reliability, with Cronbach's alpha values ranging from .765 to .936. The Usability (α = .883), Engagement and Motivation (α = .910), and Perceived Effectiveness (α = .936) scales showed excellent reliability, while the Clarity of Instructions scale demonstrated good reliability (α = .845). The Overall Satisfaction scale also met acceptable reliability standards (α = .765), exceeding the conventional criterion of .70 (George & Mallery, 2019).

Table 3.1 *Cronbach alpha reliability of the pre-test and post-test*

Tests	Items	Cronbach alpha
Pre-test	40	.937
Post-test	40	.955

Table 3.2 *Cronbach alpha reliability of the feedback survey*

Scale	Number of Items	Cronbach's α
Usability	8	0.883
Clarity of Instructions	8	0.845
Engagement & Motivation	8	0.91
Perceived Effectiveness	10	0.936
Overall Satisfaction	6	0.765

7. Literature Review

7.1 English as a Foreign Language Vocabulary Learning

Vocabulary refers to the set of words and expressions that convey meaning in a language (Noor & Ameer, 2009). In EFL contexts, vocabulary learning involves acquiring both the breadth and depth of lexical knowledge, enabling learners to recognize, understand, and appropriately use words across language skills (Teng, 2022). Vocabulary knowledge is widely recognized as the foundation of communicative competence, as learners require sufficient lexical resources to comprehend input and express ideas effectively. Contemporary research conceptualizes vocabulary knowledge as multidimensional, consisting of vocabulary size, or the number of words known, and depth, which reflects how well words are understood, including their meanings, associations,

and contextual use (Qian, 2002; Schmitt, 2014; Zhang & Lu, 2015). This distinction explains why learners may recognize many words receptively yet struggle to use them productively in speaking or writing (Yilmaz & Kavanoz, 2025).

7.2 Importance of Vocabulary in EFL Learning

Vocabulary acquisition plays a critical role in EFL learning and directly influences learners' performance across reading, writing, listening, and speaking skills (Macis & Schmitt, 2017). In EFL contexts such as Saudi Arabia, where exposure to English outside the classroom is limited, vocabulary knowledge becomes even more crucial (Alshammari, 2020; Almusharraf, 2021). Nation (2001) emphasizes the reciprocal relationship between vocabulary knowledge and language use, as vocabulary supports communication while communicative practice further expands lexical knowledge. Empirical studies consistently demonstrate that learners with broader and deeper vocabularies achieve higher levels of comprehension and language proficiency across skills (Han, 2024; Mahmood, 2022; Tong et al., 2023). These findings confirm that vocabulary is not an isolated component of language learning but a central resource underpinning overall EFL proficiency.

7.3 Challenges of EFL Vocabulary Learning

Despite its importance, vocabulary acquisition presents persistent challenges for EFL learners. At lower levels, learners often struggle with spelling, pronunciation, and word form, leading to inaccurate usage and limited retention (Ali et al., 2023; Lutfiyah et al., 2022). Heavy reliance on rote memorization may support short-term recall but fails to promote long-term retention or flexible use (Kaphle, 2024). Limited exposure to English outside the classroom further restricts opportunities for repeated encounters with new vocabulary, which are essential for consolidation (Nation, 2001; Schmitt, 2000).
At higher levels, learners frequently experience difficulty using vocabulary productively, particularly in speaking and writing. Large class sizes, limited feedback, learner anxiety, and restricted access to authentic practice contexts further compound these challenges (Ali et al., 2024; Medina et al., 2025). Advanced lexical features such as collocations, idiomatic expressions, and polysemy are especially difficult to master without meaningful and repeated exposure (Biseko, 2025). These challenges span all cognitive levels, from basic recall to analysis and application, underscoring the need for instructional approaches that support vocabulary development across multiple stages of learning.

7.4 Vocabulary Learning Strategies

Vocabulary learning strategies (VLSs) refer to deliberate techniques learners use to acquire, retain, and apply new lexical items (Schmitt, 2000; Nation, 2001). Research indicates that strategic vocabulary learning promotes deeper processing and more durable retention compared to rote memorization (Chen, 2025; Teng, 2022). Commonly identified strategies include determination strategies (e.g., guessing from context, dictionary use), cognitive strategies (e.g., repetition, note-taking), memory strategies (e.g., semantic mapping, imagery), metacognitive strategies (e.g., planning and monitoring), and social strategies (e.g., interaction with peers or teachers). These strategies align with different cognitive processes and support vocabulary learning from basic recognition to higher-order application and creation (Schmitt, 2000; Teng, 2022).
However, studies show that EFL learners often underuse metacognitive and social strategies, despite their importance for long-term retention and productive use (Ali et al., 2024; Yilmaz & Kavanoz, 2025). This limitation highlights the need for instructional designs that encourage strategic engagement with vocabulary beyond memorization.

7.5 From Traditional to Technology-Supported Vocabulary Learning

Traditional EFL vocabulary instruction has typically relied on memorization, word lists, and teacher-centered practices. Although these methods may produce short-term gains, they rarely support deep processing or communicative use of vocabulary (Wang, 2023; Schmitt, 2000). This gap has led to increased interest in technology-supported approaches, which provide interactive, contextualized, and learner-centered learning opportunities.
Research in Saudi Arabia demonstrates that technology integration in EFL instruction enhances learner motivation, retention, autonomy, and engagement (Abdelhalim & Alsehibany, 2025; Noorwali & Sabir, 2025). Digital tools such as mobile applications, online dictionaries, corpora, and gamified platforms allow learners to practice vocabulary at their own pace, access authentic input, and receive immediate feedback, supporting self-regulated learning beyond the classroom.

7.6 Artificial Intelligence in EFL Vocabulary Learning

Recent technological advances have shifted digital learning from static tools to adaptive and intelligent systems. Artificial intelligence (AI) represents a significant development in EFL education by enabling data-driven personalization and real-time feedback (Huang et al., 2023; Xiao & Wu, 2024). AI-based tools adapt content and practice based on learners' performance,

proficiency levels, and learning needs, providing targeted support that strengthens retention and engagement (Polyzi & Moussiades, 2023; Li & Hafner, 2022).
AI also supports contextualized learning by embedding vocabulary in authentic scenarios and interactive tasks, while immediate feedback promotes accuracy and metacognitive awareness (Nguyen, 2024). Gamified features further enhance motivation and reduce learning anxiety (Bambang & Ariya Agustin, 2022). Although concerns remain regarding overreliance on technology and access inequities, research indicates that thoughtful integration of AI can effectively complement traditional vocabulary learning strategies.

7.7 Bloom's Taxonomy as a Theoretical Framework

Bloom's Taxonomy provides a structured framework for organizing learning objectives across increasing levels of cognitive complexity (Anderson & Krathwohl, 2001). The revised taxonomy includes six cognitive levels: Remember, Understand, Apply, Analyze, Evaluate, and Create. In EFL vocabulary learning, this progression supports movement from word recognition to meaningful and creative language use (Adams, 2015; Han, 2024).
When combined with constructivist theory (Vygotsky, 1978), metacognitive theory (Flavell, 1979), and depth of processing theory (Craik & Lockhart, 1972), Bloom's framework offers a comprehensive model for vocabulary development. AI-based systems can operationalize this framework by adapting tasks to learners' cognitive levels, allowing non-linear yet coherent progression through vocabulary learning stages.

7.8 Relevance to the Present Study

In the present study, Bloom's Taxonomy serves as both the theoretical foundation and instructional design framework for the AI-based vocabulary learning application. Tasks are aligned with specific cognitive levels, enabling learners to progress from basic recall to higher-order application and creation. The integration of AI adaptivity, constructivist scaffolding, and metacognitive support ensures personalized, interactive, and cognitively meaningful vocabulary learning. This approach aligns with Saudi Vision 2030's emphasis on digital innovation, human capability development, and learner-centered education, reinforcing the relevance of AI-supported instruction within the Saudi EFL context.

8. Discussion and Findings

8.1 Vocabulary Learning Outcome

Pretest results indicated a moderate level of vocabulary knowledge (M = 68.9%), with noticeable variation across cognitive levels. Learners performed relatively well on higher-order tasks such as Evaluating and Creating, while lower performance was observed in foundational skills, particularly Remembering and Applying. This pattern suggests that although students possessed general academic reasoning skills, they required further support in vocabulary recall and practical use.
Following the intervention, posttest results revealed an overall improvement in vocabulary performance (M = 72.3%). A paired-samples *t* test showed a statistically significant gain, $t(25) = -2.346$, $p = .027$, with a moderate effect size (Cohen's $d = 0.46$). These findings indicate that the AI-based vocabulary application had a meaningful impact on learners' vocabulary development within a relatively short instructional period.

8.2 Bloom's Taxonomy–Based Analysis

Analysis across Bloom's cognitive levels revealed a clear learning trajectory. The greatest improvements occurred in lower- and mid-order cognitive domains, including Remembering (+7.4 percentage points), Understanding (+5.3), and Applying (+7.9). These gains align closely with the app's instructional design, which emphasized spaced repetition, contextualized examples, and repeated practice. Moderate improvement was also observed at the Analyzing level (+5.2), indicating enhanced ability to interpret relationships and distinctions between vocabulary items.
Performance at higher-order levels remained generally stable. Evaluating showed minimal change, reflecting strong baseline proficiency prior to the intervention. Scores at the Creating level decreased slightly; however, this reduction is best explained by the increased abstraction and novelty of posttest tasks rather than a decline in learners' creative ability. Overall, the results suggest that the application was particularly effective in strengthening foundational vocabulary skills while maintaining higher-order cognitive performance.

8.3 Learner Perceptions and Usability

Learner feedback strongly supported the quantitative findings. Descriptive statistics from the feedback survey showed consistently high mean scores across all dimensions (M = 3.49–3.61 on a 4-point Likert scale), indicating strong agreement

among participants. Students reported that the application was easy to use, clear in its instructions, motivating, and effective for learning vocabulary. All participants expressed overall satisfaction and agreed that the benefits of using the application outweighed the effort required.
Qualitative responses further reinforced these results. Learners reported noticeable improvements in vocabulary knowledge and increased confidence in using new words. Many participants emphasized that the application made vocabulary learning more engaging and less monotonous, while others highlighted its clarity and user-friendly design. Even participants who reported limited use expressed positive impressions, suggesting strong perceived value.

8.4 Areas for Improvement

Despite the overall positive evaluation, learners identified specific areas for enhancement. Some participants indicated that task difficulty did not always match their proficiency level, suggesting the need for more precise adaptive leveling. Others recommended adding pronunciation support to enhance phonological awareness. These suggestions reflect constructive engagement and provide clear directions for future refinement rather than dissatisfaction with the application.

8.5 Implications and Conclusion

In summary, the findings demonstrate that the AI-based vocabulary learning application is an effective and pedagogically sound tool for enhancing EFL vocabulary acquisition among Saudi university students. The intervention produced statistically significant and educationally meaningful gains, particularly in foundational cognitive domains essential for long-term vocabulary development. The integration of Bloom's Taxonomy with AI-driven instruction supported a structured progression from recall to application while maintaining higher-order thinking skills.

From a pedagogical perspective, the results indicate that AI-supported vocabulary learning can address common challenges in EFL contexts, such as limited exposure and insufficient individualized practice. Incorporating enhanced adaptive features and multimodal support may further strengthen learning outcomes. Overall, the study provides empirical support for the use of AI-based vocabulary applications as effective and scalable tools for EFL instruction in higher education.

9. Conclusion

This study examined the effectiveness of an artificial intelligence–based vocabulary learning application grounded in Bloom's Taxonomy in enhancing English as a Foreign Language (EFL) vocabulary acquisition among Saudi university students. Vocabulary remains a core component of language proficiency, yet many EFL learners face challenges related to limited lexical depth and overreliance on memorization. The study explored whether integrating AI with a structured cognitive framework could provide a more effective alternative to traditional vocabulary instruction.

The findings indicate that the AI-based application positively influenced students' vocabulary development. Participants demonstrated measurable improvement in posttest performance, particularly in lower- and mid-order cognitive processes such as remembering, understanding, and applying vocabulary, while maintaining strong performance in higher-order skills, including analysis, evaluation, and creative use. This pattern suggests that combining Bloom's Taxonomy with adaptive feedback and repeated exposure supported balanced growth in vocabulary breadth and depth.

Learners' perceptions of the application were also highly positive. Students reported that the app was easy to use, clearly structured, and engaging, and they highlighted the benefits of immediate feedback, interactive activities, and self-paced practice. These features appeared to enhance motivation, reduce anxiety, and promote learner autonomy and confidence in vocabulary learning.

Despite these contributions, the study has limitations. The sample was small and limited to female students from a single university, and the intervention period was relatively short. Future research should involve larger and more diverse samples, extend the duration of interventions, and examine the effects of AI-based vocabulary tools on additional language skills and proficiency levels.

Pedagogically, the findings demonstrate that Bloom's Taxonomy remains a relevant framework for vocabulary instruction in digital learning environments. When combined with AI-driven adaptivity, it enables systematic progression from basic recall to higher-order language use while addressing individual learning needs. The study also contributes context-specific evidence to

the growing body of research on AI in language education within the Saudi EFL context and aligns with the goals of Saudi Vision 2030, which emphasize digital innovation and human capability development.

In conclusion, the study provides evidence that an AI-based vocabulary learning application informed by Bloom's Taxonomy can enhance vocabulary acquisition, support personalized learning, and foster learner engagement in Saudi higher education. By integrating established pedagogical theory with adaptive technology, AI can function as a supportive tool that enriches instruction and promotes more effective and inclusive EFL learning.

Funding: This research received no external funding.
Conflicts of Interest: The authors declare no conflict of interest.
Publisher's Note: All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers.

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