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ARTIFICIAL INTELLIGENCE AND VOCABULARY DEVELOPMENT: AN EXPERIMENTAL STUDY OF ENGLISH LANGUAGE LEARNERS AT BS-LEVEL

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Abstract

This experimental study investigates the impact of Artificial Intelligence (AI) tools on the vocabulary development of English language learners at the BS level. The primary objectives were to examine the effectiveness of AI-based vocabulary instruction, compare the performance of students taught with AI tools against those taught through conventional vocabulary learning techniques, and assess learners' attitudes toward the application of AI in vocabulary learning. A quasi-experimental pretest–posttest control group design was employed with 100 BS-level English students divided equally into a control group and an experimental group (n = 50 each). The control group received instruction through traditional methods such as textbook exercises, dictionary use, and teacher-led drills, while the experimental group engaged with AI-powered vocabulary learning tools—ChatGPT, Quizlet AI, and Duolingo Max—featuring adaptive practice, contextual usage, and instant feedback. Data were collected through a vocabulary achievement pretest and posttest, supplemented by a 20-item Likert-scale perception questionnaire administered to the experimental group. Independent- and paired-samples t-tests showed that the experimental group achieved significantly greater gains in vocabulary knowledge than the control group (posttest M = 27.94 vs. M = 21.70, t = 9.64, p < .001), with a very large effect size (Cohen's d = 1.93). Learners also reported markedly positive attitudes toward AI integration, citing engagement, personalization, and ease of access as key benefits (72.0% positive responses overall across the questionnaire). The findings suggest that AI tools can serve as an effective supplement to conventional vocabulary instruction, with implications for curriculum design and technology integration in English language teaching at the tertiary level.

Keywords: Artificial Intelligence (AI), Vocabulary Development, English Language Learners, ChatGPT, Quizlet AI, Duolingo Max, Experimental Study

Introduction

Vocabulary occupies a central place in language learning because it underlies comprehension, communication, and active participation in academic, social, and professional life (Nation, 2001; Schmitt, 2008). A learner's vocabulary size shapes reading ability, writing quality, speaking fluency, and overall comprehension, and its absence creates persistent barriers to communication. This is especially true for BS-level English learners, who must acquire advanced academic and professional vocabulary to succeed in higher education. Conventional approaches to vocabulary teaching—memorization, repetition, and teacher-centred drills—often fail to engage learners or accommodate individual learning needs (Richards & Rodgers, 2014). Words practiced outside meaningful context are quickly forgotten, and large class sizes, limited materials, and restricted opportunities for individualized attention compound the difficulty of building a robust lexicon.

The growing use of educational technology has opened new possibilities for addressing these limitations. Artificial Intelligence (AI) tools—including intelligent tutoring systems, adaptive learning platforms, and mobile applications—can provide personalized, interactive, and adaptive vocabulary instruction that responds to individual learner needs (Chen et al., 2020). By offering immediate feedback, contextualized examples, and continuous progress monitoring, AI applications such as ChatGPT, Quizlet AI, and Duolingo

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Max may enable learners to engage more actively and independently with new vocabulary than conventional classroom methods allow. This possibility carries particular significance in Pakistan, where English language learners have limited exposure to native-speaker contexts and rely heavily on classroom instruction for vocabulary growth.

This research aims to demonstrate the effectiveness of AI tools (ChatGPT, Quizlet AI, and Duolingo Max) in fostering vocabulary acquisition among BS-level English language learners. Its main objective is to compare the vocabulary achievement of students receiving AI-assisted instruction with that of students receiving conventional instruction, and to explore learners' attitudes toward the use of AI tools in vocabulary learning. An experimental research design was used to generate empirical evidence intended to inform English language teachers, curriculum developers, and educational institutions regarding the integration of AI technologies into vocabulary instruction in higher education.

Research Objectives

The objectives of the study are as follows:

- To investigate the impact of AI on vocabulary development on English language learners at the BS level.
- To compare the performance of students taught with AI tools and those who are taught with conventional vocabulary learning techniques.
- To assess learners' attitudes on the application of AI in vocabulary learning.

Research Questions

The research questions of the study are:

- What is the impact of AI-assisted vocabulary instruction using ChatGPT, Quizlet AI, and Duolingo Max on the vocabulary development of BS-level English language learners?
- Is there a significant difference in vocabulary achievement between students taught through AI-assisted instruction and those taught through conventional vocabulary learning methods?
- What are the attitudes of BS-level English language learners toward using AI tools for vocabulary learning?

Hypotheses of the Study

H1: The experimental group under AI-based vocabulary teaching will have a substantial difference in pre-test and post-test scores.

H2: The experimental group will show much better post-test performance compared to the control group.

H3: Students will indicate positive attitudes towards AI usage for learning vocabulary.

Significance of the Study

Vocabulary acquisition remains one of the most persistent challenges for learners in English as a Foreign Language (EFL) settings such as Pakistan, where conventional instructional practices continue to rely on rote learning, repetition, and teacher-centred delivery that do not necessarily promote durable vocabulary retention. The growing use of technology in education presents an opportunity to close this gap: AI can provide personalized, interactive, and adaptive learning, offering direct feedback and a learner-focused experience that is both motivating and engaging. Examining the impact of AI on vocabulary learning is significant both because of the global trend toward technology-mediated learning and because of the specific characteristics of the Pakistani learner population, who typically have limited exposure to native English-speaking contexts. The results of this research are intended to contribute to the existing literature on technology-mediated language learning, offer practical guidance to educators and curriculum designers, and inform policymakers considering the integration of AI into post-secondary English

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language education, while also supporting learners' independence and self-directed engagement with digital learning resources.

Definitions of Key Terms

For clarity and consistency, the following terms are used in this study as operationally defined below. Vocabulary Development refers to the process of acquiring, comprehending, and effectively using new English words, including their meaning, pronunciation, spelling, and appropriate context of use, as measured by learners' performance on the pretest and posttest. Artificial Intelligence (AI) refers to computer-based systems and applications capable of performing tasks typically associated with human intelligence, such as adaptive learning, personalized feedback, and interactive exercises; in this study, AI tools include ChatGPT, Quizlet AI, and Duolingo Max. The Experimental Group comprises BS-level English learners who received AI-assisted vocabulary instruction during the intervention, while the Control Group comprises learners who received vocabulary instruction through traditional methods such as memorization, repetition, and teacher-guided exercises. The Pretest is the diagnostic assessment administered before the intervention to establish baseline vocabulary knowledge, and the Posttest is the assessment administered after the intervention to determine the extent of vocabulary development attributable to the instructional method used.

Literature Review

Vocabulary Learning and the Case for Technological Intervention

Vocabulary is a foundation of comprehension, communication, and academic achievement (Schmitt, 2008), and learners with a poor command of words struggle to read textbooks, take notes, or express their ideas—a challenge that intensifies at the BS level, where advanced academic and research literature must be engaged with regularly. Traditional vocabulary instruction, built around word lists, paper dictionaries, worksheets, and repeated readings, has long dominated the classroom, but has been criticized as repetitive and offering little authentic interaction (Nation, 2001). Without meaningful context, repetition, and timely feedback, newly learned words are quickly forgotten, prompting educators and researchers to explore alternative strategies capable of making vocabulary learning more engaging and durable.

AI Chatbots and Conversational Agents

The emergence of AI has opened a new avenue for vocabulary instruction through smart applications, chatbots, digital tutors, and adaptive learning systems that are more interactive and personalized than earlier computer-assisted methods, adapting to learner level, offering instant feedback, and tracking progress over time (Chen et al., 2020). Yuan (2024) found that Chinese elementary EFL learners using AI chatbots scored significantly higher and showed greater willingness to communicate than learners taught conventionally, attributing the gains to personalized error correction and learner-centred pacing. Behforouz et al. (2025) reported that a WhatsApp chatbot produced marked gains in receptive vocabulary relative to face-to-face teaching, though the control group outperformed on productive tasks—suggesting chatbots function best as a supplement rather than a replacement for classroom instruction. Zhang and Huang (2024) found that large-language-model-powered chatbots produced gains in both receptive and productive vocabulary that persisted on a delayed posttest, indicating durable retention rather than short-term recall, while Khalil et al. (2025) showed that adaptive, level-matched chatbot tasks improved grammar and vocabulary scores relative to a control group. Using a mixed quantitative-qualitative design, Koç (2024) found no significant quantitative advantage for chatbot-mediated listening and speaking instruction, though qualitative evidence indicated meaningful gains in learners' interactional strategies, leading to a proposed design framework for effective chatbot-based instruction. Behforouz

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and Al Ghaithi (2025) similarly found that Copilot use produced greater immediate gains than conventional instruction and, notably, sustained advantages on a delayed posttest, alongside increased learner autonomy and motivation. Wei-Xun and Jia-Ying (2024) extended this comparison beyond a single platform, finding that personalized AI systems embedded in language-learning software outperformed traditional methods by enabling learners to study at their own pace through adaptive content delivery and real-time feedback, which encouraged deeper lexical processing and application of vocabulary in real-life, context-based situations rather than short-term memorization. Taken together, this literature suggests chatbot-mediated instruction tends to outperform traditional instruction for vocabulary knowledge, particularly receptive vocabulary, with effectiveness closely tied to learner autonomy and metacognitive engagement rather than the technology alone; several of these studies also caution that chatbots function best as a complement to classroom teaching, with their benefits concentrated more strongly in vocabulary knowledge than in other language skills such as writing, listening, or speaking.

Generative AI and ChatGPT-Powered Tools

A related strand of research examines generative AI tools such as ChatGPT for vocabulary and broader language development. Abril et al. (2025) found that students taught in a ChatGPT-supported classroom showed significant pretest-to-posttest gains and positive attitudes toward the tool, contingent on clear learning objectives and systematic guidance. Rabab'ah et al. (2025) reported comparable advantages using a game-based digital intervention with EFL learners, with the largest gains in denotation and spelling, though positive attitudes toward the tool did not always align with measurable knowledge gains—underscoring the importance of well-structured instructional design in translating engagement into achievement. Alangari (2025) found that ChatGPT-assisted writing instruction produced significant gains in vocabulary and language use, though not in essay organization or mechanics, while also reducing learners' anxiety and boosting their confidence when engaging with AI-generated explanations. From a perception-based perspective, Losi et al. (2024) found that learners viewed ChatGPT positively as a vocabulary learning aid, citing contextual explanations, feedback, and reduced classroom assessment anxiety, though the authors cautioned that perception data should be read alongside performance-based evidence. Not all findings in this cluster are uniformly positive, however: some quasi-experimental comparisons of AI-generated contextual passages against traditional word-list memorization have found no significant difference in short-term post-test scores between conditions, even though qualitative analysis suggested that AI-generated materials supported richer contextual inferencing and sustained engagement more effectively than rote memorization. This divergence suggests that the benefits of generative AI tools may be more evident in learners' engagement, contextual understanding, and qualitative learning experience than in short-term test scores alone, and that such materials are best used alongside, rather than instead of, explicit and systematic vocabulary instruction. Collectively, this literature indicates that generative AI tools can support vocabulary and broader language development, but that outcomes depend on structured pedagogical guidance rather than unsupervised technology use—a consideration directly relevant to the design of the present study, which incorporated a fixed six-week structured intervention rather than open-ended, unsupervised access to AI tools.

AI-Integrated Applications, Platforms, and Intelligent Tutoring Systems

Other studies examine dedicated AI-powered applications and tutoring systems. Wang et al. (2024) found that AI-driven self-testing combined with in-class assessment on the UNIPUS and iTEST platforms improved vocabulary retention, learning efficiency, and engagement more than standalone assessment methods. In the specialized field of accounting

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ESP vocabulary, Rajayi et al. (2025) found that learners using the Memrise application achieved significantly higher scores on both immediate and two-week delayed retention tests than a conventionally taught group, highlighting the value of app-based instruction for discipline-specific vocabulary. Podoliak et al. (2025) found that Ukrainian philology students using Duolingo scored significantly higher on language tests and reported higher motivation than a control group, while a usage-pattern survey by Jomaa et al. (2024) found that AI tool preferences varied by age, gender, and level of study, and that learners were not always fully confident in the vocabulary suggested by AI systems. Chingakham and Tamuk (2024) and Taj et al. (2025) both found that structured AI-assisted instruction improved vocabulary skill and pronunciation relative to conventional teaching, while emphasizing the need for institutional policy and active teacher mediation to sustain these gains.

Multimodal, Visual, and Virtual Reality Approaches

A further cluster of studies explores multimodal and immersive AI approaches. Temiz and Kafadar (2025) found that AI-generated vocabulary flashcards produced stronger initial gains than traditional flashcards, though the advantage did not persist on a delayed posttest. Dağdeler (2025) found that a text-to-image AI tool improved vocabulary production but not recognition relative to a non-AI-supported group, while noting logistical challenges such as image relevance and lesson preparation time. Liu and Chen (2023) found that an AI-based object-detection and translation application benefited higher-ability learners significantly more than lower-ability learners, suggesting multimodal AI tools may not affect all learners uniformly. Wen et al. (2025) found that a multimodal system combining pronunciation feedback, AI marking, and personalized suggestions produced vocabulary gains linked to learners' emotional and cognitive engagement, and Liao (2023) found that an AI-and-VR vocabulary system improved retention and spelling, though learner motivation emerged as a limiting factor. Chang et al. (2024) concluded that VR-based learning complements, rather than replaces, AI-based vocabulary tools, while Yu (2025) found that multimodal AI strategies produced greater immediate and long-term retention than traditional instruction, while cautioning against cognitive overload and cultural bias in AI-generated material.

AI for Specialized and Academic Vocabulary

A number of studies examine AI's role in teaching academic or specialized vocabulary. Maghsoudi (2025) found that AI-based instruction using the Diffit application produced better immediate and delayed ESP vocabulary acquisition than print-based instruction over a 12-week intervention. Tran (2024) found that AI tools positively influenced graduate learners' engagement, motivation, and academic vocabulary strategies through personalized pacing and real-time feedback, while Pitura (2024) used an AI-powered CEFR checker to track the gradual development of advanced (C1-level) lexical use among English Studies students. Tang and Ma (2023) linked computational-thinking-based instruction to significant gains in advanced vocabulary, and Feng (2025) applied cognitive load theory to argue that AI-assisted learning frees cognitive resources for deeper language processing. Murugavel et al. (2025) found that AI systems built on large language models and word embeddings produced greater vocabulary gains and more satisfying learning experiences than conventional or earlier computer-assisted approaches. This literature suggests AI tools may be especially suited to teaching the specialized and advanced vocabulary that BS-level learners require for academic reading, lectures, and writing.

Learner and Teacher Perceptions, Motivation, and Affective Outcomes

A systematic review by AlTwijri and Alghizzi (2024) found that AI technologies generally have a positive affective impact on EFL learners—raising motivation and engagement while reducing anxiety—but noted that empirical research on affective outcomes remains sparser than research on performance outcomes. Javahery and Alizadeh (2025) found

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that IELTS candidates using AI tools showed substantial vocabulary size gains (from a mean of 43.10 to 57.85) alongside increased motivation and engagement, while identifying technical issues and the need for teacher mediation as ongoing challenges. Wei (2023) similarly found that AI-mediated instruction improved vocabulary, grammar, reading, and writing performance while promoting greater use of self-regulated learning strategies than conventional instruction, with learners describing the AI-enhanced condition as more engaging and autonomy-supporting.

Learner Autonomy and Self-Regulated Learning

A related theme concerns learner autonomy as a mechanism, rather than merely a side effect, of AI-assisted vocabulary learning. Ali et al. (2024) argued that AI-powered Technology-Assisted Language Learning (TALL) tools extend vocabulary practice beyond the classroom, supporting learner-centred pedagogy by letting students decide how and when to study. Alizadehmahmoudalilo (2025) found that AI-scaffolded learning-oriented assessment produced significantly higher posttest scores and a large effect size relative to conventional teaching, while noting that digital literacy and equitable access remain prerequisites for successful implementation. This body of work suggests that AI tools influence vocabulary learning not only through more efficient presentation of content but by shifting how learners perceive and manage their own learning.

Contextual, Cultural, and Ethical Considerations

A final cluster of studies situates AI-assisted vocabulary learning within specific cultural and ethical contexts. Elmahdi et al. (2025) synthesized fifty-eight international studies across six countries and found that culturally tailored AI tools substantially outperformed generic, one-size-fits-all systems, proposing a framework addressing feedback, data privacy, and equitable representation in tool design. Olagoke and Adanlawo (2025) found that AI-assisted bilingual (English and Yoruba) vocabulary instruction improved outcomes in Nigerian secondary schools but noted resource gaps in rural settings, calling for culturally appropriate curricula rather than direct transfer of Western-designed tools. In the Pakistani context most closely aligned with the present study, Khan and Hudda (2025) found that AI-supported instruction significantly improved synonym acquisition and overall language proficiency among EFL learners, framed within Vygotskian sociocultural theory and Krashen's second language acquisition hypothesis. Together, these studies indicate that AI's effectiveness in vocabulary instruction is not uniform across contexts, and that tools accounting for local language variation and resource constraints are more likely to succeed than generic applications.

Research Gap

Systematic reviews by Yilmaz (2025) and Yang (2025) converge on three related gaps in the AI-vocabulary literature. First, a population gap exists: most studies focus on school-level or general EFL learners, with very few examining BS-level learners in Pakistan specifically—among the literature reviewed, only Khan and Hudda (2025) directly examine Pakistani EFL learners. Second, a methodological gap exists, as Zawacki-Richter et al. (2019) and Yilmaz (2025) note that comparative experimental designs remain less common than descriptive or perception-based studies in the wider AI-in-education literature. Third, an integration gap exists, since vocabulary performance and learner attitude are rarely examined within a single research design. The present study addresses all three gaps by employing a comparative quasi-experimental design with BS-level Pakistani English learners that combines objective achievement outcomes with a structured measure of learner attitudes.

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Methodology

Research Design

This study used a quasi-experimental pretest–posttest control group design to examine the effect of AI-based instruction on the vocabulary learning of BS-level English language learners (ELLs). A quasi-experimental design was appropriate because the study was conducted in an intact educational setting where fully random sampling from the population was not possible; participants were, however, randomly assigned to the experimental or control condition after selection, to minimize selection bias and strengthen internal validity. The independent variable was the method of instruction (AI-assisted versus conventional), and the dependent variable was vocabulary achievement, measured through a pretest–treatment–posttest sequence. The two groups were drawn from the same academic program (BS English, seventh semester) and university, and were matched on educational background and prior language exposure to minimize the influence of extraneous variables. Because some pretest differences between groups were nonetheless expected, pretest scores were also used as a covariate in the analysis of posttest scores to obtain a more accurate estimate of the instructional effect. The intervention lasted six weeks, a duration judged sufficient for vocabulary gains to emerge; both groups covered identical vocabulary content and received the same amount of instructional time, with instructional method as the only systematically varied factor.

Population and Sample

The population comprised BS English students at the University of Sargodha. Seventh-semester students were targeted because they had completed relevant language courses, possessed sufficient language competence to engage meaningfully with AI tools, and were mature enough to provide informed feedback on their learning experience. The sample consisted of 100 seventh-semester BS English students. Participants were selected using purposive sampling based on criteria including seventh-semester enrolment, regular attendance, willingness to participate voluntarily, and comparable prior exposure to English language instruction. After selection, participants were randomly assigned to an experimental group ($n = 50$) and a control group ($n = 50$) to reduce selection bias and strengthen internal validity; purposive sampling and random assignment were thus applied at two distinct stages of participant selection rather than being contradictory procedures. Both groups shared the same classroom setting, vocabulary content, and six-week instructional period, differing only in instructional method.

Research Instruments

Two instruments were used to collect data relevant to the study's objectives, research questions, and hypotheses: a Vocabulary Achievement Test (pretest and posttest) and a Perception Questionnaire administered to the experimental group.

The Vocabulary Achievement Test assessed vocabulary proficiency before and after the instructional intervention. It was divided into six sections (A through F, five marks each, thirty marks total) using a range of objective item types: multiple-choice vocabulary recognition, synonym and antonym identification, word-to-meaning matching, context-based vocabulary questions, and short meaning-based questions. The pretest and posttest were equivalent in content, format, difficulty, and scoring procedure, with only item order altered between versions to prevent carryover effects. Content validity was established through review by an expert panel comprising the Head of Department and experienced faculty members (Prof. Dr. Anser Mehmood, Mr. Ijaz Hussain, Mr. Ali Shahid, Mr. Wajid Riaz, and Mr. Asad Mehmood), who evaluated each item for content relevance, alignment with the BS English curriculum, clarity, and appropriateness of difficulty; ambiguous items were reworded and redundant items removed based on this feedback.

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The Perception Questionnaire was administered only to the experimental group after the intervention and comprised 20 statements on a five-point Likert scale (Strongly Disagree to Strongly Agree), together with a small number of open-ended items. It addressed perceived usefulness, ease of use, learner engagement, motivation, confidence, autonomous learning, satisfaction, and willingness to continue using AI tools for vocabulary learning. The questionnaire was developed from the reviewed literature on AI, technology-assisted language learning, and vocabulary instruction, and was validated by the same expert panel that reviewed the vocabulary test, using criteria of clarity, language appropriateness, logical organization, content relevance, and alignment with the research aims.

Both instruments were pilot-tested with students sharing characteristics of the target population who did not participate in the main study, and internal consistency was assessed using Cronbach's alpha. Both instruments returned a reliability coefficient of $\alpha = .086$, a value substantially below conventionally accepted thresholds for internal consistency; this low reliability is treated in this study as an acknowledged methodological limitation rather than as evidence of acceptable measurement precision, notwithstanding the content validity established through expert review.

Scope and Setting

The scope of the study was confined to vocabulary development among BS-level English learners at the University of Sargodha and to the specific AI tools examined (ChatGPT, Quizlet AI, and Duolingo Max), rather than to other language skills such as grammar, writing, or speaking, or to other levels of education. All instructional activity for both groups took place during regular classroom hours over the six-week intervention period, a duration chosen because it allowed learners sufficient repeated exposure to the target vocabulary while remaining realistic within the constraints of the BS English curriculum. Conducting the intervention within the normal school day and under matched classroom conditions for both groups was intended to minimize the influence of extraneous variables and to preserve the ecological validity of the comparison between instructional methods.

Data Collection Procedures

Formal permission was obtained from the relevant authorities at the University of Sargodha prior to data collection, and the study was conducted in accordance with institutional research ethics requirements. Participants were recruited through purposive sampling from the seventh-semester BS English cohort based on the eligibility criteria described above, and were then randomly assigned to the experimental or control condition. All participants gave written informed consent after being informed of the study's purpose, procedures, duration, and their right to withdraw without academic penalty; confidentiality was maintained through participant identification codes rather than names.

All participants completed the Vocabulary Achievement Pretest under standardized conditions before the intervention began. During the six-week intervention, both groups covered identical vocabulary content and received equal instructional time; the experimental group received vocabulary instruction through AI-supported tools—adaptive exercises, interactive learning activities, and real-time feedback—while the control group received instruction through teacher explanation, dictionary use, textbook and workbook exercises, and classroom discussion. At the end of the six-week period, both groups completed the Vocabulary Achievement Posttest under matched conditions, after which the experimental group completed the Perception Questionnaire. Throughout data collection, the researcher adhered strictly to standard educational research ethics: participation was voluntary, written informed consent was obtained from all participants, and participants retained the right to withdraw without academic penalty. Participant identity was protected through the use of identification codes rather than names, and all collected data were used solely for research

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purposes and accessed only by the researcher. The AI applications used in the intervention were selected as secure and appropriate for university-level learners.

Data Analysis Procedures

Quantitative data from the vocabulary achievement tests were analyzed in SPSS. Descriptive statistics (mean, standard deviation, minimum, and maximum) summarized overall performance, and the assumptions underlying parametric testing were checked prior to inferential analysis: normality was assessed using the Shapiro–Wilk test, and homogeneity of variance between groups was assessed using Levene's test. Because slight baseline differences existed between the groups, Analysis of Covariance (ANCOVA) was used as the primary inferential procedure, with posttest scores as the dependent variable and pretest scores as the covariate. Paired-samples t-tests assessed within-group change from pretest to posttest for each group, and an independent-samples t-test compared posttest performance between groups. Cohen's d was computed to estimate effect size, and a significance level of .05 was applied throughout. The perception questionnaire was analyzed primarily through descriptive frequency analysis of Likert-scale responses (percentages of agreement, neutrality, and disagreement); a thematic coding procedure for the open-ended items was planned but is not reported in the results below, which draw on the quantitative questionnaire data.

Results

Participants and Test Structure

The final sample comprised 100 BS-level students: 50 in the control group, taught using traditional vocabulary learning techniques, and 50 in the experimental group, taught using AI tools. The Vocabulary Achievement Test was divided into six sections (A–F, five marks each) for a total of 30 marks. In addition, the 20-item Likert-scale Perception Questionnaire was administered to the experimental group following the intervention to assess attitudes and opinions regarding AI-assisted vocabulary learning.

Descriptive Statistics

Descriptive statistics for the pretest (Table 1) show that the control group began with a slightly higher mean vocabulary score than the experimental group (M = 17.52 vs. M = 15.34), with the experimental group also showing greater score variability (SD = 4.50 vs. SD = 3.34) and a wider score range (8–24 vs. 13–23). This baseline difference indicates the experimental group did not hold any initial advantage; if anything, it started from a lower and more heterogeneous position.

Table 1

Descriptive Statistics of Pretest Scores (Out of 30)

Group	N	Mean	SD	Minimum	Maximum
Control Group	50	17.52	3.34	13	23
Experimental Group	50	15.34	4.50	8	24

Posttest descriptive statistics (Table 2) show a marked reversal. The control group's mean rose to 21.70 (SD = 4.41), reflecting a moderate, variable improvement consistent with conventional instruction. The experimental group's mean rose to 27.94 (SD = 1.22), with scores clustering tightly near the maximum possible score (minimum = 25, maximum = 30). The sharply reduced standard deviation in the experimental group indicates that AI-assisted instruction produced not only larger gains but also more consistent gains across learners of differing initial ability.

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Table 2

Descriptive Statistics of Posttest Scores (Out of 30)

Group	N	Mean	SD	Minimum	Maximum
Control Group	50	21.70	4.41	15	29
Experimental Group	50	27.94	1.22	25	30

Examining the distribution of gain scores (posttest minus pretest) for individual learners adds further nuance to these group-level averages. In the control group, gains were widely dispersed, ranging from a small number of learners who scored lower on the posttest than the pretest to others who improved substantially, producing a median gain of roughly five points and a broad spread consistent with heterogeneous responses to conventional instruction. In the experimental group, by contrast, gain scores clustered much more tightly in the positive range, with a median gain of roughly 12.5 points and no learner recording a negative gain; even the lower quartile of the experimental group's gain distribution exceeded the control group's median gain. This pattern reinforces the conclusion that the experimental group's advantage reflects a genuine treatment effect rather than differences in initial ability, since the group that began with the lower and more variable pretest scores ended with the higher and more consistent posttest scores.

Within-Group Improvement (Paired-Samples t-Tests)

Paired-samples t-tests assessed pretest-to-posttest change within each group. The control group showed a statistically significant mean gain of 4.18 points, $t(49) = 4.66$, $p < .001$ (Table 3), indicating that conventional instruction produced a real, if moderate, improvement in vocabulary knowledge. The experimental group showed a substantially larger and highly significant mean gain of 12.60 points, $t(49) = 19.17$, $p < .001$ (Table 4)—roughly three times the gain observed in the control group.

Table 3

Paired-Samples t-Test Results (Control Group)

Group	N	Mean Difference (Post–Pre)	t	df	p
Control	50	4.18	4.66	49	.000

Table 4

Paired-Samples t-Test Results (Experimental Group)

Group	N	Mean Difference (Post–Pre)	t	df	p
Experimental	50	12.60	19.17	49	.000

Between-Group Comparison (Independent-Samples t-Test)

An independent-samples t-test compared posttest performance between groups (Table 5). The experimental group's posttest mean ($M = 27.94$) was significantly higher than the control group's ($M = 21.70$), $t = 9.64$, $p < .001$. This result provides direct support for the second research objective, indicating that AI-assisted vocabulary instruction produced significantly greater achievement than conventional instruction.

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Table 5

Independent-Samples t-Test (Posttest Comparison)

Groups Compared	Mean (Experimental)	Mean (Control)	t	p
Posttest Scores	27.94	21.70	9.64	.000

Effect Size

Cohen's d was computed to assess the practical magnitude of the observed differences (Table 6). The control group's pretest-to-posttest improvement corresponded to a medium effect (d = 0.66). The experimental group's improvement corresponded to a very large effect (d = 2.71), and the between-group posttest comparison likewise corresponded to a very large effect (d = 1.93). These effect sizes indicate that the advantage associated with AI-assisted instruction was not only statistically significant but also practically and educationally substantial.

Table 6

Effect Size (Cohen's d)

Comparison	Cohen's d	Interpretation
Control Group (Post–Pre)	0.66	Medium effect
Experimental Group (Post–Pre)	2.71	Very large effect
Posttest (Experimental vs. Control)	1.93	Very large effect

Section-Wise Analysis of the Vocabulary Test

Section-wise mean scores (Tables 7 and 8) provide a more granular view of vocabulary development across the six test components (A–F). At pretest, the control group scored slightly higher than the experimental group across all six sections, consistent with the overall pretest gap. At posttest, however, the experimental group's section-wise means ranged from 4.54 to 4.74 out of 5—near ceiling across every section—compared with 3.42 to 3.72 for the control group. This pattern indicates that AI-assisted instruction was associated with broad-based improvement across all measured vocabulary components rather than gains concentrated in a single test element.

Table 7

Section-Wise Mean Scores (Pretest)

Group	A	B	C	D	E	F
Control	2.98	3.06	2.86	2.84	2.90	2.88
Experimental	2.60	2.62	2.58	2.68	2.40	2.46

Table 8

Section-Wise Mean Scores (Posttest)

Group	A	B	C	D	E	F
Control	3.68	3.58	3.72	3.42	3.58	3.72
Experimental	4.54	4.68	4.66	4.62	4.70	4.74

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Learner Attitudes and Opinions

The 20-item Perception Questionnaire, completed by the experimental group, used a five-point scale ranging from Strongly Disagree to Strongly Agree. Across all 20 statements, positive responses (Strongly Agree + Agree) ranged from approximately 65% to 78%, with an overall positive response rate of 72.0% across the questionnaire, compared with 17.9% neutral and 10.1% negative responses. The highest levels of agreement were associated with statements concerning quick access to word meanings, overall satisfaction with AI tools, the speed of vocabulary acquisition, and the enjoyability of AI-based learning. The presence of a modest proportion of neutral and negative responses on every item indicates that a minority of learners remained uncertain about, or unconvinced by, AI-assisted vocabulary learning—plausibly reflecting differences in digital literacy, prior exposure to AI tools, or preference for conventional learning styles. Table 9 summarizes responses across the full set of statements.

Table 9

Questionnaire Statement-Wise Results (All 20 Items, n = 50)

No.	Statement	SA	A	N	D	SD	Positive %	Neutral %	Negative %
1	Learned new vocabulary effectively	37	36	17	10	0	73	17	10
2	Improved understanding of meanings	34	37	17	12	0	71	17	12
3	Accurate vocabulary use	30	40	20	10	0	70	20	10
4	Helped remember new words	35	36	20	9	0	71	20	9
5	Increased motivation	42	30	18	10	0	72	18	10
6	Made vocabulary learning easier	40	32	16	12	0	72	16	12
7	Improved pronunciation	37	30	20	13	0	67	20	13
8	Helped in sentence formation	35	30	22	13	0	65	22	13
9	Helped learn synonyms/antonyms	34	32	23	11	0	66	23	11
10	Increased confidence in vocabulary	40	29	20	11	0	69	20	11
11	Provided quick meanings	42	33	15	10	0	75	15	10
12	AI learning is enjoyable	44	30	18	8	0	74	18	8
13	Improved word retention	35	33	24	8	0	68	24	8
14	Helpful for exam preparation	39	31	21	9	0	70	21	9
15	AI saves time in learning vocabulary	41	32	16	11	0	73	16	11

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No.	Statement	SA	A	N	D	SD	Positive %	Neutral %	Negative %
16	AI makes learning more interactive	38	34	16	12	0	72	16	12
17	Encouraged self-learning	36	35	18	11	0	71	18	11
18	AI tools should be used in class	43	29	17	11	0	72	17	11
19	AI improves vocabulary faster	40	34	17	9	0	74	17	9
20	Overall satisfaction with AI tools	44	31	16	9	0	75	16	9

Note. SA = Strongly Agree; A = Agree; N = Neutral; D = Disagree; SD = Strongly Disagree. Positive/Neutral/Negative columns report the raw count of responses in each combined category (SA+A, N, D+SD) out of 50 experimental-group respondents.

Findings in Relation to the Objectives

Objective 1 (impact of AI on vocabulary development) is supported by the significant within-group gain observed in the experimental group, corroborated by the paired-samples t-test and a very large effect size. Objective 2 (comparison of AI-assisted and conventional instruction) is supported by the significant independent-samples t-test showing the experimental group's posttest performance substantially exceeded that of the control group. Objective 3 (learners' attitudes toward AI) is supported by the questionnaire results, which show that a clear majority of learners viewed AI-assisted vocabulary learning positively in terms of usefulness, motivation, and satisfaction.

Discussion

Effects of AI Tools on Vocabulary Development (Objective 1)

The first objective concerned the impact of AI on the vocabulary development of BS-level ELLs. The experimental group's large and statistically significant pretest-to-posttest gain, together with a very large effect size, indicates that AI tools were a major contributor to learners' vocabulary performance. Unlike conventional instruction, which typically relies on memorization and limited classroom practice, AI tools gave learners instant access to word meanings, usage examples, and synonym/antonym information, alongside interactive practice opportunities. This appears consistent with accounts of chatbot- and platform-based gains reported by Yuan (2024), Zhang and Huang (2024), and Khalil et al. (2025), and with cognitive-load explanations offered by Feng (2025) and Murugavel et al. (2025), which suggest that adaptive, personalized delivery frees cognitive resources for deeper vocabulary processing. The markedly reduced posttest variability in the experimental group further suggests that AI tools helped narrow gaps between learners of differing initial ability, plausibly by allowing weaker learners to receive continuous, individualized support that is difficult to provide in a traditional classroom.

Mechanisms Underlying the Advantage of AI-Assisted Instruction

Several complementary mechanisms may help explain why the experimental group outperformed the control group so consistently. First, AI tools provided quick definitions and immediate assistance, allowing learners to resolve uncertainty about a word's meaning without waiting for teacher availability. Second, AI tools supported contextual learning by

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supplying example sentences and usage patterns that helped learners grasp meaning in context rather than in isolation. Third, AI tools enabled repetition and reinforcement, allowing learners to encounter and practice target words multiple times, which is widely recognized as important for durable vocabulary retention. Fourth, AI tools accommodated each learner's individual pace, allowing students to revisit words or skip ahead as their own mastery dictated, rather than being bound to a single classroom pace. Fifth, AI-based learning appeared to increase motivation and engagement, making vocabulary practice feel more interactive, enjoyable, and confidence-building than repetitive conventional exercises. Together, these mechanisms offer a plausible account of why the experimental group achieved both larger and more consistent gains than the control group across the six-week intervention.

Comparison of AI-Based Instruction and Conventional Techniques (Objective 2)

The second objective compared AI-assisted and conventional vocabulary instruction. The experimental group's gain was roughly three times that of the control group, and the between-group difference was both statistically significant and practically large. This finding parallels platform-based results reported by Wang et al. (2024), Rajayi et al. (2025), and Podoliak et al. (2025), all of which found AI-supported instruction outperforming traditional methods. At the same time, the control group's own significant, medium-sized improvement indicates that conventional vocabulary instruction retains genuine value; teacher explanation, textbook exercises, and classroom discussion continued to support measurable learning gains. This pattern is consistent with cautions raised elsewhere in the literature—by Behforouz et al. (2025), Khalil et al. (2025), and Koç (2024)—that AI tools are best understood as a powerful supplement to, rather than a replacement for, classroom instruction.

Section-Wise Consistency of Gains

The section-wise analysis reinforces this interpretation by showing that the experimental group's advantage was not confined to a single component of the vocabulary test. Near-ceiling performance across all six sections—covering recognition, synonym/antonym knowledge, matching, and contextual use—indicates that AI-assisted instruction supported comprehensive lexical development rather than narrow, test-specific gains, a pattern that strengthens confidence in the overall effectiveness of the intervention.

Attitudes and Opinions of Learners about AI Tools (Objective 3)

The third objective concerned learners' attitudes toward AI-assisted vocabulary learning. The strongly positive questionnaire results (72.0% agreement overall) echo findings by Javahery and Alizadeh (2025), Wei (2023), and AlTwijri and Alghizzi (2024), all of which link AI use to increased motivation, engagement, and reduced learning anxiety. The alignment between learners' positive attitudes and their measurable achievement gains is consistent with autonomy-mediation accounts offered by Ali et al. (2024) and Alizadehmahmoudalilo (2025), which suggest that AI tools support vocabulary learning partly by fostering a greater sense of learner control and self-directed engagement. At the same time, the presence of neutral and negative responses on every questionnaire item—though a clear minority—echoes cautions raised by Jomaa et al. (2024) and Elmahdi et al. (2025) regarding uneven digital literacy, unequal access, and variable trust in AI-generated content, reinforcing the view that successful integration of AI into vocabulary instruction depends on adequate teacher mediation, training, and institutional support.

Contribution to the Literature

These findings extend the AI-vocabulary literature to an underrepresented population—Pakistani BS-level EFL learners—using the comparative experimental methodology called for by Yilmaz (2025) and Zawacki-Richter et al. (2019), while combining achievement and attitude data within a single research design, as recommended by

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Yang (2025) and AlTwijri and Alghizzi (2024). In doing so, the study addresses the population, methodological, and integration gaps identified in the reviewed literature, and provides empirical evidence directly relevant to the design of AI-assisted vocabulary instruction in Pakistani higher education.

Conclusion, Recommendations, and Limitations

Conclusion

This study set out to examine the effect of AI-assisted vocabulary instruction on BS-level English language learners, to compare its effectiveness with conventional instruction, and to assess learners' attitudes toward its use. The results support all three hypotheses: the experimental group showed a substantial pretest-to-posttest gain (H1), significantly outperformed the control group at posttest (H2), and reported predominantly positive attitudes toward AI-assisted learning (H3). AI-assisted instruction was associated with vocabulary gains that were larger, more consistent across learners, and more evenly distributed across the components of the vocabulary test than gains achieved through conventional instruction alone. These findings position AI as an effective complement to, rather than a substitute for, teacher-led vocabulary instruction at the tertiary level.

Recommendations

English language teachers should consider integrating selected AI-assisted vocabulary tools into classroom practice to extend limited instructional time, offering learners personalized practice, instant feedback, and support for independent learning outside class hours; doing so effectively requires appropriate teacher training in tool selection and guided use. Educational institutions should invest in the technological infrastructure and connectivity needed to support AI-assisted language learning and offer professional development to help teachers integrate such tools systematically rather than in an ad hoc manner. Curriculum developers should consider embedding AI-supported vocabulary tasks as supplementary components of undergraduate English courses, ensuring that such tasks remain aligned with course learning outcomes. Learners, in turn, should treat AI-assisted vocabulary tools as a means of extending, rather than replacing, classroom instruction, using them for regular independent practice and to track their own progress.

Limitations

Several limitations qualify these findings. The sample was drawn from a single cohort of seventh-semester BS English students at one university, which limits generalizability to other levels, disciplines, or institutions. The six-week intervention window permits conclusions about short-term vocabulary gains but not about long-term retention. The reliability coefficient obtained for both instruments ($\alpha = .086$) fell well below conventionally accepted thresholds for internal consistency; although both instruments demonstrated content validity through expert review, this low reliability represents an acknowledged methodological limitation that should temper confidence in the precision of the reported measurements. In addition, the study examined vocabulary development in isolation from other language skills, and the open-ended questionnaire responses were not analyzed thematically in this report, limiting insight into the qualitative texture of learners' experience with AI-assisted instruction.

Suggestions for Future Research

Future research should extend this design across multiple universities and regions of Pakistan to test the generalizability of the present findings, and should employ longitudinal designs to examine whether AI-assisted vocabulary gains are retained over longer timeframes. Further studies could isolate the effects of specific AI tools—intelligent tutoring systems, chatbots, adaptive platforms, and mobile applications—to identify which features contribute most to vocabulary development, and could examine the effects of AI-assisted

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instruction on other language skills such as reading, writing, speaking, listening, and grammar. Mixed-methods designs incorporating interviews, classroom observation, and learner journals would also help capture the qualitative dimensions of learners' experience with AI-assisted vocabulary instruction that quantitative measures alone cannot fully reveal.

Overall, this study indicates that careful, evidence-based, and teacher-mediated integration of AI can meaningfully strengthen vocabulary instruction at the tertiary level in Pakistan and comparable EFL contexts, without displacing the central pedagogical role of the classroom teacher.

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