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AI-ENHANCED VOCABULARY TOOLS AND THEIR IMPACT ON ACADEMIC WRITING DEVELOPMENT AMONG EFL COLLEGE STUDENTS

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Abstract

This research paper examines how AI vocabulary tools affect the academic writing skills of EFL college students. The research design combines quantitative and qualitative methods to evaluate writing assessment results, vocabulary quiz outcomes, and student feedback before and after the intervention. The intervention employs adaptive AI systems which provide immediate lexical suggestions and domain-specific customization combined with metalinguistic explanations for authentic coursework and self-directed learning activities. The research shows significant progress in three main areas, which cover both lexical variety and exact word choice, cohesive structure, and student engagement through customized tools and teamwork capabilities. Research indicates that students need AI tools together with human instructor guidance to develop critical thinking skills while avoiding excessive dependence on technology. The study examines three main obstacles to digital transformation, which consist of digital literacy deficits, unbalanced technology and digital resource availability, and ethical problems that need ongoing support and proper regulatory frameworks. The study reveals implications for curriculum development, which supports the use of AI-enhanced language learning tools throughout language skills and subject areas, while identifying research directions for studying AI tool retention, scalability, and cultural adaptability.

***Keywords*:** Artificial Intelligence (AI), AI-powered vocabulary tools, EFL academic writing, Lexical diversity, Automated writing feedback, Language learning technology

Introduction

Artificial intelligence (AI) has made significant changes to English as a Foreign Language (EFL) teaching method, which focuses on vocabulary development, writing skills, and student participation. AI tools enable students to receive immediate assessments, customized learning routes, and interactive tasks that may help them build writing skills and vocabulary through individualized feedback and practice opportunities ((Phanwiriyarat et al., 2025). For example, gamification elements integrated into these platforms help reduce linguistic anxiety and sustain motivation, although their integration with traditional pedagogical frameworks requires further investigation (Phanwiriyarat et al., 2025).

From another angle, AI-driven feedback systems like Grammarly improve linguistic accuracy and sentence clarity, supporting overall writing quality (Guendouz

et al., 2024). Students can improve their vocabulary, writing skills, and build their learning confidence through the use of Generative AI tools, such as ChatGPT, when teachers provide guidance (Baskara et al., 2024; Tran, 2025). Research studies in Vietnam, together with other areas, show students learn better self-directed skills and motivation, but face problems with privacy protection, content standards, and skill maintenance (Ngo, 2024; Nhan et al., 2025). The research indicates that students perform better in grammar and coherence, but experts disagree about the adverse effects of algorithm dependency because it may restrict students from developing critical thinking and creative abilities(Nhan et al., 2025; Ya'u & Mohammed, 2025). Future research must analyze the potential of AI-based systems to collaborate with human teachers for developing optimal English as a foreign language teaching approach. The current study examines how AI vocabulary tools affect the academic writing skills of EFL college students in the Saudi Arabian context.

Background and Theoretical Foundations

The Role of Vocabulary in EFL Academic Writing

The development of EFL academic writing depends on two essential components of vocabulary knowledge which include *breadth* and *depth* of word understanding (Haque et al., 2024). *Breadth* allows learners to explore diverse topics, while *depth* supports precise, discipline-specific expression and the creation of grammatically correct, persuasive arguments (Hossain et al., 2025). The study by Haque et al. shows that learning vocabulary through context-based methods produces better results than memorization by rote (Haque et al., 2024), and digital tools, including ChatGPT and Quillbot, enhance these benefits through their instant feedback about word choices, writing structure, and sentence arrangement (Hossain et al., 2025; Ngo, 2024; Shahdid Siswanto et al., 2025; Tran, 2025) (Ngo, 2024; Siswanto et al.,2025; Tran, 2025.

Furthermore, the AI tools enable students to build metalinguistic awareness together with critical thinking skills (Chuanpipatpong, 2025; Tran, 2025). However, teachers need to maintain their role in teaching direct instruction for hedging, evaluative language, and academic authority. Lexical diversity is key to clarity and persuasiveness (Haque et al., 2024). The study by Khampusaen (2025) shows that the language is still in use today and that not understanding it can result in incorrect interpretation and communication breakdowns. Students require authentic tasks and teacher feedback to enhance their writing abilities because they rely on automated structures, as Tran (2025) points out. The detection of informal speech and repetitive language by AI systems does not replace the need for authentic tasks and teacher feedback which students need to build enduring writing improvement skills. The main problems in the current study consist of polysemy, idiomatic expressions, phrasal verbs, and short-term program retention (Pitura, 2024; Pondelíková & Luprichová, 2024). Affective factors such as anxiety and limited autonomy further restrict growth(Haque et al., 2024; Ngo, 2024). The research by Ngo (2024) showed that traditional grammar-based tests do not effectively measure lexical development (Ngo, 2024). Effective instruction, therefore, combines direct vocabulary teaching with contextual practice and positive teacher feedback to build critical thinking (Mekheimer, 2025; Pitukwong & Saraiwang, 2024; Tran, 2025).

Artificial Intelligence in EFL Language Education

AI technology in EFL education delivers personalized feedback to students based on their unique learning requirements. The tools Grammarly, Write & Improve, and ChatGPT

provide students with instant formative assessment that enables them to become more independent learners (Nabila & Erliani, 2025; Ngo, 2024; Nhan et al., 2025). The research by Phanwiriyarat et al. (2025) demonstrates how gamification systems with chatbots establish motivational frameworks which help users develop genuine social bonds (Ngo, 2024). Additionally, mobile/web platforms make learning accessible to everyone by removing all barriers to education. The implementation of AI systems creates privacy threats and digital resource disparities because of varying technical abilities and produces superficial learning outcomes because of excessive dependence on automated assessment methods (Jomaa et al., 2025).

Educational frameworks such as SAMR and structured teacher development programs should be used to implement sustainability integration according to Muslimin et al. (2024). Adaptive algorithms deliver individualized learning paths and discipline-specific vocabulary through real-time performance analysis (Wang et al., 2024; Wu et al., 2024). The combination of gamified microlearning with scenario-based tasks, according to Haque et al. (2024), enables learners to decrease their anxiety while learning vocabulary through incidental learning (Phanwiriyarat et al., 2025). The dialogic tools, Grammarly and ChatGPT, enhance both lexical diversity, cohesion, and syntactic complexity according to Mekheimer (2025), Haque et al. (2024), and Alghasab (2025). Personalized modules and affective computing systems enhance engagement and adaptive challenge delivery (Mekheimer, 2025; Phanwiriyarat et al., 2025). Collaborative pairing, on the other hand, enables authentic practice (Alghasab, 2025; Al-Raimi et al., 2024). Yet meaningful skill acquisition still depends on human oversight and reflective prompts ((Mekheimer, 2025).

Pedagogical Perspectives and Ethical Considerations

Traditional rote-based vocabulary instruction produces short-term receptive learning, but it does not lead to deep semantic understanding (Haque et al., 2024; Wang et al., 2024). Students benefit from AI technology integration in learning spaces through mobile learning platforms and interactive glossaries that deliver personalized feedback which helps them maintain information retention and work independently (Mekheimer, 2025; Nabila & Erliani, 2025; Ngo, 2024; Wang et al., 2024). Student-centered methods have become the standard approach which trains teachers to act as mentors who help students learn AI applications and self-assessment techniques (Al-Raimi et al., 2024; Nhan et al., 2025; Pondelíková & Luprichová, 2024). Gamification and spaced repetition techniques help students stay motivated (Mekheimer, 2025; Pondelíková & Luprichová, 2024; Wang et al., 2024). Effective prompting skills and equitable access remain critical (Chen, 2024; Jamshed et al., 2024).

AI system ethical deployment needs three essential components, which include robust data protection systems, academic honesty rules, and scheduled bias detection methods (Baskara et al., 2024; Kohnke & Ulla, 2024; Mabuan, 2024). Teacher training in AI-result interpretation and reflective, metacognitive instruction safeguards independence and critical thinking while maintaining fairness and privacy (Mabuan, 2024). AI integration in EFL education requires a combination of technological advancement and human oversight and ethical management to achieve better vocabulary development, academic writing skills, and equal learning opportunities.

Literature Review

Vocabulary Development in EFL Contexts

Non-native English learners encounter ongoing difficulties when they try to pick suitable words and create logical connections between ideas and follow the rules of their academic field (Khampusaen, 2025). Students who learn to use collocations and idiomatic expressions and polysemous terms can develop advanced syntactic variation, cohesive devices, and evaluative lexis which enables them to express complex ideas and show academic authority (Haque et al., 2024; Hossain et al., 2025). Specialized terminology serves as a fundamental requirement for both scientific and humanities writing because it helps establish credibility according to Haque et al. (2024). The processes of drafting, revising, and editing need proper lexical control, which AI tools support through their ability to suggest appropriate word choices (Aldossary, 2025; Mekheimer, 2025). The acquisition of discipline-specific vocabulary presents major cognitive obstacles for EFL students according to Wu et al. (2024) and Khampusaen (2025).

The development of vocabulary faces three main obstacles, which include instructional barriers, cognitive limitations, and affective challenges. Firstly, students can identify words through traditional list-based drills. However, these methods do not teach them to use words in practical situations (Haque et al., 2024; Pondelíková & Luprichová, 2024). Idiomatic expressions and discipline-specific jargon often elude durable retention when programs lack authentic practice (Pitura, 2024). Secondly, students choose familiar words because their anxiety levels and limited control over their learning process stop them from building their vocabulary (Ngo, 2024). Thirdly, natural language acquisition encounters two types of obstacles which include socio-cultural factors and knowledge domain limitations according to Khampusaen (2025) and Pondelíková & Luprichová (2024). The problems will become more severe because people who lack digital literacy skills and heavily rely on automated tools struggle to perform deep semantic processing (Jomaa et al., 2025; Yuniasih et al., 2025).

Students can learn new vocabulary through various teaching methods. The combination of authentic speaking and listening activities with spaced repetition techniques leads to better long-term retention of information (Haque et al., 2024; Wu et al., 2024). AI-driven adaptive review systems adjust reinforcement intervals based on the unique learning pace of each student (Haque et al., 2024; Wu et al., 2024). Students can use low-stakes interactive tools in Quizlet and Duolingo's learning environment for independent learning which helps them manage their anxiety levels (Jomaa et al., 2025; Phanwiriyarat et al., 2025). The combination of AI glossaries with image-based definitions and audio-visual text through multimodal methods leads to better understanding according to Haque et al. (2024) and Wu et al. (2024). The combination of AI-based collaborative writing tools and performance-tracking systems helps students develop their metalinguistic abilities and subject-specific terminology (Aldossary, 2025; Al-Raimi et al., 2024; Wu et al., 2024). Educational programs that teach contextual learning methods, analytical practice, and task-based application help students achieve academic discourse standards and lasting lexical development (Haque et al., 2024).

AI-Assisted Vocabulary Tools and Writing Skills

EFL instruction that incorporates AI vocabulary tools enables students to enhance their writing abilities through interactive learning activities which deliver immediate feedback for improvement. ETS Criterion and Grammarly operate automated grammar and vocabulary

assessment systems through their platforms. Grammarly uses these platforms to provide immediate feedback for enhancing word choice and sentence structure (Al-Raimi et al., 2024; Pitura, 2024). According to Alghasab (2025), students can learn vocabulary through real-life situations when they use dialogic tutoring with ChatGPT as a generative model to improve their writing skills. These systems create individualized practice paths for learners based on their performance data (Nhan et al., 2025; Pitura, 2024). Furthermore, the hybrid platforms provide students with adaptive reading features and glossaries which help them discover vocabulary through accidental learning and purposeful learning (Muslimin et al., 2024).

Mobile gamified trainers and collaborative AI editors heighten engagement and metalinguistic awareness through peer review and interactive challenges (Al-Raimi et al., 2024; Wang et al., 2024). During the learning process, the writing process receives instant feedback from AI tools, which also provides recommendations for academic synonyms (Mekheimer, 2025). The system allows teachers to monitor student development through analytics dashboards and offers multiple vocabulary support tools, which include clickable glossaries, audio pronunciation, and visual examples (Alghasab, 2025; Kohnke & Ulla, 2024; Phanwiriyarat et al., 2025; Wang et al., 2024; Wu et al., 2024). These systems implement mechanical correction to help students learn independently while practicing reflection (Mekheimer, 2025; Muslimin et al., 2024).

Research evidence shows that AI tools enhance lexical diversity, grammatical accuracy, and organizational coherence when teachers provide guidance. The studies by Khampusaen (2025) and Ya'u & Mohammed (2025) show that using Grammarly as a tool for writing regularly results in better type–token ratio and syntactic precision. AI explanations help users improve their self-correction and argument organization but excessive dependence on these tools results in repetitive output (Mekheimer, 2025; Nhan et al., 2025). The implementation of AI systems decreases student anxiety while boosting their confidence but teacher training programs continue to play a vital role in helping students develop critical thinking and evaluation competencies (Utami et al., 2023; Wu et al., 2024; Ya'u & Mohammed, 2025). Students will develop advanced vocabulary and technical precision in their zones of proximal development through authentic tasks that teach discipline-specific content according to sociocultural theory (Alghasab, 2025; Muslimin et al., 2024). AI systems enhance the prewriting process through draft organization yet teachers must create pedagogical scaffolding to connect technological efficiency with advanced rhetorical goals (Mekheimer, 2025).

Student Engagement and Perceptions of AI in Learning

Students learning English as a Foreign Language show positive reactions to AI-based vocabulary and writing tools because these systems offer interactive, personalized feedback in real time (Chen, 2024; Phanwiriyarat et al., 2025; Shahdid Siswanto et al., 2025). The systems allow flexible short study sessions through their mobile-friendly design and gamified elements of points and leaderboards, and contextual synonym explanations according to Wu et al. (2024) and Guendouz et al. (2024). This boosts both motivation and trust levels. Students value self-paced learning autonomy most when they do not have enough classroom time (Shahdid Siswanto et al., 2025; Utami et al., 2023). The system achieves better student motivation and context understanding

through its integration of peer feedback with social interaction features (Al-Raimi et al., 2024; Phanwiriyarat et al., 2025).

Students have expressed two main worries about AI writing tools according to Guendouz et al. (2024) and Mekheimer (2025). The students worry that using AI tools too much will lead to repeated language patterns and lower their ability to think critically (Guendouz et al., 2024; Mekheimer, 2025). People establish trust in AI systems through three fundamental factors which consist of delivering precise content and showing system performance and being sensitive to cultural differences (Chen, 2024; Guendouz et al., 2024). People use technology based on their digital competencies and device accessibility during training programs which build their self-assurance and digital optimism (Ngo, 2024). Online learning adoption requires three fundamental elements which consist of dependable internet connectivity and affordable technology solutions and accessible software platforms (Jomaa et al., 2025; Phanwiriyarat et al., 2025). Skilled students can critically evaluate AI feedback and adjust learning strategies (Mekheimer, 2025; Ngo, 2024), while academic relevance drives tool selection (Wu et al.,2024). Educational games integrated into learning management systems create lasting student involvement according to Nhan et al. (2025) and Wang et al. (2024).

Teachers hold essential roles because they need to establish reflective work and AI implementation as core components of their teaching responsibilities (Nhan et al., 2025). Gamification tailored to learner preferences sustains motivation (Utami et al., 2023). The way people view privacy settings affects their willingness to take risks because risk-averse students use these settings to try new things (Al-Raimi et al., 2024; Chen, 2024). The way people experience AI systems determines their trust levels in AI systems while affecting their adoption of new AI-based applications (Khampusaen, 2025). The implementation of institutional support through licensing and curriculum integration and data policy clarity helps solve privacy concerns (Baskara et al., 2024).

Ethical considerations remain paramount. The automated paraphrasing tools according to Hossain et al create plagiarism opportunities that endanger academic integrity (Ya'u & Mohammed, 2025). Overreliance risks formulaic writing and undermines independent thought, making reflective assignments and human oversight vital (Guendouz et al., 2024; Kohnke & Ulla, 2024; Mekheimer, 2025). Organizations must create robust data protection systems and intellectual property security protocols and governance frameworks to execute responsible AI implementation according to Baskara et al. (2024). Teachers need to support AI integration in education through balanced methods which ensure all students obtain equal access to technology and training about ethical AI usage to develop vocabulary and critical thinking skills without limiting student freedom or academic integrity.

Gaps in Existing Research

The majority of research about AI-based EFL instruction examines general language development rather than academic writing skills. Research studies investigate basic language learning results, such as grammar precision and speaking ability, but they fail to track how language education affects specialized terminology, cohesive argumentation, and evaluative stance (Nabila & Erliani, 2025; Nhan et al., 2025; Ya'u & Mohammed, 2025). The evaluation of writing tools that offer synonym suggestions and basic correction features happens through general writing quality metrics, which hide their effects on advanced academic abilities, including hedging, source integration, and thematic development (Chen, 2024; Wu et al., 2024).

The general indicators generate incorrect results because they assess mechanical precision and word selection but fail to show progress in rhetorical competence and organizational skills (Nhan et al., 2025; Ya'u & Mohammed, 2025). Students who depend on AI feedback for editing will develop fewer metalinguistic abilities and problem-solving competencies because they follow suggestions without doubt and fail to develop their own editing techniques (Nabila & Erliani, 2025). The research uses multiple assessment techniques, which demonstrate that students who possess advanced digital competencies and writing experience do not perform at the same level as new students, even though they demonstrate superior academic register abilities (Wu et al., 2024).

The research field requires vocabulary-based interventions which go beyond conventional grammar and fluency assessment methods to handle present-day difficulties. AI tools today improve mechanical writing and basic vocabulary diversity, but they do not enhance semantic accuracy, collocational diversity, or suitable register application, which are vital for academic writing (Khampusaen, 2025; Pitura, 2024). Targeted programs should incorporate adaptive spaced-repetition models that reinforce advanced terms across diverse contexts, while AI platforms could track word usage and create customized review materials for discipline-specific tasks (Wang et al., 2024; Wu et al., 2024). Specialized vocabulary modules, integrated word banks, and authentic rhetorical exercises would promote deeper lexical understanding and long-term retention, especially when paired with peer interaction and reflective evaluation of AI-generated suggestions (Aldossary, 2025; Phanwiriyarat et al., 2025; Tran, 2025). The combination of audio pronunciations and visual examples in multimodal resources helps students manage their mental workload, and gamification systems with balanced features and collaborative elements help students stay motivated while maintaining inclusivity (Mekheimer, 2025; Ngo, 2024; Phanwiriyarat et al., 2025).

The assessment of writing results faces additional difficulties as a major obstacle. The assessment of AI effects on vocabulary expansion requires sophisticated evaluation techniques to distinguish between vocabulary development and other language learning processes. The type–token ratio (TTR) and other common metrics demonstrate high sensitivity to text length and genre which results in possible incorrect interpretations of surface-level word variety (Khampusaen, 2025). The results of frequency analysis become exaggerated when students substitute common words with less common synonyms (Pitura, 2024). Reliable assessment needs three methods to evaluate writing performance through delayed testing for retention assessment and dual-evaluation designs that compare AI-assisted writing to independent writing and mixed-effects statistical models to manage participant and task differences (Wu et al., 2024; Ya'u & Mohammed, 2025). The detection of rhetorical coherence by automated systems requires human evaluation or hybrid approaches because these systems lack sufficient ability to perform this task (Alghasab, 2025; Mekheimer, 2025). The analysis of motivational factors through gamification faces challenges because researchers need to work within privacy restrictions which limit their ability to gather data (Al-Raimi et al., 2024; Phanwiriyarat et al., 2025).

The research literature demonstrates that scientists need to develop exact research methods which combine sophisticated statistical techniques with complete user data collection and proper ethical protection mechanisms. The proposed methods would exceed basic language enhancement metrics to show how AI feedback affects student learning of academic vocabulary and their development of argumentation skills and scholarly writing abilities (Mekheimer, 2025; Phanwiriyarat et al., 2025; Ya'u & Mohammed, 2025).

Research Methodology

This section describes the research design which shows how AI vocabulary tools affect EFL students' academic writing performance. It outlines the research design together with participant selection methods, intervention approaches, data collection methods, analytical approaches, and ethical protection measures to guarantee research validity, reliability, and reproducibility.

Research Design and Rationale

The research used a mixed-methods design which integrated quantitative and qualitative methods to measure language progress and understand student experiences. The previous measurement problems in Quantitative analysis were solved by using statistical methods to analyze lexical diversity, accuracy, and engagement indicators (Guendouz et al., 2024). The researchers conducted automated corpus tool analysis and human rater evaluation of pre- and post-test essays that had equivalent genre and difficulty levels to assess type–token ratio (TTR) and terminology patterns and error frequency assessment (Mekheimer, 2025; Santillán-Iñiguez & Rodas-Pacheco, 2022).

The researcher used semi-structured interviews and focus groups to obtain qualitative data about AI dependency, style consistency, and usability (Kohnke & Ulla, 2024; Tran, 2025). The researchers used this combined system to monitor student behavioral patterns against their language development progression which provided exact data about AI tool performance in actual classroom settings (Guendouz et al., 2024; Ya'u & Mohammed, 2025).

Participant Profile and Recruitment

The research involved undergraduate EFL students who reached intermediate to advanced language proficiency levels according to institutional evaluation results. The research used stratified sampling to get a representative sample of three academic fields which need different vocabulary levels (Wu et al., 2024). The researcher worked with instructors to explain study goals, privacy measures, and withdrawal options in order to prevent coercion (Baskara et al., 2024).

The research used Stratified and purposive sampling to achieve a balance between gender, discipline, and digital confidence and technology attitudes (Guendouz et al., 2024; Phanwiriyarat et al., 2025; Utami et al., 2023). Onboarding sessions equalized AI familiarity and trust, while attendance and engagement were monitored to maintain data integrity (Wang et al., 2024).

AI Vocabulary Tools and Intervention Strategies

The researcher chose two AI tools because they offer context-based synonym recommendations, repetition identification, and domain-related vocabulary assessment (Mekheimer, 2025; Wu et al., 2024). The research by Alghasab (2025), Chen (2024), and Phanwiriyarat et al. (2025) shows that generative conversational systems help users at all stages

of writing, from brainstorming to revision, while providing mobile access and low-bandwidth operation, and cloud-based logging with privacy protection (Baskara et al., 2024).

The training program used a systematic educational approach which combined group learning with personal learning activities (Mekheimer, 2025; Wang et al., 2024). The research by Wu et al. (2024) demonstrated that students learn synonym creation through demonstrations which enable them to understand context and adjust language register and receive metalinguistic feedback for subject-based tasks. Students took part in multiple workshop sessions and regular gamified challenges that applied spaced repetition to boost their semantic accuracy and syntactic flexibility, according to studies by Baskara et al. (2024), Tran (2025), and Ngo (2024).

Personalization was achieved through diagnostic assessments that set individualized learning paths, continuous tracking of synonym requests and acceptance rates, and integration of discipline-specific term banks (Phanwiriyarat et al., 2025; Wang et al., 2024; Wu et al., 2024). Students maintained their engagement through privacy-protecting analytics and reflective prompts and adaptive spaced repetition systems which also helped them build critical thinking skills and learn ethical technology use (Alghasab, 2025; Kohnke & Ulla, 2024).

Data Collection Procedures

The study used three separate methods to obtain its data, an essay, a vocabulary quiz, and a questionnaire. The participants wrote 350–400-word argumentative essays in controlled testing conditions to assess changes in their lexical diversity (TTR, MTLD) and grammatical accuracy and error rates and cohesion (Aldossary, 2025; Khampusaen, 2025; Nhan et al., 2025; Ya'u & Mohammed, 2025).

The assessment tools tested vocabulary skills through recognition tasks, sentence completion, and free composition with vocabulary quizzes and lexical analysis. Computational lemmatization and diversity metrics were verified by human raters for collocational accuracy and discourse coherence (Alghasab, 2025; Khampusaen, 2025; Wang et al., 2024).

The researcher used surveys together with qualitative feedback from students to evaluate their perceptions at both the mid-point and post-intervention stages for assessing user experience, confidence levels, and intervention relevance. The study employed hybrid thematic coding for reliability to analyze the qualitative data which came from follow-up interviews (Mekheimer, 2025; Pitukwong & Saraiwang, 2024; Wu et al., 2024).

Data Analysis Methods

The research used repeated-measures designs for quantitative analysis to evaluate changes in lexical diversity, grammatical accuracy, and cohesion. Furthermore, it employed paired-samples t-tests together with Wilcoxon signed-rank tests to evaluate pre-post changes and MANOVA and mixed-model ANOVAs to study multiple variable effects and proficiency level interactions (Aldossary, 2025; Phanwiriyarat et al., 2025; Wang et al., 2024; Wu et al., 2024). The research used Linear mixed-effects models to study how participants developed throughout the study period.

The researcher conducted thematic coding analysis of user experiences through member checking to identify themes and motivational factors while combining

qualitative data with quantitative results for triangulation (Alghasab, 2025; Mekheimer, 2025; Muslimin et al., 2024; Nhan et al., 2025). Multiple data sources used for triangulation validated statistical results through their conflicting examples which combined to create a complete understanding of AI tool effects.

Ethical Considerations

All participants provided their consent before beginning the study while keeping the freedom to withdraw from the study whenever they wanted. The researchers anonymized all data while using encryption for protection before storing it in secure systems (Hossain et al., 2025; Muslimin et al., 2024). Media outlets focused on third-party AI platform privacy practices while students learned about stress reduction from technology and how to prevent plagiarism and technology addiction (Kohnke & Ulla, 2024; Ya'u & Mohammed, 2025). The research followed international research standards because the study received oversight from the institutional ethics review board (Baskara et al., 2024; Mabuan, 2024).

Results and Discussion

Descriptive Statistics of Participant Data

The participant group consisted of 160 EFL undergraduates who showed academic and demographic diversity because of the recruitment methods explained in Section 4.2. The gender distribution showed a balanced pattern because males outnumbered females by a small margin which matches research findings about classroom participation that show males make up 55% of participants. As Table 1 shows, the majority of students fell within the 19 to 22 age range, while students from older age groups made up a smaller portion. The majority of participants were upper-year students who had experienced more discipline-specific writing requirements, according to previous studies (Alghasab, 2025). The research study used participants from business studies, engineering, and computer science colleges to evaluate AI tool performance with their specific vocabulary modules (Wu et al., 2024). The baseline proficiency assessment through institutional placement showed that all participants had CEFR levels between intermediate and advanced which led to their distribution into three subgroups at mid-B1 and B2 and C1 levels for further evaluation. The study revealed that participants had basic software application competencies, but their understanding of AI-assisted systems varied because 67% of participants felt comfortable with online tools and 89% were already familiar with AI writing assistance as defined in previous research (Alghasab, 2025; Milton et al., 2024). The research found that users faced two main barriers to participation because they lacked equal access to shared devices and experienced unstable internet connectivity which required the development of low-bandwidth tools and institutional backing (Jomaa et al., 2025). The researcher used a diverse participant group to determine how AI-based vocabulary training performs for students who have varying learning abilities, technology proficiency, and home access to technology.

Table 1

Descriptive Characteristics of Participants

Variable	Value
Sample size (N)	160
Gender: Male (%)	56
Gender: Female (%)	44

Age: 19–22 (%)	76
Age: >22 (%)	24
Discipline: Business (%)	24
Discipline: Engineering (%)	36
Discipline: Computer science (%)	40
CEFR: B1-mid (%)	18
CEFR: B2 (%)	58
CEFR: C1 (%)	24
Digital literacy: Confident with ed-tech (%)	66
Prior AI writing tool awareness (%)	89
Prior AI writing tool deep use (%)	28
Paid subscription users (%)	17
Own laptop meeting specs (%)	81
Intermittent device access (%)	19
Stable internet off-campus (%)	78
Attendance <10% absenteeism (%)	92
Weekly formal English study (median hours)	5

Note. Values are percentages unless otherwise indicated. CEFR = *Common European Framework of Reference.*

Changes in Writing Performance

Lexical Diversity Improvements

The comprehensive analysis of pre- and post-intervention writing samples demonstrates significant enhancements in lexical diversity among learners engaging with AI-powered vocabulary tools. As table (2) indicates, the TTR and MTLD results show that students made continuous progress through their writing since their output length increased and their vocabulary usage became more varied. The students used fewer words from the General Service List (GSL) core vocabulary at high frequency while they used more words from the Academic Word List (AWL) and mid- and low-frequency academic terms. The intervention team introduced these changes to enable students to reach their main objectives of generating synonyms and spotting repeated words which led students to use complex technical terms that did not exist in their first drafts (P<.001). The results support Khampusaen's (2025) findings that there is significant enhancement in writing performance, with the most substantial improvements in academic integrity (p.963). The research shows that students developed their vocabulary through better use of collocations and appropriate bigram and trigram combinations after receiving feedback about their correct and contextually appropriate word pairings, as referred to byMekheimer (2025).

The research results received support from automated discourse analysis which showed that using particular terms instead of broad terms leads to improved thematic development, better vocabulary range, and formal writing style. The study demonstrates that students who possess higher proficiency levels gain more advantages from domain-specific feedback, but spaced-retrieval quiz reinforcement benefits all students regardless of their proficiency level. Students achieve better confidence and attempt

new vocabulary when working in groups, according to Guendouz et al. (2024)Guendouz and Al-Raimi et al. (2024), because analytics integration with qualitative feedback shows that reflective engagement works effectively. The student results show potential but need teacher oversight because they selected words based on appearance instead of meaning which might result in incorrect academic writing usage. Overall, the convergence of automated metrics, human evaluations, and learner perceptions affirms that structured AI-assisted vocabulary interventions can substantively enhance lexical diversity in academic writing, provided they are integrated within pedagogically guided frameworks that emphasize semantic precision and contextual relevance (Alghasab, 2025; Mekheimer, 2025).

Table 2

Lexical Diversity Metrics, Pre- and Post-Intervention

Metric	Pre_Mean	Pre_SD	Post_Mean	Post_SD	Cohen d	p
TTR	**0.43**	**0.06**	**0.51**	**0.07**	**1.23**	**< .001**
MTLD	**73.0**	**12.0**	**92.0**	**13.0**	**1.52**	**< .001**
GSL share (%)	**66.0**	**8.0**	**54.0**	**9.0**	**-1.41**	**< .001**
AWL share (%)	**7.5**	**2.5**	**12.2**	**3.0**	**1.7**	**< .001**
Mid/Low frequency share (%)	**27.0**	**7.0**	**33.8**	**8.0**	**0.9**	**< .001**
Valid Academic Collocations per 1000w	**22.0**	**6.0**	**33.0**	**7.5**	**1.62**	**< .001**

Note. TTR = Type–Token Ratio; MTLD = Measure of Textual Lexical Diversity; Cohen d computed with pooled SD; p values are thresholds.

Accuracy in Vocabulary Usage

Academic writing instruction has achieved better lexical accuracy, semantic precision, and register conformity through the implementation of AI-based feedback systems. The research shows that quantitative evidence proves error reduction in lexical usage results in enhanced micro-level sentence clarity and macro-level discourse coherence, according to Mekheimer (2025) and Ya'u & Mohammed (2025). The system detected L1 interference through real-time composition prompts which then offered suitable alternatives with explanations to help students understand the correct usage. The explanations about register and collocational constraints helped students develop reflective thinking, which resulted in better retention of lexical knowledge and enhanced writing accuracy in their following assignments, as is the case in Alghasab's(2025) study.

The research showed that students used discipline-specific collocations more frequently through corpus-based analysis which included "high tensile strength" in engineering texts because the tailored lexicon modules helped them learn domain-specific vocabulary (Wu et al., 2024). Engagement with explanatory content and the acceptance of suggestions correlated positively with accuracy gains, emphasizing the importance of active learner participation in feedback processes (Wang et al., 2024). Students face two primary challenges when learning vocabulary through reading: they fail to retain new words, and they select easy words instead of challenging vocabulary, which hinders their writing style growth (Phanwiriyarat et al., 2025; Pitura, 2024). The research demonstrates that AI-based interventions with structured methods

that teach reflective learning and domain-specific content enable students to enhance their academic writing abilities through improved lexical accuracy and register appropriateness, which results in advanced EFL writing competencies.

Table 3

Vocabulary Accuracy Metrics, Pre- and Post-Intervention

Metric	Pre_Mean	Pre_SD	Post_Mean	Post_SD	Cohen d	p
Error-free clauses (%)	74.0	8.0	83.0	7.5	1.16	< .001
Lexical error rate per 1000w	28.0	9.0	16.5	7.5	-1.39	< .001
Inappropriate register incidents per 1000w	7.5	3.5	3.6	2.4	-1.3	< .001
Incorrect POS choice per 1000w	9.2	4.0	5.0	3.2	-1.16	< .001
Atypical collocations per 1000w	11.8	4.5	6.4	3.6	-1.33	< .001
Correct domain terms per 1000w	18.0	6.0	28.0	7.0	1.53	< .001

Note. Negative change in error metrics reflects improvement. POS = Part of Speech; Cohen d computed with pooled SD.

Writing Coherence and Organization

Student essay analysis (Table 4) shows that AI vocabulary tools create better global coherence and organizational control through their continued use before and after intervention. As demonstrated in Alghasab's (2025) findings, the study shows students use more cohesive devices in their writing as they move from simple "and" and "but" to sophisticated connectors, which include "consequently", "nevertheless", and "in addition". The text reaches better logical connections and rhetorical diversity through its wide range of vocabulary which leads to more effective argumentation. The thematic progression between paragraphs shows better alignment of focus statements with supporting details, which results in fewer off-topic sections and abrupt transitions, according to Alwasidi & Al-Khalifah (2025), who discovered that AI prompts detect unrelated content and produce alternative topic sentences. Students achieve better structural coherence through generative pre-writing tools which pair with collaborative features that use lexical prompts and peer models to improve their discourse organization abilities (Al-Raimi et al., 2024; Wang et al., 2024).

Furthermore, the human raters agree with these results because the paper shows enhanced purposeful paragraph organization and exact semantic connections between sentences, which result in better scores for coherence and organizational structure. These findings chime well with Ya'u & Mohammed (2025). Students maintain their use of linear list-based writing despite new writing instruction methods because teachers need to develop creative teaching methods for students to grasp sophisticated text

structures. Overall, the convergence of quantitative metrics, engagement analytics, and qualitative assessments underscores the efficacy of AI-mediated vocabulary and organizational support in enhancing academic writing within EFL contexts, especially when combined with reflective and collaborative practices (Alghasab, 2025; Al-Raimi et al., 2024).

Table 4

Coherence and Organization Indicators, Pre- and Post-Intervention

Metric	Pre_Mean	Pre_SD	Post_Mean	Post_SD	Cohen d	p
Cohesive devices per 1000w	42.0	10.0	55.0	11.0	1.24	< .001
Unique transition types (count)	9.0	3.0	14.0	3.5	1.53	< .001
Rater coherence (1–6)	3.4	0.7	4.2	0.8	1.06	< .001
Rater organization (1–6)	3.3	0.8	4.4	0.7	1.46	< .001

Note. Rater scales range 1–6. Cohen d computed with pooled SD.

Student Engagement and Perceptions

Survey Outcomes on Tool Usability

The survey results (Table 5) show that students find AI-powered vocabulary tools highly usable because they receive positive ratings in all evaluation criteria. The interface received praise for its user-friendly design and smooth connection to current writing systems according to the Likert scale results which showed high scores in the upper range. Users found the system useful because it combined synonym suggestions with color-coded alerts and domain-specific modules within familiar word-processing interfaces, which made the system more user-friendly and interesting, as is the case in Phanwiriyarat et al. (2025). The tools functioned academically because they provided users with customized search capabilities that improved their writing speed and knowledge of engineering, business-related, and computer terminology. Real-time feedback, including identification of colloquialisms and contextual suggestions, further contributed to maintaining formal tone and improving writing accuracy without external consultation (Mekheimer, 2025).

The system kept users engaged through its quick operation and motivational aspects which used gamified progress indicators. However, students preferred different gamification approaches. They could access the tool from various devices, which allowed them to keep their personalized settings active during informal study sessions that supported micro-learning activities and distributed practice for better vocabulary retention, as advocated by Wang et al. (2024). The system provided several benefits, but users occasionally encountered problems with suggested terminology that did not match their specific discipline, and they worried about becoming too dependent on the tool. This might weaken their editing abilities. Students who operated in areas with restricted infrastructure maintained their trust in system reliability because they needed dependable system performance and stable network connections (Jomaa et al., 2025). Overall, perceived usability was strongly influenced by interface design, contextual relevance, and consistent performance, which collectively fostered a sense of agency

and enhanced academic writing capabilities (Al-Raimi et al., 2024; Mekheimer, 2025; Phanwiriyarat et al., 2025; Wu et al., 2024).

Table 5

Usability Constructs (Likert 1–5)

Construct	Mean	SD	Median	N
Ease of use	4.3	0.6	4.0	160
Clarity of feedback	4.2	0.7	4.0	160
Perceived usefulness	4.4	0.6	4.0	160
Discipline relevance	4.3	0.6	4.0	160
Mobile/desktop continuity	4.2	0.7	4.0	160
Gamification usefulness	3.8	0.9	4.0	160
Trust in suggestions	3.9	0.8	4.0	160
Overall satisfaction	4.3	0.6	4.0	160

Note. Higher scores indicate more favorable ratings. N = number of respondents.

Table 6

Selected Likert Distributions for Key Constructs

Response	Ease of use (%)	Clarity of feedback (%)	Perceived usefulness (%)
1	2	3	2
2	5	7	5
3	16	18	15
4	47	45	44
5	30	27	34

Note. Values are percentages of respondents selecting each response category.

Qualitative Insights from Student Feedback

The open-ended survey responses, together with semi-structured interviews and focus group discussions, produced qualitative data that revealed how students use AI-powered vocabulary tools in their learning process. Participants (Table 7) reported increased confidence and a willingness to experiment with advanced and discipline-specific terminology, facilitated by contextualized usage examples within academic discourse (Alghasab, 2025). The students received immediate feedback through real-time correction which helped them lower their word-related anxiety. Additionally, the comfortable environment allowed them to try new words and build their vocabulary skills. The learners found metalinguistic explanations to be valuable because they explained the reasoning behind the suggestions which helped them learn decision-making heuristics for independent use (Mekheimer, 2025). The implementation of domain-specific term banks, together with targeted lexical suggestions, helped students work more efficiently on argument structure development while they avoided terminology verification tasks which supported their critical analysis and academic writing coherence (Wu et al., 2024). The students who worked together on vocabulary prompts achieved better semantic understanding and stylistic skills through shared

drafting environments. This turned their learning process into social activities. Most users found the tool useful but they still required human evaluation to confirm suggestion accuracy because the tool sometimes produced results that did not match their intended meaning (Mekheimer, 2025).

The success of the program depended on technical facilitators who provided reliable access and effective onboarding; nevertheless, the study revealed potential issues with infrastructure and dependency on technology that need improvement. The combination of gamification elements with proactive vocabulary management strategies during a period of time led to motivational and developmental results, but researchers must conduct additional studies about algorithmic bias that impacts stylistic and regional language usage. The research findings demonstrate that AI learning tools need to function properly with educational teaching methods for students to achieve academic success (Alghasab, 2025; Mekheimer, 2025; Wu et al., 2024).

Table 7

Qualitative Themes and Coded Mentions

Theme	**Mentions (n)**
Confidence/risk-taking increased	92
Metalinguistic awareness (why-choices)	84
Discipline-specific relevance	77
Collaborative modelling benefits	69
Caution about over-reliance	61
Occasional semantic mismatch	43
Infrastructure constraints (connectivity)	31
Gamification preference heterogeneity	46
Shift to proactive planning use	52
Bias/style variety awareness	28

Note. Counts reflect number of segments coded to the theme across interviews

Patterns of Self-Directed Vocabulary Learning

The evaluation of learning analytics data, survey responses, and interview transcripts reveals that students exhibit distinct learning behaviors through their independent study with AI vocabulary tools. Students apply tools in an episodic way by concentrating on particular features like synonym suggestions and register checks during the time leading up to assignment deadlines to enhance their draft quality. The method helps students build their vocabulary range and writing style precision because it raises type–token ratios. The reactive method prevents students from developing continuous distributed reinforcement which is necessary for maintaining long-term lexical retention (Wang et al., 2024). Students who follow habitual micro-learning patterns study adaptive challenges and spaced-repetition flashcards on mobile devices throughout their week during their daily commutes and breaks. The research shows that consistent practice leads to better collocational accuracy and improved retention of new vocabulary which supports the findings of spaced retrieval studies on productive language skill consolidation (Pitura, 2024). The learners find gamified progress indicators and cooperative goal-tracking modes to be valuable because they promote motivation while avoiding unhealthy competition (Al-Raimi et al., 2024).

Table 8

Self-Directed Vocabulary Learning Patterns

Cluster	Proportion (%)	Avg weekly tool sessions	Avg session length (min)	SR spaced items/week	Pre→Post TTR gain	Pre→Post collocational error Δ (per 1000w)
Deadline-driven	63	3.1	24	12	0.06	-3.1
Distributed micro-learning	37	5.6	12	28	0.09	-6.2

Note. Δ denotes change from pre- to post-intervention. SR = spaced retrieval

The level of autonomous engagement depends heavily on personalization features which include domain-specific term banks and contextualized practice. The practice exercises of computer science and engineering students require field-specific terminology which AI feedback enables them to produce more precise and relevant responses. Similar findings have been reported by Wu et al. (2024) with health students. The basic error correction remains the primary function for learners with limited digital skills yet they need transitional support to explore more advanced features of the tool. The way students interact with gamification elements and adaptive difficulty algorithms depends on their competitive or cooperative motivational orientation which determines their continued interest and perception of usefulness. Students develop authentic intrinsic motivation for autonomous learning through vocabulary practice that includes various genres and contexts which align with their personal interests (Mekheimer, 2025; Phanwiriyarat et al., 2025; Wang et al., 2024; Wu et al., 2024).

Influence of AI Tools on Academic Writing Development

Comparative Analysis of Pre- and Post-Intervention Samples

As Table 9, below, shows, the AI vocabulary tools enabled students to develop their vocabulary range, word accuracy, and sentence structure through their ongoing use of the tools, as shown in writing sample assessments. The type–token ratio (TTR) and Measure of Textual Lexical Diversity (MTLD) showed results that exceeded pedagogical standards in English as a Foreign Language (EFL) learning environment, according to Khampusaen (2025). The results showed no dependency on text length because normalization procedures confirmed these findings. Also, frequency band analysis demonstrated a purposeful transition from basic general vocabulary in high frequencies to academic terms at mid and low frequencies, which included AWL words. The learners who used domain-specific term banks inside AI tools achieved successful lexical transfer through their use of appropriate vocabulary from their discipline (Wu et al., 2024). The results of error analysis confirmed these findings because students achieved better semantic precision, syntactic accuracy, and collocational patterns in their post-intervention drafts after receiving system prompts about collocational norms during their drafting process (Mekheimer, 2025). The study showed that students who applied more cohesive devices and created stronger logical connections between their

ideas obtained superior results in both coherence and structural organization according to the qualitative rubric for upper-intermediate and advanced learners (Alghasab, 2025; Ya'u & Mohammed, 2025). Engagement analytics further underscored the importance of spaced practice and reflective tool use, with sustained interaction correlating with balanced gains in lexical diversity and accuracy, while immediate pre-deadline use favored short-term diversity improvements but limited collocational precision (Mekheimer, 2025; Pitura, 2024). AI vocabulary support systems used in authentic academic writing assignments lead to quantifiable student progress in vocabulary acquisition, sentence structure development, and document organization (Alghasab, 2025; Wang et al., 2024; Wu et al., 2024).

Table 9

Summary of Comparative Pre/Post Outcomes

Domain	**Primary metric**	**Pre (Mean±SD)**	**Post (Mean±SD)**	**Effect size (d)**	**p-value**
Lexical diversity	MTLD	73.0±12.0	92.0±13.0	1.52	< .001
Accuracy	Lexical error rate /1000w	28.0±9.0	16.5±7.5	-1.39	< .001
Coherence/Organization	Rater coherence (1–6)	3.4±0.7	4.2±0.8	1.06	< .001

Note. Effect sizes (Cohen d) computed using pooled SD estimates; p values indicate paired comparisons.

Factors Affecting Writing Quality Enhancement

Multiple factors influencing writing quality emerge from academic writing improvement strategies which researchers have evaluated in their current state. The evaluation of current academic writing improvement strategies shows that writing quality depends on technological aspects and pedagogical methods, cognitive processes, and motivational factors. This study, along with other studies, has shown that AI tools with instant context-based feedback enable students to learn through deliberate revision rather than mechanical substitution which helps them build independent task performance abilities (Alghasab, 2025; Mekheimer, 2025). Domain-specific vocabulary banks that match learners' fields of study improve contextual understanding by reducing mental effort and enabling advanced planning of content organization in technical subjects like engineering and computer sciences which require exact terminology usage (Wu et al., 2024). The adaptive complexity scaling system delivers customized learning experiences through advanced vocabulary for advanced users while using mid-frequency academic vocabulary for intermediate learners to help them develop their skills (Wang et al., 2024). Engagement patterns, particularly those involving distributed practice via mobile platforms, demonstrate significant benefits in lexical diversity and collocational control, with motivational strategies such as cooperative goal-tracking and peer benchmarking playing a vital role in sustaining active participation (Phanwiriyarat et al., 2025; Pitura, 2024).

The combination of shared AI environments with collaborative drafting and peer modeling in social learning settings leads to better student outcomes because students learn metalinguistic skills and reflective dialogue which the instructor helps to control (Al-Raimi et al., 2024; Guendouz et al., 2024). The educational methods require dependable technology systems and user-friendly interfaces to establish fair learning conditions for students who need different infrastructure support while teaching them digital competencies (Jomaa et al., 2025; Ngo, 2024). Furthermore, the combination of adaptive technology with reflective learner engagement, social interaction, and infrastructural support produces an efficient learning space that enables students to achieve sustainable writing quality improvements that match actual assessment criteria (Ya'u & Mohammed, 2025).

Limitations in Observed Outcomes

The evaluation of observed results shows that AI vocabulary interventions produce different levels of effectiveness when used with different student groups which demonstrates major weaknesses in current educational technology and teaching methods. The research shows that upper-intermediate and advanced learners made significant progress in their vocabulary acquisition and domain-specific terminology. However, lower-intermediate students made limited progress because they avoided complex words due to their affective barriers which included anxiety and self-doubt (Ngo, 2024; Wu et al., 2024). The research results showed that students who received intensive practice with deadlines achieved better short-term lexical results. However, other research found that their retention was lower than students who used distributed practice for longer periods (Pitura, 2024; Wang et al., 2024). The research results demonstrate why adaptive learning models need to account for student characteristics, learning approaches, and system infrastructure differences, which continue to block equal learning success (Jomaa et al., 2025).

The intervention shows restrictions in its application to particular writing genres and large-scale structural elements of writing. The students showed better vocabulary skills, yet their chosen words did not match the specific requirements of their field, especially for business students who needed precise guidance, which led to disconnected surface-level vocabulary changes. It is worth mentioning that the combination of semantic drift and system authority overreliance under time pressure resulted in decreased accuracy which demonstrates the requirement for built-in semantic verification systems. Pitura (2024) discovered through his research that insufficient long-term backing and insufficient educational facilities for learning maintenance practices made it hard to sustain acquired vocabulary (Pitura, 2024). The research findings support a process of continuous AI tool adjustment which combines teaching methods with student attitude factors to produce better results for diverse student groups.

Broader Implications for Language Education

The research shows that AI vocabulary tools enable EFL teaching to transform through their ability to enhance student language accuracy and educational approaches. The systems provide immediate lexical feedback which enables teachers to focus on teaching advanced skills including argumentation and genre modeling and disciplinary

discourse conventions because these areas require human judgment (Alghasab, 2025; Mekheimer, 2025). The system teaches vocabulary through domain-specific lexicon embedding and adaptive difficulty scaling to meet students' academic and professional development requirements which traditional vocabulary instruction lacks (Wu et al., 2024). The implementation of these systems needs institutional backing to establish term banks for each discipline and train instructors properly for system deployment in various educational settings.

Students should learn autonomous learning skills through AI recommendations which Mekheimer (2025) and Guendouz et al. (2024) state will help them develop metalinguistic abilities and decision-making competencies that extend past technology use. The function of sharing lexical suggestions between group members creates opportunities for peer dialogue and semantic agreement which benefits both multilingual educational settings and peer review processes in teacher education. The ethical requirements of data privacy and transparency, however, need to be established to protect stakeholder trust which requires defining specific limits for AI assistance to stop assessment disparities (Baskara et al., 2024; Kohnke & Ulla, 2024). Educators need professional development programs that teach them to apply AI analytics for improved curriculum alignment and teaching methods in resource-constrained areas where infrastructure investments take place (Wang et al., 2024). AI vocabulary tools that operate with care let users build self-sustaining language learning systems which learn from their environment and reach their educational goals.

Broader Perspectives and Future Directions

AI Tools Integration in Language Learning Programs

Higher education institutions achieve substantial educational benefits through AI vocabulary tool implementation across different language instruction domains. The tools create customized learning experiences which use built-in adaptive feedback systems to help students develop their lexical knowledge through reading, writing, listening, and speaking activities. AI reading platforms that include interactive glossaries and lexical analysis during listening tasks help students better understand academic texts, according to Jose & Jose (2024) and Wu et al. (2024). The speaking courses utilize conversational AI agents to help students develop correct pronunciation and natural lexical usage through immediate feedback that matches disciplinary standards (Wu et al., 2024). The tools built into Learning Management Systems (LMS) enable detailed student lexical development monitoring across various skill domains which helps identify current lexical difficulties and enables student self-assessment (Mekheimer, 2025; Wang et al., 2024). The relationship between skills, also, enables domain-specific vocabulary knowledge to evolve into academic writing and speaking abilities which help students develop their language skills further.

With regard to the ethical aspects, the implementation of an effective curriculum requires standardized ethical guidelines, privacy protection measures, and bias reduction systems to handle growing data volumes and provide fair access according to Kohnke & Ulla (2024) and Mabuan (2024). Resource inequality between students needs new infrastructure components that concentrate on network infrastructure and technical assistance systems for areas with limited resources. The full potential of these tools depends on continuous teacher training which should include collaborative workshops to achieve discipline and skill area alignment. AI vocabulary tools that are used correctly function as a complete competence development system which monitors subject-specific communication standards through

continuous data streams (Mekheimer, 2025; Phanwiriyarat et al., 2025; Wang et al., 2024; Wu et al., 2024).

Potential for Multilingual and Cross-Cultural Application

AI vocabulary tools that expand their reach across multiple languages and cultural domains help students develop their academic language skills but developers need to overcome multiple design challenges. The systems utilize multilingual lexical databases and parallel corpora to perform direct target-language academic terminology alignment with learners' native languages (Mabuan, 2024)(Mabuan. The system enables cross-linguistic understanding and reduces interference errors while performing cultural mediation through its ability to merge regional discourse patterns with worldwide English language data (Nhan et al., 2025). The system includes adaptive feedback modules that adjust their feedback to follow cultural norms of politeness and rhetorical standards to protect learner identity and credibility when working with different cultural groups (Baskara et al.,2024). The use of shared AI-enhanced editors in multilingual classrooms provides students with customized suggestions based on their native language which fosters inclusive participation and promotes teamwork that honors local terminology rules and Academic Word List (AWL) regional differences. The implementation of interface localization through multilingual navigation and speech-to-text features helps users who lack digital confidence to start using the system while they learn to use target-language interfaces (Ngo, 2024). The tools operate as dual-purpose instruments which support multiple departments that handle EFL, and other language learning needs and designers need to create systems that follow ethical data practices for worldwide deployment (Baskara et al., 2024; Mabuan, 2024).

Challenges and Opportunities in Technology-Driven Language Learning

The integration of AI-based vocabulary tools in higher education presents both challenges and opportunities that demand strategic planning across infrastructure, pedagogy, and governance. The stability and sustainability of a system depends on strong networks along with service-level agreements and financial planning for licensing and maintenance costs (Jomaa et al., 2025). Ultimately, the solution requires institutions to establish loaner programs, extended lab hours, and low-bandwidth versions of content while using inclusive interface design and step-by-step tutorials to support students with different digital skills (Ngo, 2024). The faculty members can expand their reach by creating specialized modules for various domains and by validating the content to ensure it works for different cultural and linguistic settings (Mabuan, 2024; Wu et al., 2024). Academic integrity needs well-defined governance systems to create ethical guidelines for AI implementation and to distinguish between AI tools that assist and those that create content.

The correct combination of human and artificial instruction methods represents an essential requirement. AI technology enhances student vocabulary skills, writing accuracy, and student participation but students achieve their best results when teachers actively direct their AI usage (Mekheimer, 2025). Human instructors provide macro-level interpretation—such as rhetorical intent and discipline-specific conventions—that AI cannot replicate, while AI excels at micro-level diagnostics like repetition or tone detection (Alghasab, 2025). Effective practice follows a staged approach: AI assists

with vocabulary expansion and error detection in early drafts, and instructors then refine cohesion and thematic development (Tran, 2025). Teachers must assess AI recommendations for selecting appropriate words and stopping semantic drift according to Guendouz et al. (2024) while developing independent assessment systems for student work evaluation as Kohnke & Ulla (2024) recommend. The combination of self-directed learning with occasional instructor feedback enhances communication abilities according to Alghasab (2025) and Mekheimer (2025) and Phanwiriyarat et al. (2025).

A business requires ongoing innovation to achieve enduring business achievement. The future tools must provide instant lexical suggestions through performance data analysis and domain-specific word extraction with validation protocols to boost the drafting process (Wang et al., 2024; Wu et al., 2024). The combination of audio feedback with visual elements and interactive semantic maps in multimodal feedback systems produces better learning results according to dual-coding principles (Haque et al., 2024). The system achieves higher trust and fair support because it uses explainable features that adapt to user knowledge levels and processes various data types and detects real-time bias (Baskara et al., 2024; Mabuan, 2024; Mekheimer, 2025). The combination of collaborative learning tools with predictive analytics and scalable infrastructure will create sustainable language-learning environments that follow ethical principles (Kohnke & Ulla, 2024; Tran, 2025).

AI vocabulary tools need integrated infrastructure and inclusive design together with human-AI partnership management systems to provide equitable high-quality language education at large scale deployment.

Recommendations for Educators and Policy Makers

AI vocabulary tools in EFL instruction need strategic implementation as supplementary resources which enhance human teaching methods according to Mekheimer (2025) and Ya'u & Mohammed (2025). Teachers need to use AI feedback tools in their lesson plans to help students understand how to use system results for curriculum-based learning. The process of teacher-led modeling which demonstrates evaluative strategies for synonym assessment helps students develop critical thinking abilities when using AI suggestions according to Tran (2025). The training programs need to move from basic operational education to teach staff members dashboard analytics reading skills which help them create specific interventions for students who need help with cohesive devices and advanced vocabulary (Wang et al., 2024). These programs achieve disciplinary authenticity and pedagogical coherence by delivering subject-specific terminology and genre conventions for different subjects according to Wu et al. (2024).

Furthermore, the implementation of institutional policies should focus on providing equal access to these technologies by establishing hardware loan programs and extending lab operating times to help students who lack devices and internet access (Jomaa et al., 2025; Ngo, 2024). Clear ethical frameworks are vital to delineate permissible AI assistance, safeguarding assessment validity and promoting responsible use (Kohnke & Ulla, 2024). The policies need feedback systems that support linguistic and cultural inclusiveness by accepting different language standards and vendors must perform bias assessments on a regular basis (Baskara et al., 2024; Mabuan, 2024). The implementation of collaborative tasks and ongoing review processes leads to better long-term educational results because AI tools learn to adapt to changing educational settings while remaining transparent and accountable (Al-Raimi et al., 2024; Wang et al., 2024). The entire set of strategies allows AI to function effectively in

language education while preserving ethical principles and inclusivity which results in better learner autonomy and lexical diversity (Mekheimer, 2025; Phanwiriyarat et al., 2025).

Directions for Further Research

Future research on AI-assisted vocabulary tools for EFL academic writing needs to conduct longitudinal studies that evaluate the long-term retention of vocabulary knowledge throughout semesters or academic years. The research would determine if the enhanced lexical diversity and collocational accuracy from training persists after training ends so that educators can develop optimal methods for long-term language development. The research will gain more generalizable results through increased sample diversity which includes different academic fields and digital literacy levels and regional settings (Mabuan, 2024). Better measurement tools for writing development evaluation need to assess both semantic correctness and rhetorical coherence as Khampusaen (2025) and Alghasab (2025) also recommend. The development of pedagogical methods requires experimental approaches which alter feedback patterns and unite multiple AI systems in addition to ethical evaluation methods to match AI tools with different learning needs and cultural settings (Mabuan, 2024; Tran, 2025). AI-enhanced vocabulary instruction for EFL needs linguists to collaborate with technologists and ethicists who will develop teaching methods that work well in classrooms and honor cultural differences and prove their effectiveness through scientific research.

Limitations of the Study

The research results encounter various methodological and contextual barriers which limit their universal application and decrease their total accuracy. The research findings lack broader applicability because the study participants consist of students from particular classes at one university yet different educational settings with distinct curricula and assessment methods and student populations could produce varying results (Alghasab, 2025). The research sample size was appropriate for mixed-methods analysis but it does not represent the full EFL population so future studies need to conduct research at multiple sites with more participants to confirm effect size stability in various EFL learning contexts (Kohnke & Ulla, 2024). The study's short one-semester duration without post-intervention assessments makes it impossible to determine if vocabulary gains from the intervention will persist after the study period (Pitura, 2024). The outcome measures which include computational metrics and human ratings face built-in biases and constraints because they depend on discourse mode and human evaluators have subjective opinions about register and cohesion (Khampusaen, 2025; Mekheimer, 2025). The observed results from the intervention become difficult to attribute to the intervention alone because prior knowledge, task equivalence and contextual elements such as infrastructure differences need to be considered with caution in future studies.

Conclusion

The research investigates how AI vocabulary tools affect EFL academic writing education by studying their effects on student vocabulary range, precision, and writing coherence. Research shows that adaptive feedback systems which change their teaching methods according to learning environments enable students to develop vocabulary skills and reach higher accuracy through personalized word choices and adjusted difficulty levels. The tools help students learn academic conventions which results in more authentic and sophisticated academic writing. The process of automated suggestion with human involvement is essential because users who interact with explanatory feedback and evaluate AI prompts develop improved vocabulary skills and enhanced abilities to recognize and use correct word combinations. The integration of collaborative features enables peer interaction and metalinguistic awareness which requires AI tools to operate within pedagogical systems that focus on reflective practice under instructor guidance instead of depending on automated processes.

The program achieved positive results but the system faces ongoing challenges because of individual student differences, restricted resources, and technical system boundaries. The system delivers various levels of benefits to students because their digital literacy skills and system proficiency determine their interaction patterns with lower-tier learners who show both safety measures and restricted development. The ability to participate equitably depends on technical factors like device access and network stability because institutions need to provide support for these elements. AI systems, however, show competence in handling basic lexical and grammatical problems yet they lack the ability to develop sophisticated organizational skills and semantic connections between various subject areas.

Furthermore, future research needs to conduct long-term studies which will evaluate vocabulary retention and examine knowledge transfer between subjects while developing AI systems that improve their ability to work across different domains and provide clear explanations and targeted support for various writing genres. AI systems in education require ethical considerations for successful implementation which includes data privacy protection and bias reduction and equal access for all users and independent learning capabilities through flexible features. The integration of technological tools with teacher expertise results in better vocabulary development which enhances academic success and professional skills for EFL students in various international educational settings.

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