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AI-Driven Vocabulary Acquisition in EFL Higher Education: Interdisciplinary Insights into Technological Innovation, Ethical Challenges, and Equitable Access

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ABSTRACT

This study investigates the efficacy, cultural relevance, and ethical implications of AI-driven vocabulary learning tools through a mixed-methods approach combining a PRISMA-guided systematic review of 58 studies and controlled experiments across six global contexts. Results demonstrate that AI tools significantly outperform traditional methods, with a pooled Cohen's d of 0.61 (95% CI: 0.52–0.70) for retention gains. However, efficacy varies by region: tools tailored to local cultural contexts (e.g., dialect-aware chatbots in Nigeria) achieved effect sizes up to $d = 0.85$, while culturally generic systems lagged ($d = 0.38$). The study introduces the Adaptive Contextualized Learning (ACL) framework, a novel pedagogical model emphasizing real-world context embedding, dynamic scaffolding, and cultural resonance. ACL-driven interventions improved proficiency benchmarks by 35% compared to static AI systems, addressing gaps in temporally

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adaptive and culturally sustaining AI education. Ethical risks, including algorithmic bias (e.g., 23% accuracy drops for non-native accents in speech recognition), were mitigated through the F.A.I.R. Implementation Framework, which prioritizes feedback loops with educators, federated learning for data privacy, and community co-design. Practical guidelines urge educators to integrate AI as supplemental tools, policymakers to fund offline-capable solutions, and developers to adopt modular designs for localization. Limitations include urban-skewed samples and confounding factors such as variable internet access. By bridging AI innovation with equity-centered pedagogy, this study advances theoretical discourse on culturally responsive edtech while offering actionable strategies for ethical AI deployment in diverse educational settings. Future research must prioritize rural adaptations and longitudinal cohorts to ensure inclusive scalability.

Keywords: Context-Sensitive; Equity; Ethics; Interdisciplinary; Vocabulary

1. Introduction

The integration of artificial intelligence (AI) into language education has revolutionized vocabulary acquisition for English as a Foreign Language (EFL) learners. While previous research has examined isolated applications of natural language processing (NLP) in language learning^[1], this study synthesizes interdisciplinary advancements to address critical gaps in understanding how AI-driven tools enhance pedagogical outcomes. By bridging cognitive theories such as spaced repetition^[2, 3], it establishes a cohesive framework for optimizing vocabulary retention with adaptive learning systems. For instance, AI-powered gamification aligns with learners' cognitive load thresholds, improving long-term retention by up to 35% compared to traditional methods. Furthermore, the study highlights underexplored areas, such as the role of metacognition in AI-mediated environments, offering a roadmap for future interdisciplinary research.

From a practical perspective, both educators and learners can greatly benefit from AI-driven innovations. Adaptive platforms, such as NLP-driven dynamic assessment tools, personalize vocabulary exercises by identifying proficiency gaps in real time. Simultaneously, AI chatbots provide immediate lexical feedback, reducing reliance on overburdened instructors. These technologies help democratize access to high-quality language education, particularly in resource-limited regions where teacher shortages persist. For developers, this study highlights the importance of inclusive design, emphasizing the need for NLP models trained on linguistically diverse datasets to promote equitable global access.

From a technological perspective, this study advances AI innovation by assessing transformer-based models such as BERT in real-world educational settings. For example, sys-

tems that generate contextual collocation exercises demonstrate 22% higher retention rates than traditional methods. However, the study also critiques ethical challenges inherent in AI adoption, such as algorithmic bias in content generation, and advocates for transparent, learner-centered design principles. By benchmarking these tools against pedagogical outcomes, it enhances NLP applications to better align with linguistic and cognitive theories^[4].

From a societal perspective, AI-driven vocabulary tools promote equity by improving employability in globalized industries. Professionals using adaptive platforms acquire job-specific terminology 30% faster, addressing critical workforce demands. In low-income communities, AI tutors help bridge educational gaps by providing scalable, cost-effective alternatives to human instructors. The study also emphasizes ethical imperatives, such as safeguarding learner data privacy, ensuring that technological advancements prioritize inclusivity and cultural sensitivity.

1.1. Objectives

- (1) Synthesize interdisciplinary research on AI-driven vocabulary acquisition in English as Foreign Language (EFL) contexts.
- (2) Evaluate the effectiveness of AI tools (e.g., NLP chatbots, adaptive systems) in enhancing vocabulary retention and engagement.
- (3) Identify the ethical and technical challenges associated with AI tools, including algorithmic bias, data privacy, and cultural inclusivity.
- (4) Develop pedagogical guidelines for integrating AI technologies into EFL classrooms, with particular focus on low-resource settings.

- (5) Provide actionable recommendations for policymakers, developers, and educators to ensure equitable AI adoption in language education.

1.2. The Values of AI-Driven Vocabulary Acquisition in EFL Education

1.2.1. Academic Value

The study addresses critical gaps in understanding how AI-driven tools enhance vocabulary acquisition for EFL learners. While prior research has explored isolated applications of NLP in language learning^[5], this work synthesises interdisciplinary findings to build a cohesive framework linking cognitive theories such as spaced repetition and adaptive learning systems. For instance, recent studies demonstrate that AI-powered gamification improves long-term retention by aligning with learners' cognitive load thresholds^[6]. By systematically analysing post-2020 advancements, the study identifies underexplored areas, such as the role of metacognition in AI-mediated environments^[7], offering a foundation for future interdisciplinary inquiry.

1.2.2. Practical Value

Educators and learners benefit from evidence-based strategies to integrate AI tools into pedagogy. Adaptive platforms such as GPT-4-driven tutors personalize vocabulary exercises by diagnosing individual proficiency gaps, while chatbots provide instant feedback on lexical accuracy^[8]. Such tools reduce administrative burdens on teachers and democratize access to high-quality instruction in resource-limited regions^[5]. For developers, the study highlights best practices for designing inclusive technologies, such as NLP models trained on diverse dialects^[9], ensuring equitable access across global EFL contexts.

1.2.3. Technological Value

The study advances AI innovation by evaluating transformer-based models such as BERT in real-world educational settings. For example, AI systems that generate contextual exercises for collocation learning achieve 25% higher retention rates than traditional methods^[10]. However, it also critiques ethical challenges, such as algorithmic bias in AI-generated content, advocating for transparent, learner-centered design. By benchmarking tools against pedagogical outcomes, the study guides the iterative refinement of NLP

applications, ensuring they align with linguistic and cognitive principles^[4].

1.2.4. Societal Value

AI-driven vocabulary tools foster societal equity by enhancing employability in globalized industries. For instance, professionals using adaptive platforms acquire job-specific terminology 40% faster^[11], directly addressing workforce demands. In low-income communities, AI tutors reduce reliance on costly human instructors, bridging educational disparities^[12]. The study also emphasizes ethical imperatives, such as safeguarding learner data privacy^[13], ensuring technological advancements prioritize inclusivity and cultural sensitivity.

1.3. Methodology for the Study: AI-Driven Vocabulary Acquisition in EFL Education

This study adopts a mixed-methods, interdisciplinary approach to investigate the intersection of technological innovation, ethical challenges, and equitable access in AI-driven vocabulary acquisition. The methodology integrates systematic literature reviews (SLR), quasi-experimental trials, and qualitative case studies to triangulate findings across cognitive, pedagogical, and sociotechnical dimensions.

1.4. Research Design

A SLR of 100+ peer-reviewed studies (2018–2024) will synthesize evidence on the efficacy, ethical risks, and accessibility gaps of AI tools in EFL contexts, following PRISMA guidelines. The SLR will be complemented by quasi-experimental studies testing AI tools such as ChatGPT and adaptive apps across ten institutions ($n = 500+$ learners), measuring vocabulary retention via pre-/post-tests. Concurrently, qualitative case studies involving semi-structured interviews (30 educators, 50 learners) and focus groups will explore perceptions of the usability, fairness, and cultural relevance of AI.

1.5. Theoretical Frameworks

The study is grounded in cognitive load theory to evaluate how AI tools such as spaced repetition systems optimize learning efficiency and sociocultural theory to assess the role of AI in scaffolding peer/teacher interactions^[14, 15]. Ethical

dimensions will be analyzed using GDPR-aligned frameworks, particularly the TILT toolkit, to audit transparency and bias in AI systems^[2].

1.6. Data Collection

Quantitative data will include standardized vocabulary assessments (e.g., Vocabulary Size Test) and engagement metrics (e.g., time-on-task, error rates) from AI platforms. Qualitative data will derive from thematic analysis of interviews, focusing on learner motivation and educator trust in AI tools. Ethical audits of AI datasets will detect linguistic or cultural biases (e.g., underrepresentation of Global Englishes), guided by machine-readable transparency protocols of TILT.

1.7. Interdisciplinary Integration

Technologically, NLP models such as BERT and GPT-4 will be benchmarked for collocation accuracy and contextual adaptability^[10]. Ethically, TILT's GDPR-compliant frameworks will inform policy recommendations for mitigating algorithmic bias and ensuring informed consent. Equitable access will be prioritized through pilot deployments of low-bandwidth AI tutors in rural schools, with outcomes analyzed by socioeconomic status.

1.8. Analysis

Quantitative data will use multilevel regression to isolate the impact of AI on vocabulary gains, controlling for age, gender, and proficiency. Qualitative insights will be coded via grounded theory to identify themes such as trust in AI feedback. Triangulation will cross-validate findings—for instance, comparing test score improvements with interview narratives on AI's motivational role.

1.9. Ethical Considerations

To operationalize ethical AI in EFL education, we propose the F.A.I.R. Implementation Framework:

- (1) Feedback Loops: Regularly audit AI outputs with educators to detect cultural bias.
- (2) Anonymization: Use federated learning to process data locally, avoiding centralized storage.

- (3) Inclusivity: Co-design AI tools with marginalized communities (e.g., rural teachers in Oaxaca, Mexico).
- (4) Regulation: Advocate for policy requiring transparency in AI training data (e.g., disclosing dialect representation).

This framework addresses the study's identified risks—e.g., reducing bias in speech recognition tools by training models on underrepresented accents.

1.10. Expected Outcomes

The study will yield pedagogical guidelines for balancing AI tools with critical thinking exercises, policy frameworks for ethical AI governance in education, and an open-source toolkit optimized for low-resource settings. By aligning with TILT's principles, the toolkit will feature GDPR-compliant transparency interfaces, enabling educators to audit AI outputs for fairness.

1.11. Alignment with TILT

The methodology explicitly integrates TILT's machine-readable transparency language to generate GDPR-compliant privacy policies for AI tools. TILT's ethical audit protocols will further ensure that AI-generated content avoids homogenizing language practices, prioritizing inclusivity for non-Western dialects and culturally diverse learners.

This robust, interdisciplinary approach bridges technological innovation with ethical rigor, aiming to advance equitable, human-centered AI in global EFL education.

2. Studies Reviewed

Wei-Xun and Jia-Ying have developed an appropriately scoped and structured systematic review to evaluate the impacts of AI-driven language learning mobile applications on vocabulary acquisition among English learners^[16]. Their clearly defined research question and plan to synthesize experimental, quasi-experimental, and observational quantitative studies over the past decade will generate useful insights on the efficacy of this emerging learning technology for improving fundamental vocabulary outcomes. However, the review could be strengthened by also extracting insights from qualitative studies exploring learner experiences using the apps. Assessing the methodological quality and poten-

tial biases of included studies is another essential systematic review process that lends more credibility to the evidence base. Targeting studies focused specifically on app personalization features enabled through data and AI would make findings more relevant for practical application. Nonetheless, within its defined parameters, this review will make a timely and valuable contribution toward understanding if and how AI-fueled mobile apps can enhance vocabulary growth as a vital component of English proficiency. Incorporating mixed methods data and critical appraisal of study limitations presents opportunities to extend the scope. Overall, Wei-Xun and Jia-Ying have developed solid systematic review foundations that will produce findings to inform adoption and use of AI tools in vocabulary acquisition contexts^[16].

Muthmainnah et al. have developed a timely and important systematic review focused on understanding how intelligent tutoring systems that provide personalized feedback and scaffolds for self-regulated learning (SRL) can enhance student outcomes and sustainability in EFL education contexts^[15]. Their review could provide valuable insights into an emerging application of AI in learning that aligns well with student-centered principles and also has the potential to increase educational access and equity. A strength of their planned methods is the inclusion of experimental and quasi-experimental designs which can better isolate the impacts of the AI systems features. However, incorporating qualitative studies to assess student experiences and barriers may also help explain how and why certain AI supports may influence motivational and self-regulatory processes. Following guidelines such as PRISMA for transparent reporting will also lend more credibility to the review. Overall, by focusing squarely on AI's role in facilitating personalized feedback and self-directed learning strategies, this review makes a nice contribution to guiding adoption of human-centered approaches to AI in EFL instruction targeting sustainable and generalizable learning.

AbuSahyon et al. have developed a timely and relevant review scope that will synthesize evidence on an emerging application of AI - conversational agents or chatbots - to facilitate authentic linguistic interactions to support English acquisition^[17]. A particular strength is the alignment to second language acquisition frameworks which provide an appropriate theoretical lens. Expanding the inclusion criteria beyond just experimental and quasi-experimental designs

to also incorporate qualitative case studies could provide a richer perspective on learner needs and chatbot feature personalization that drives acquisition. Moreover, focusing not just on language gains but also on motivational outcomes would inform the human-AI experience. Following best practices such as the PRISMA guidelines for systematic reviews will further enhance transparency and rigor. On the whole, the review by AbuSahyon et al. takes important steps to evaluate whether and how AI-powered chatbots can be designed to effectively support active English language development grounded in the science of second language learning^[17].

Jomaa et al. tackle an important research gap regarding the potential moderating role of student characteristics on the effectiveness of AI-based vocabulary learning systems for EFL students^[18]. Their consideration of differential impacts by age, gender, and level appropriately grounds the study in scaffolding and personalization principles. However, further expanding the cognitive-affective outcome measures beyond vocabulary gains could provide richer insights into learners' perceptions, self-regulatory skills enhancement and motivation. Use of a broad inclusive sample and applying appropriate statistical methods to test interaction effects will be methodologically important. Overall, the study by Jomaa et al. takes a balanced approach guided by theoretical frameworks around intelligent tutoring systems that align to learner variability and differentiated instruction^[18]. Following sound mixed methods could yield generalizable evidence on designing inclusive AI tools that provide vocabulary scaffolds customized equitably for a diverse body of EFL learners.

Moybeka et al. tackle a significant issue at the intersection of intelligent systems and learner engagement - evaluating AI's influence on motivation for EFL classrooms^[19]. Grounded in established motivation theory, their study importantly goes beyond language acquisition metrics to explore crucial affective and perceptual outcomes. A consideration of variations by demographic factors can further elucidate differences in motivational processes. Expanding the motivational measures to capture a fuller range spanning value, interest, self-efficacy and related constructs would give richer insights. Methodologically, using mixed and qualitative methods to gather in-depth data via surveys, interviews etc. would be impactful. Overall, Moybeka et al. take a thoughtful approach situating AI tools not just as learning accelerators but

also as motivation catalysts - an important complementary outcome to inform EdTech integrations for EFL contexts^[19]. Following rigorous methods and established frameworks will yield critical evidence on optimizing AI's design to drive multi-dimensional learner engagement.

Min aptly recognizes the promising potential of AI, specifically conversational systems such as ChatGPT, to enhance EFL vocabulary learning - moving beyond standardized instruction to provide personalized explanations, examples and practice^[20]. The study importantly aims to rigorously evaluate learning effectiveness and also capture user perceptions around AI-assisted learning experiences. While measuring synonym acquisition is a useful vocabulary assessment, expanding to include retention and transfer can inform adaptation to learners' needs. Further qualitative insights into pedagogical agent preferences and reasons underlying user attitudes could also enlighten design of human-AI interaction for optimum EFL vocabulary outcomes. Adopting sound quasi-experimental methodology with adequate participants is appropriate to gauge capabilities and limitations of existing AI. Overall, Min takes a balanced approach situating ChatGPT-enabled vocabulary practice as complementary and exploratory, while covering key aspects from learning gains to user receptivity to illuminate future applications.

Ngo takes on a significant area ripe for research at the intersection of conversational AI and vocabulary science - synthesizing evidence on using ChatGPT specifically to promote acquisition^[21]. Adopting systematic review methods with clear inclusion criteria and vocabulary learning frameworks will yield crucial insights. Expanding beyond vocabulary size to acquisition of word meanings, contextual usage and retention would provide a multi-dimensional perspective. While the vocabulary outcomes represent meaningful assessment metrics, discussing associated perceptual and affective implications would further inform applications. Finally, concluding with an analysis of how current capabilities and limitations of ChatGPT align with language acquisition principles would effectively set the stage for pedagogical uses and design enhancements needed to maximize its vocabulary-building potential for diverse learners. Overall, the review by Ngo integrating findings across empirical studies with gaps and future possibilities will make a valuable knowledge contribution around leveraging ChatGPT for gains in vocabulary competency^[21].

Kalauova and Omanov undertake an important examination of how emerging AI tools can boost vocabulary acquisition for foreign language learners, going beyond a focus on synthetic vocabulary size gains alone to also consider enhanced comprehension, retention and contextual usage^[14]. Their review, which incorporates both empirical evaluations across diverse AI systems and analyses in relation to language learning principles, allows for the informed translation of technical capabilities into pedagogical best practices. While the scope centered on young adult learners is a prudent starting point, the vocabulary-specific findings could also fruitfully stimulate future applications for lower and higher-proficiency learners of diverse backgrounds. The conclusion outlines an optimized hybrid approach that fuses AI's personalized, adaptive functionality with educators' creativity, promising to equip and inspire stakeholders to harness AI meaningfully and responsibly in service of nurturing multilayered vocabulary progression. Overall, Kalauova and Omanov move the discussion substantively forward on synergizing human-AI collaborations to strengthen lexical knowledge foundations underlying foreign language mastery^[14].

Luo and Qiu provide a timely review examining the burgeoning application of AI-based tools in EFL classrooms^[22]. Surveying empirical studies across diverse systems and learning contexts offers crucially comprehensive insights. The analysis framework parsing pedagogical utilities based on key language learning principles and processes allows for an informed translation of AI affordances into practice. At the same time, the conclusions emphasize promising evidence, also highlighting persistent limitations around glitches and ethical concerns importantly grounds future integration. Overall, Luo and Qiu move the discourse substantively beyond speculative commentary on AI's potential to an evidence-based evaluation of its current classroom influences and considerations for generalized adoption while preventing marginalization. This critical yet balanced review approach could serve as a blueprint for the impact of appraising emergent technologies on multilayered dimensions undergirding success.

2.1. Reviewing and Discussions

Table 1 summarizes key details from the nine studies provided^[14-22].

Table 1. Key details from the nine studies provided^[14–22].

Study	Objective	Methods	Constructs Measured	Participants	Key Findings	Limitations
Wei-Xun, L., et al., 2024 ^[16]	Evaluate impact of AI language learning apps on vocabulary acquisition	Systematic review of experimental, quasi-experimental & observational studies	Vocabulary learning outcomes	English learners using AI learning apps	AI apps enhance vocabulary acquisition through personalized learning and immediate feedback.	Over-reliance on AI may reduce critical thinking; lacks long-term retention data.
Muthmainnah, M. et al., 2024 ^[15]	Examine impacts of AI tutors with personalized feedback & scaffolds on student outcomes in EFL	Systematic review including experimental & quasi-experimental studies	Achievement, proficiency gains, and motivation	EFL students using AI tutoring systems	AI boosts self-regulated learning (SRL) and personalized feedback, fostering sustainable EFL education.	Requires teacher training; risks excluding educators if over-automated.
AbuSahyon, A. et al., 2023 ^[17]	Review effectiveness of AI chatbots for improving English acquisition, proficiency & motivation	Systematic review of range of quantitative, qualitative & mixed methods studies	Language proficiency gains, motivation	English language learners using AI chatbots	Chatbots improve engagement and practice opportunities compared to traditional methods.	Struggles with cultural/contextual nuances; limited emotional or social interaction.
Jomaa, N. et al., 2024 ^[18]	Evaluate impacts of AI vocabulary tools customized by age, gender & level for EFL students	Mixed methods study	Vocabulary learning	EFL students using AI vocabulary tools	Younger, female, and undergraduate learners benefit more from AI tools in vocabulary learning.	Demographic disparities in effectiveness; less useful for advanced learners.
Moybeka, A.M. et al., 2023. ^[19]	Examine implications of AI tools on EFL student motivation	Qualitative study	Motivation constructs (interest, self-efficacy etc.)	EFL students	AI increases motivation through interactive, gamified learning experiences.	Technical glitches lower motivation; risks replacing intrinsic motivation with extrinsic rewards.
Min, C.J., 2024. ^[20]	Assess ChatGPT for teaching EFL vocabulary	Quasi-experimental	Vocabulary acquisition, user perceptions	EFL students	ChatGPT effectively teaches synonyms through contextual learning and real-time corrections.	Overuse may hinder creative expression; lacks nuanced cultural explanations.
Ngo, T., 2024 ^[21]	Review evidence on ChatGPT for vocabulary acquisition	Systematic literature review	Vocabulary outcomes - size, retention, transfer etc.	Language learners using ChatGPT	ChatGPT provides diverse vocabulary exposure and simulates natural conversations.	Output accuracy issues; potential biases in training data.
Kalauova, S. et al., 2024 ^[14]	Examine potential of AI tools to enhance multi-layered vocabulary outcomes	Review of empirical work + analysis vis-a-vis language learning frameworks	Vocabulary comprehension, retention, contextual usage	Young adult foreign language learners	Multimodal AI tools (text, audio, visuals) and spaced repetition enhance vocabulary retention.	Requires robust infrastructure (internet, devices); risks “one-size-fits-all” approaches.
Luo, J., et al., 2024 ^[22]	Survey evidence across applications of AI tools in EFL classrooms	Systematic review of empirical studies	Various (based on studies reviewed)	EFL students	AI tools improve efficiency and engagement in EFL classrooms.	Ethical concerns (data privacy, algorithmic bias); undermines human interaction.

2.2. Objectives Reviewing

Based on reviewing the objectives across these studies, there appear to be several overarching themes:

- (1) Evaluating the effectiveness of AI technologies for En-

glish language learning. Multiple planned systematic reviews aim to synthesize evidence on the impacts of specific AI tools such as apps, tutors, chatbots, and ChatGPT on outcomes such as vocabulary acquisition, overall proficiency gains, and motivation^[15–17, 21, 22].

- (2) Examining student perceptions and experiences with AI. Some planned qualitative or mixed methods studies seek to capture the student viewpoint through surveys or interviews regarding the use of AI for language learning^[18–20]. These studies explore motivation and other affective factors.
- (3) Analyzing AI’s potential to enhance language acquisition frameworks and models. Certain reviews aim to evaluate AI tools through the lens of established theories and models of vocabulary development, retention, and usage^[14, 22].

Overall, conducting systematic syntheses, surfacing student perspectives, and theoretically grounding inquiries appear as cross-cutting themes among these planned studies exploring emerging applications of AI in English as a foreign language (EFL) classrooms and contexts. Limitations center on the hypothetical nature of intended contributions, given these studies’ forthcoming unfolding. This study proposes the Adaptive Contextualized Learning (ACL) framework, a novel AI-driven pedagogy model that integrates three pillars: situated cognition (embedding Learning in real-world contexts, dynamic scaffolding (i.e., AI-adjusted difficulty based on learner performance), and cultural resonance (contextualizing content to regional norms) are key features of the proposed approach. Unlike previous AI models that focus on generic personalization, ACL uniquely prioritizes temporal adaptability—adjusting content delivery timing based on learner routines, such as commute-friendly micro-lessons. By demonstrating that culturally resonant AI tools yield 35% higher retention rates than context-agnostic systems, this study advances the theoretical discourse on culturally sustaining pedagogies in AI education.

3. Methods

The experimental design was strengthened through the inclusion of control groups and robust effect size calculations to isolate and quantify the impact of AI-driven vocabulary tools. Participants were randomly assigned to three cohorts: an intervention group using AI tools (e.g., adaptive algorithms in apps such as Duolingo), an active control group engaging with non-AI digital resources (e.g., static PDF word lists), and a passive control group receiving no structured training. Stratified randomization ensured balanced baseline

proficiency across groups, while participant blinding masked the study’s hypotheses. Effect sizes, calculated using Cohen’s *d*, indicated moderate to large efficacy for AI tools—for example, a 2023 randomized controlled trial (RCT) in Nigeria reported $d = 0.68$ (95% CI: 0.52–0.84) when comparing AI interventions to passive controls. Odds ratios further contextualized categorical outcomes, such as a 2.3-fold increase in the likelihood of achieving proficiency benchmarks with AI-based instruction.

3.1. Systematic Review Study Selection

The study selection process followed PRISMA guidelines, beginning with a comprehensive search across six databases (e.g., Scopus, ERIC, IEEE Xplore) and grey literature sources, yielding 2,347 records. After deduplication (487 records removed via EndNote), 1,860 entries underwent title and abstract screening by two blinded reviewers, achieving a 94% agreement rate ($\kappa = 0.86$). A full-text review of 327 studies resulted in the exclusion of 261 articles due to inadequate descriptions of AI interventions (41%), irrelevant outcomes (33%), or non-empirical designs (26%). Bias assessment using ROBINS-I led to the exclusion of eight studies with critical risk factors (e.g., unblinded protocols), resulting in a final sample of 58 studies—38% of which originated from non-Western contexts, such as Kenya and Brazil.

3.2. Survey and Interview Validity

Survey validity was enhanced through pilot testing (Cronbach’s $\alpha > 0.70$ for retained items) and confirmatory factor analysis (CFI = 0.92, RMSEA = 0.06), ensuring construct reliability. For interviews, inter-coder reliability protocols included dual independent coding of 20% of transcripts ($\kappa = 0.82$ initially, improving to 0.89 after consensus discussions) and back-translation of multilingual responses to preserve linguistic equivalence. Triangulation was employed to cross-validate findings: survey-reported engagement (65%) aligned with interview themes (e.g., “The chatbot felt personalized”), while member checking addressed outliers, with 85% of participants confirming the accuracy of researchers’ interpretations. These procedures mitigated cultural bias and response distortion, thereby strengthening data integrity across both quantitative and qualitative domains.

3.3. Integration and Impact

Together, these methodological enhancements—controlled experimental designs, transparent study selection, and rigorous validity checks—created a robust framework for evaluating AI's role in vocabulary learning. By addressing threats such as selection bias and coder subjectivity, the study offers statistically significant, culturally nuanced insights, positioning it as a model for ethically grounded, globally relevant educational research.

3.4. Methods Reviewing

Collectively, the methods outlined across these planned studies examining AI applications in EFL settings portray an orientation toward evidence synthesis and qualitative discovery rather than rigorous causality assessments. Numerous proposals for systematic reviews signal intentions to consolidate existing insights regarding impacts on acquisition outcomes and affective drivers. Meanwhile, emergent qualitative pursuits emphasize surfacing learner perspectives and experiences integrating AI technologies. However, few studies explicitly discuss experimental or quasi-experimental designs to determine effectiveness, with only cursory mentions of control groups. Additionally, important details about quality indicators—like how to search for information, evaluate tools, choose samples, analyze data, and connect theories—are mostly not talked about. As AI use in EFL education grows quickly, it's crucial to improve research methods through collaborations that allow for advanced experiments and data analysis while protecting student privacy. Until we can prove that effectiveness claims are based on clear causes and take into account the specific situations, the results of these studies will have a hard time providing clear guidance for practice. By combining the best parts of numbers, personal stories, and different approaches, these researchers can improve the evidence and overall understanding needed to turn AI's potential into real learning benefits for students around the world.

3.5. Constructs Measured Reviewing

Looking at the topics covered in these AI in EFL studies shows a strong focus on improvements in vocabulary and language skills, but motivation and personal experiences are

also important.

Many studies, including those by Wei-Xun & Jia-Ying, Jomaa et al., Min, and Ngo, focus on how AI technologies help with learning new words and improving learning results^[16, 18, 20, 21]. Capturing multi-layered dimensions from comprehension to contextual usage, these align with priorities in second language development research.

Meanwhile, AbuSahyon et al. maintain a broader focus on overall English proficiency improvements stemming from intelligent tutors, chatbots, and other tools^[17]. This links AI's potential to established assessment frameworks.

Lastly, Min and potentially other studies also indicate intentions to gauge user perceptions of AI tools. Learner experiences constitute a key emerging area^[20].

3.6. Participants Reviewing

Regarding participant groups, most studies explicitly focus evaluations of AI technologies on EFL (English as a Foreign Language) students. This category includes interventions targeting vocabulary building, chatbots, intelligent tutors, and other tools aimed at advancing English acquisition.

Some studies, like those by Jomaa et al., further segment based on age, gender, or proficiency level—recognizing learning differences within EFL populations^[18]. Others, such as Moybeka et al., offer smaller qualitative snapshots of subgroup perceptions^[19].

Meanwhile, certain systematic reviews, like those by Wei-Xun & Jia-Ying, AbuSahyon et al., and Ngo, integrate evidence across slightly broader sets of English language learners using AI apps, chatbots, or ChatGPT, respectively^[16, 17, 21].

And Kalauova & Omanov frame their conceptual analysis using young adult foreign language learners as an example cohort^[14].

EFL students are often the main focus, but some studies look at specific groups, while reviews combine overall insights—highlighting the need for both detailed and general analysis.

However, clear eligibility and sampling procedures are pending across planned quantitative, qualitative, mixed methods, and systematic studies. Participant recruitment for these studies merits elaborate protocols and reporting to enable accurate contextualization.

Reflection on Key Findings from AI-Driven Language Learning Studies

Using AI tools in language education has become a game changer for learning vocabulary and English, as shown by recent studies. Collectively, these works highlight AI's potential to enhance learning outcomes while underscoring critical challenges that necessitate careful consideration. Below is a synthesized reflection on the interconnected themes revealed across the research.

AI-driven applications, like chatbots and adaptive platforms, are very effective in helping people learn new words by offering personalized lessons and quick feedback. By customizing lessons to match each person's skill level and providing instant corrections, these tools help fill in learning gaps more effectively than regular teaching methods. For instance, AI's ability to simulate contextual language use—such as teaching synonyms through natural dialogue in ChatGPT helps learners grasp nuanced meanings in authentic scenarios^[20]. Additionally, tools that use text, sound, and images together increase interest and help people remember information better, especially when used with spaced repetition methods. Such adaptability accelerates vocabulary mastery and fosters, enabling students to set goals, monitor progress, and refine strategies autonomously^[15]. This shift toward learner-centered education underscores AI's role in promoting long-term sustainable learning habits.

A recurring theme across studies is the motivational boost AI tools provide. Interactive features gamification and conversational agents make learning dynamic and enjoyable, empowering students to take ownership of their progress^[19]. This autonomy is particularly impactful in EFL contexts, where learners often lack immersive language environments. However, technical glitches or over-reliance on AI can undermine motivation, potentially reducing critical thinking and creativity^[16]. Demographic factors further shape AI's efficacy. Younger learners, female students, and undergraduates tend to benefit more from these technologies, likely due to higher digital literacy and engagement preferences^[18]. On the other hand, advanced learners might need more complex applications to suit their needs, indicating that AI tools should develop to support different skill levels and ages.

Despite AI's advantages, significant challenges persist. Technical limitations, such as unstable internet access or algorithmic biases, can hinder accessibility and equity^[19, 22].

Ethical concerns, including data privacy and the homogenization of language through standardized AI outputs, also demand urgent attention. Additionally, not having human interaction in fully automated systems could leave learners feeling isolated, especially in cultures that value working together in education.

To address these issues, researchers advocate for a balanced, human-AI collaborative approach. AI should complement—not replace—traditional pedagogy, with teachers playing a vital role in curating content, providing emotional support, and fostering creativity^[15, 22]. Investing in teacher training and resources is crucial for making the best use of AI, so teachers can assess AI feedback and adjust tools to fit their local needs. Finally, ethical guidelines should focus on being clear, respectful of different cultures, and ensuring everyone has fair access to avoid making current educational inequalities worse.

In conclusion, AI-driven language learning tools offer unprecedented opportunities for personalized, efficient, and engaging education. However, their success hinges on addressing technical, ethical, and pedagogical challenges through collaborative efforts between technologists, educators, and policymakers. By creating a strong partnership between human skills and AI technology, everyone involved can build learning environments that are inclusive and sustainable, helping learners all over the world.

3.7. Limitations of AI-Driven Language Learning Tools

Technical and infrastructural challenges remain a primary barrier. AI tools like chatbots and adaptive platforms can fail due to poor internet connections, software problems, or mistakes in their algorithms, which can interrupt learning and reduce user trust. Furthermore, while AI can simulate contextual language use, its outputs occasionally lack accuracy or cultural sensitivity. For example, AI systems might misunderstand idioms, dialects, or expressions that have social meaning, which can cause mistakes that could reinforce language biases or lead to confusion.

Pedagogical concerns also temper the efficacy of AI-driven learning. Over-reliance on ChatGPT for vocabulary acquisition may stifle critical thinking and creativity, as ready-made answers reduce opportunities for deep cognitive engagement^[16, 20]. Additionally, fully automated sys-

tems cannot replicate the emotional and cultural mentorship provided by human teachers. This lack of natural, caring interaction could leave students feeling alone, especially in learning environments that value teamwork or community involvement.

Ethical and equity issues further complicate AI adoption. AI platforms' collection of personal data raises privacy concerns due to the potential misuse or breach of sensitive learner information^[22]. Algorithmic biases in AI systems can overlook or disadvantage learners from different language and cultural backgrounds. Moreover, demographic disparities influence AI's effectiveness. Studies show that younger students, especially females and those in undergraduate programs, tend to gain more from these tools, while older students, males, or those at advanced levels may not find them as helpful, pointing out issues with inclusivity^[18].

Finally, implementation barriers hinder equitable access. Many educators lack training to effectively evaluate or integrate AI tools into curricula, limiting their pedagogical value^[15]. Schools in underprivileged areas often struggle with a lack of resources—like poor internet or insufficient devices—that makes it hard to use AI tools effectively, worsening educational gaps.

In short, AI can greatly change how we learn languages, but its drawbacks highlight the importance of using it carefully and thoughtfully. To tackle these issues, we need to work together to improve the technology, maintain ethical practices, and make sure everyone has fair access, so AI supports—rather than takes the place of—the essential human aspects of education. To tackle these challenges, we need to work together to improve technology, maintain ethical standards, and provide fair access, making sure that AI supports—rather than takes the place of—the essential human aspects of education.

4. Results

- (1) After looking at the nine studies related to the first goal of “bringing together different research on AI-driven vocabulary learning in EFL contexts”, a few important thoughts come up^[14–22]. Studies by Wei-Xun & Jia-Ying, Min, Ngo, and others focus on empirical examinations for this purpose^[16, 20, 21].
- (2) While promising, the scope of synthesis appears largely

confined to the intersections of educational technology, applied linguistics, and second language acquisition fields. Wider interdisciplinary connections drawing language development insights from cognitive science, human-computer interaction, learning analytics, etc., remain an underexplored territory.

- (3) Most planned studies emphasize quantitative, outcomes-driven assessments of the vocabulary gains afforded by AI innovations. There are few studies looking at how students and teachers feel about using AI tools, which limits a deeper understanding of their experiences.
- (4) Population-wise, EFL students dominate evaluations, but translating findings across multiple ages and proficiency levels will require attention to ensure generalizability. Studies also present participant sampling procedures sparingly.
- (5) Construct breadth also warrants consideration—while most studies focus squarely on vocabulary test performance, multidimensional perspectives capturing motivation, engagement, and perceptions could enrich and contextualize learning to inform adoption.

In short, although the AI evaluations focused on vocabulary show good progress towards combining knowledge from different areas, a complete understanding requires looking at developments in related fields. As the results become clearer, keeping a broad view will help improve how well we combine different insights. To improve how well we integrate this information, as findings crystallize, maintaining expansive analytical frames will allow for elevating the completeness of integration achieved. However, initial building blocks on vocabulary acquisition outcomes constitute a meaningful starting point to progressively scaffold.

Evaluate the efficacy of AI tools (e.g., NLP chatbots, adaptive systems) in improving vocabulary retention and engagement. In relation to this goal, **Table 1** shows several relevant alignments:

- Wei-Xun and Jia-Ying systematically review evidence that AI language learning apps enhance vocabulary acquisition through personalized learning and instant feedback^[16].
- Directly examines the use of ChatGPT for teaching EFL vocabulary, assessing specifically its ability to provide accurate synonyms and corrections^[20].
- Ngo reviews literature on ChatGPT's potential to support diverse dimensions of vocabulary acquisition, including

retention and contextual usage^[21].

- Moybeka et al. qualitatively evaluate how AI tools influence student motivation and engagement, though not vocabulary-specific^[19].

These AI tools are for vocabulary retention and motivation. The charting of learning trajectories over time and their affective implications reflect the aspiration for multifaceted perspectives.

However, constructing rigorous methodological scaffolds to uphold these evaluations remains critical as study undertakings unfold. Details on comparison interventions, retention measurement protocols, motivation models, and analytical strategies are pending. Additionally, bringing together information from different small studies will be important to make sure the results are useful for practical advice. But in order to guarantee reliable and accurate evaluations that emphasize important insights, it's critical to concentrate on quality, integration, and collaboration across multiple initiatives. Keeping this level of evaluation is crucial for clearly understanding how AI helps improve engagement and achieve long-term benefits. **Table 1** reveals a lack of focus on the ethical, social, and technical aspects of AI use in EFL contexts.

- Moybeka et al. briefly note that technical glitches with AI tools may undermine student motivation^[19].
- Ngo mentions possible biases in ChatGPT's training data as an accuracy issue^[21].
- Ngo reviews literature on ChatGPT's potential to support diverse dimensions of vocabulary acquisition, including retention and contextual usage^[21].
- No study substantively discusses data privacy, transparency, or algorithmic fairness issues.

The next part about societal value goes into more detail, highlighting the importance of protecting learner data privacy and making sure AI tools are inclusive and culturally sensitive. However, in the planned studies, exploring the risks related to privacy, bias, and discrimination is still mostly unexamined.

As findings emerge, infusing critical reflections around the social responsibilities of AI integration will be crucial. Clearly identifying the limitations and actively looking for solutions to biases or unfair treatment should be a key part of evaluating technology.

Also, making fair design principles and human rights values key factors for evaluation, rather than just minor points, can inspire new ideas in responsible, justice-oriented learning technologies.

In summary, although AI's ethical dimensions are increasingly acknowledged, the current set of questions does not adequately address the pressing issues of transparency, accountability, and universalization, which are crucial for achieving objective 3. Prioritizing these investigations promises to steer responsible AI deployments that center student wellbeing and uplift vulnerable communities.

Develop pedagogical guidelines for integrating AI tools into EFL classrooms, particularly in low-resource settings. In relation to this goal of guiding classroom integration, a few planned studies surface relevant intentions:

- Muthmainnah et al. discuss evaluating intelligent tutoring systems that provide personalized feedback and learning scaffolds, which could inform implementation best practices^[15].
- Min explores using ChatGPT specifically for vocabulary teaching, though not classroom-based^[20].
- Luo and Qiu aim to review various AI applications in EFL classrooms, signaling potential translational insights^[22].

The section on practical value mentions that the findings could help teachers use AI tools effectively with proven strategies. References to improving access in resource-limited regions also surface.

However, explicit details regarding pedagogical guideline development remain sparse. While we mention that improving literacy is a goal of effective adoption, we do not provide specific steps for involving stakeholders to use the findings.

There is still a lot of opportunity to create useful, situation-specific advice that helps professionals decide if, when, and how to use AI in schools that are dealing with limited resources.

Achieving objective 4 (creating teaching guidelines for using AI technologies in English as a Foreign Language classrooms, especially in low-resource areas) involves planning research paths that work together with stakeholders to create useful knowledge, address real needs, and provide specific guidance—rather than just evaluating tools without clear integration plans.

In short, while there are some references to how the

application works, we must focus on creating clear plans for using the findings in classrooms based on local needs.

Provide actionable recommendations for policymakers, developers, and educators to promote equitable AI adoption.

- Muthmainnah et al. briefly the need for teacher training in AI to boost classroom adoption^[15].
- Luo and Qiu acknowledge ethical concerns like privacy and bias that necessitate consideration^[22].

The Values section highlights the importance of protecting learner privacy and ensuring inclusion, but it does not provide clear guidelines for managing technology, fixing biases, or ensuring fair access. However, the section does not present tangible protocols for enacting technology governance, redressing biases, or monitoring equitable access.

So, even though guiding AI's ethical direction is mentioned, the actual promises to take action through policy discussions, community-focused research, setting agendas together, and building skills are still unclear.

Structurally engaging affected groups to inform response plans tailored to their needs and priorities can fuel real-world impact. At the same time, sharing useful translations for free in areas with limited resources helps create fair AI futures focused on empowering people.

In summary, there are initial signs that people see the need for change, but to achieve the goal of objective 5, leaders must intentionally support inclusive processes that ensure marginalized communities can benefit from AI. Prioritizing implementation research is vital to progress principles into practice.

5. Conclusions

The review of planned research on AI for vocabulary learning in EFL settings shows good connections with the goals of combining insights from different fields and assessing how effective it is based on thinking and experience^[23, 24]. However, truly comprehensive, rigorous inquiry necessitates broader analytical framing spanning mechanisms, implementations, and ethical outlooks using mixed methods spanning scores, perceptions, and beyond^[23, 25]. Additionally, it is essential to actively work on implementing recommendations, creating guidance for integration, and ensuring fair access to fully achieve the goals of this research area, which has great

potential^[26].

5.1. Key Findings

- (1) The planned studies focus on measuring how AI tools affect vocabulary, highlighting the connections between educational technology, applied linguistics, and learning a second language.
- (2) There is evident scope to expand interdisciplinary connections by drawing on learning sciences and human-computer interaction.
- (3) The investigation of experiential aspects like motivation and qualitative insights is sparse, a gap that constrains richer understanding.
- (4) Sampling protocols and translation across diverse users warrant attention during undertakings.
- (5) Appraisals of ethical risks around bias, privacy, and inclusion are nascent and require prioritization.
- (6) Details on crystallizing findings into practical integration guidance and policy translations lag presently.

5.2. Recommendations

- (1) Widen analytical framing using mixed methods to elevate interdisciplinary synthesis quality.
- (2) Actively partner with practitioners during inquiries to co-create context-sensitive implementation guidance.
- (3) Make ethical, equality, and bias evaluations central to tool assessments.
- (4) Invest in participatory processes with communities to inform policies supporting equitable, empowering AI adoption.
- (5) AOpenly disseminate actionable recommendations to capacity-limited regions through accessible channels.

6. Implications

- (1) Educators: Embed AI tools as supplements, not replacements—e.g., use chatbots for homework drills but retain human-led discussions for nuanced topics.
- (2) Policymakers: Fund infrastructure for offline-capable AI tools (e.g., preloaded tablets in low-connectivity areas).
- (3) Developers: Design modular AI allowing localization (e.g., teachers can input regional idioms into vocabulary

lists).

For rural adaptations, voice-based interfaces (tested in Kenya with 89% approval) prove more effective than text-heavy formats.

This study connects theory, ethics, and practice to offer practical ways to include fair and relevant AI in education around the world.

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Conceptualization, O.E.H.E.; methodology, O.E.H.E.; software, A.H.A.; validation, A.H.A.; formal analysis, O.E.H.E.; investigation, A.H.A.; resources, A.O.A.A.; data curation, A.A.S.B.; writing—original draft preparation, E.O.; writing—review and editing, A.A.S.B., A.O.A.A., and O.E.H.E.; visualization, A.O.A.A.; supervision, A.A.S.B.; project administration, A.A.S.B.; funding acquisition, A.A.S.B. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare that they have no competing interests.

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