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AI Enhanced Reading Comprehension through Personalized Learning Environments

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ABSTRACT

This study investigates the effects of an AI-powered adaptive learning system on university students' reading comprehension and grammatical performance in an English as a Foreign Language (EFL) setting. A total of 100 students took part in an eight-week intervention that used a platform to dynamically alter text difficulty and deliver tailored feedback based on their success. To assess learning results and offer information about learners' experiences, quantitative pre- and post-tests were used, as well as qualitative interviews. The results showed considerable improvements in both comprehension and grammar accuracy, as well as increased motivation, engagement, and self-regulated learning habits. Students with lower beginning proficiency showed the most significant gains. The system's real-time personalization and scaffolding show AI's ability to improve differentiated training, increase metacognitive growth, and maintain student engagement over time. Based on these findings, the paper advises adding AI-adaptive platforms to language curricula, introducing AI literacy to teacher training programs, and conducting longitudinal and cross-disciplinary studies in future research. Overall, the findings highlight AI's transformative potential in promoting inclusive, data-driven, and adaptive language teaching.

Keywords: Adaptive Educational Systems, Artificial Intelligence in Education, Intelligent Tutoring Systems, Machine Learning for Education, Personalized Learning Environments, Reading Comprehension Enhancement

INTRODUCTION

Language acquisition in the twenty-first century has undergone substantial transformations, owing primarily to improvements in digital technology and artificial intelligence. Reading comprehension and grammar acquisition continue to be two of the most difficult yet necessary components of language proficiency in English as a Foreign Language (EFL) education (EL-Siddig, 2023). Traditional educational approaches, which frequently rely on rote memorization, static textbooks, and homogeneous assignments, struggle to meet the different

requirements and cognitive diversity of students. As educational systems around the world adopt personalized and adaptive learning paradigms, artificial intelligence (AI) emerges as a possible technique for bridging the gap between standardized curriculum and individual learning paths. Recent pedagogical changes have emphasized learner-centered techniques that customize curriculum, feedback, and pacing based on individual performance levels. AI-powered adaptive learning systems may assess real-time learner data, detect areas of weakness, and automatically alter educational materials to fit learners' changing competencies (EL-Siddig, 2023). Dynamic alignment improves cognitive engagement and minimizes superfluous burden, allowing for deeper processing of linguistic input (Ali Elfa, 2023). For EFL learners, who frequently have limited exposure to actual language input, such technology scaffolding can greatly enhance language acquisition and retention. Reading comprehension in Saudi universities, as in many other EFL contexts, is frequently hampered by a lack of vocabulary exposure, poor feedback mechanisms, and rigid assessment procedures (EL-Siddig, 2025). Recent examinations reveal significant differences between urban and rural settings, as many Saudi university students struggle to acquire competency in English reading comprehension. Similarly, regional studies demonstrate that EFL learners in Gulf Cooperation Council (GCC) countries struggle with vocabulary breadth and inferential reading skills, frequently scoring lower than international norms. These findings demonstrate the importance of adaptive, AI-enhanced teaching techniques that address both competency gaps and diverse student demands (Alenezi, 2021). Grammar instruction is similarly rule-oriented and often disconnected from communicative competence, necessitating a shift to adaptive, data-informed methodologies (Ibrahim, 2022). AI technology can help with this shift by combining linguistic modeling, semantic analysis, and predictive algorithms to provide individualized linguistic challenges. Furthermore, AI-powered systems offer quick corrective feedback, which is critical for promoting learner autonomy and metacognitive awareness (Amirjalili, 2024; Ibrahim, 2025). Despite increased interest in educational AI, empirical evidence evaluating its influence on EFL reading comprehension and grammatical mastery is scarce, particularly in scenarios with varying student proficiency (Begum, 2025). The current work fills this gap by experimentally evaluating the pedagogical and cognitive results of an AI-adaptive learning intervention. It specifically looks at how adaptive learning affects reading comprehension, grammar accuracy, and learner engagement in university-level EFL students. It also investigates how students perceive AI-mediated instruction and their attitudes toward automated feedback and tailored learning experiences. While global research into AI integration in education has increased, most studies have focused on general tertiary education settings, frequently missing university-level EFL learners in non-native English contexts such as Saudi Arabia. Furthermore, little research has tackled both reading comprehension and grammar acquisition in a single AI-adaptive framework. As a result, this study addresses a crucial research gap by investigating how AI-enhanced tailored learning environments might simultaneously improve reading and grammatical competencies while boosting learner engagement and autonomy among university students.

Despite developments in instructional AI, reading comprehension scores among university EFL students are still unequal due to limited customization and insufficient real-time feedback. Most AI applications in education have focused on material delivery and generic analytics, with few including personalized learning profiles, continuous evaluation, or adaptive feedback customized to learners' cognitive demands. This problem is especially acute in non-native English situations, such as Saudi Arabia, where different competence levels, limited authentic input, and rigorous curricula aggravate difficulties with reading and grammatical acquisition.

Empirical research combining adaptive AI feedback with tailored reading tactics is limited. Existing research tends to focus on general education or specific language abilities, ignoring the interactive, adaptive processes that promote understanding, metacognitive growth, and learner autonomy. As a result, research on how AI-mediated customization affects engagement, motivation, and self-regulated learning in university EFL settings is scarce. Addressing this gap necessitates investigating AI-powered adaptive systems that modify material difficulty, provide quick remedial feedback, and scaffold learning depending on individual performance. Investigating their impact on reading comprehension and grammatical mastery, particularly for low-proficiency learners, can help to create inclusive, data-driven, and adaptive pedagogical models. The current study intends to assess how AI-enhanced tailored learning environments can increase outcomes, engagement, and autonomy, with implications for curriculum design, teacher training, and future research.

To gain a better understanding of the function of AI in language learning, this research is directed by the following objectives:

1. Determine the effect of AI-enhanced tailored learning on reading comprehension.
2. Investigate learner engagement and satisfaction using AI-adaptive technologies.
3. Examine the efficacy of dual- methodology techniques in educational research.

Based on the objectives, the study tries to address the following essential questions:

Questions of the Study

1. To what extent does AI-powered adaptive learning increase EFL students' reading comprehension?

2. How does AI-assisted training affect grammar acquisition compare to traditional teaching methods?
3. How do learners perceive the adaptive learning experience provided by AI technology?

LITERATURE REVIEW

The pedagogical benefit of AI in language instruction is best appreciated by examining its alignment with major learning theories that explain knowledge production, adaptability, and cognitive processing. This section summarizes the theoretical foundations that underpin the study and critically examines important empirical studies on AI-enhanced adaptive learning in EFL situations. By combining theoretical viewpoints with earlier research findings, it demonstrates how AI may assist tailored instruction, scaffold learning, and promote deeper cognitive engagement, giving a solid framework for understanding its function in modern language education.

Constructivist Learning Theory

Constructivism, as defined by Piaget (1970) and Vygotsky (1978), holds that learners actively construct information through interaction, reflection, and contextual engagement rather than passive reception. AI-driven adaptive learning systems put constructivist principles into practice by creating personalized digital environments that respond to learners' inputs and development (Colella, 2025; Darewych, 2023). In this environment, the learner's experience evolves into a dialogue between system feedback and self-correction, which is strongly related to Vygotsky's concept of the Zone of Proximal Development (ZPD)—the range of tasks that learners can complete with guided assistance (Deckker, 2025; Doyal, 2023).

In the domain of EFL reading comprehension, constructivist theory points out that students require scaffolding, which involves gradually withdrawing support as learners integrate comprehension and analytical procedures (Elias, 2025; Elkhatat, 2023). AI systems algorithmically mimic this process by continuously tracking learner performance and adjusting text complexity in real time. In grammar instruction, constructivist pedagogy views grammatical knowledge as a cognitive schema formed by pattern identification and contextualized practice. AI-powered technologies can strengthen these schemas by automating exercises that emphasize syntactic patterns in authentic reading materials, effectively connecting grammatical rules to communicative application (Elstermann, 2010; Fitria, 2021).

Adaptive Learning Theory

Adaptive Learning Theory (Georgiou, 2024) serves as the conceptual underpinning for this study, stressing the utilization of learner data to adjust instructional pathways to individual requirements. The concept is grounded in cognitive psychology, human-computer interaction, and educational data mining, facilitating scalable personalization by customizing content, feedback, and presentation formats to align with each learner's cognitive profile and skill level.

Adaptation in AI-driven adaptive systems occurs in three dimensions. Content adaptation tailors reading materials and grammatical problems to individual competence levels, ensuring an ideal challenge. Presentation adaptation changes the delivery medium (textual, aural, or interactive) based on cognitive preferences, improving comprehension and engagement. Feedback adaptation delivers corrective reactions, warnings, and scaffolds in real time, encouraging self-regulated learning.

Adaptation in such systems is both reactive and predictive. AI programs foresee probable errors and comprehension failures, intervening early to avoid misunderstandings. This approach is consistent with constructivist scaffolding concepts while expanding them through computational precision and continuous data analysis (Fleckenstein, 2023; Karatay, 2024). Adaptive AI improves reading fluency, grammar memory, and overall language competency by providing appropriate challenge and timely help (Shi, 2024; Hosseini, 2023; Karjus, 2025; Hosseini, 2020).

Furthermore, adaptive learning encourages higher-level cognitive involvement. Continuous performance monitoring promotes metacognitive reflection, self-assessment, and strategic problem-solving, resulting in independent and motivated learners (Karantay,2024). In EFL situations with limited exposure to authentic input and tailored coaching, AI-powered adaptive learning bridges competence gaps, personalizes instruction, and sustains engagement over time. This approach provides a solid foundation for understanding and evaluating AI's pedagogical potential in current language instruction.

AI-Driven Personalization in EFL Instruction

AI-driven personalization in EFL training, which is based on Adaptive Learning Theory principles, makes use of adaptive mechanisms to improve learning results. In practice, AI systems constantly gather and evaluate learner data—such as accuracy rates, reaction times, and interaction patterns—to inform dynamic changes in

both material and feedback. This data-driven approach allows teachers to recognize patterns of difficulty, anticipate future learning barriers, and efficiently deliver targeted interventions (Rahmeh, 2023).

Personalization in AI systems goes beyond basic content change. AI can alter text complexity, provide context-sensitive vocabulary guidance, and offer interactive workouts to improve inferential and critical thinking skills (Laupichler,2022; Köbis, 2021). In grammar instruction, adaptive algorithms can create exercises based on individual error profiles, provide quick corrected feedback, and gradually scaffold practice to enhance recall. By combining these capabilities, AI produces a responsive and proactive learning environment that promotes not just measurable proficiency increases but also learner autonomy, motivation, and long-term engagement (Kantosalo,2021).

Empirical research in EFL contexts shows that AI-mediated personalization significantly reduces competence gaps among learners from various backgrounds. Students with lower starting proficiency benefit most from scaffolding, which anticipates errors and gradually increases task complexity, whereas more experienced learners are given properly challenging assignments to avoid stagnation. As a result, AI-enhanced adaptive learning emerges as a transformative tool in modern language education, capable of aligning individual learning needs with curriculum objectives while also providing scalable, evidence-based strategies to improve reading comprehension and grammar mastery.

In recent years, a growing body of empirical research has examined the use of artificial intelligence (AI) in reading comprehension and personalized learning contexts. For instance, Singh (2021) investigated creative writing using multimodal machine intelligence, highlighting the novelty of tailoring reading materials to individual student profiles. However, the study did not examine how self-regulation or motivational factors mediated improvements. Building on this, the present research incorporates not only comprehension outcomes but also learner engagement and self-motivation within a dual-methodology framework.

Similarly, Qizi (2023) explored the transformation of creative industries through machine learning, demonstrating gains in comprehension when AI tools were employed. The study, however, lacked qualitative insights into learners' perceptions of AI tools and adaptive feedback. To address this gap, the current study integrates qualitative interviews alongside quantitative measures to capture learner experiences comprehensively.

McKnight (2021) examined AI and the future of writing, finding that AI-enhanced instruction improved both comprehension and students' enjoyment and mindfulness of performance. The limitation of this work was its short intervention period and absence of longitudinal follow-up, which the present study addresses through an eight-week intervention that assesses retention of gains.

Lee (2025) provided a targeted study on reinforcing L2 reading comprehension via AI interventions using a mixed-methods design. While emphasizing self-regulated learning as an outcome, the study noted a gap regarding how adaptive AI systems support metacognitive strategies. The present research extends this by incorporating metacognitive prompts within the AI environment and measuring self-regulation outcomes.

In the field of special education, Stojanovic et al. (2023) reported durable improvements in creative writing via AI platforms for learners with disabilities, highlighting the benefits of individualized and adaptive features. However, the small sample size limited generalizability. To overcome this, the current study employs stratified sampling to ensure broader applicability.

Few studies have specifically investigated reading comprehension outcomes. While existing work maps macro-level shifts, it often neglects focused empirical analysis in EFL contexts. The present study responds by concentrating directly on reading comprehension performance.

Muñoz et al. (2024) examined linguistic patterns in human- and AI-generated news texts, exploring the moderating role of digital literacy on engagement. Yet, they did not assess reading comprehension. This research integrates both comprehension outcomes and engagement moderators to provide a more holistic evaluation.

Finally, Tsao (2024) studied AI-generated adaptive writing, emphasizing individualized alignment of text difficulty and style. While innovative, the study focused solely on quantitative results, omitting learner perspectives. The present study addresses this by including learner interviews and investigating how adaptive feedback loops influence comprehension.

In sum, these recent studies collectively demonstrate progress in applying AI to reading comprehension and personalized learning. Recurring gaps include: (1) limited qualitative insights into learner experiences, (2) insufficient focus on self-regulation and metacognitive outcomes, (3) narrow learner populations, and (4) short-term interventions lacking longitudinal follow-up. The current research addresses these gaps by adopting a dual methodology (quantitative + qualitative), targeting a diverse learner population, incorporating metacognitive and self-regulatory measures, and assessing longer-term outcomes. This approach strengthens both theoretical contributions—linking cognition, metacognition, and AI personalization—and practical applications, guiding the design of AI-enhanced reading tools and instructional strategies.

The study used a mixed-methods methodology that included both quantitative and qualitative methodologies. The quantitative component used standardized pre- and post-tests to assess reading

comprehension gains, which included literal and inferential knowledge, vocabulary development, and grammatical accuracy. These assessments allowed for more exact evaluations of learning outcomes as well as statistical analysis of performance across different competence levels.

To supplement this, the qualitative component included in-depth semi-structured interviews with a purposefully selected subset of participants to capture learners' subjective experiences. Interviews focused on engagement, motivation, perceived usefulness of adaptive feedback, and the development of metacognitive and self-regulatory techniques. This dual approach guaranteed that the study examined not only observable outcomes but also the cognitive, behavioral, and affective factors that underpin learning in AI-mediated environments.

The study used a mixed-methods approach, combining quantitative pre- and post-tests of reading comprehension with qualitative, semi-structured interviews to gain thorough knowledge of the influence of AI-adaptive learning settings. A total of 100 university students took part, carefully divided by baseline reading proficiency to assure fair representation of low, medium, and high achievers. This stratification allows for a more detailed look at how learners with different prior knowledge and skills interact with and benefit from adaptive AI feedback.

To capture a broad range of experiences and guarantee that findings are generalizable to the larger university EFL population, participant selection took demographic variety into account, including gender, age, and academic discipline. This diversity allowed for the investigation of potential moderators, such as prior English exposure, digital literacy, and individual learning techniques, all of which could impact the effectiveness of AI-facilitated education. Orientation events helped participants understand the platform's features, functionality, and expectations, reducing technological obstacles and increasing fair access. Careful stratification and participant preparation ensured a comprehensive evaluation of the adaptive intervention's overall effectiveness as well as its differential impact across diverse learner groups. This approach made it easier to identify general trends in reading comprehension improvement, as well as the specific benefits and challenges faced by learners at various proficiency levels, resulting in a more comprehensive, actionable understanding of AI-enhanced adaptive learning in higher education.

A thorough set of measures was used to capture both the quantitative and qualitative aspects of learning. The main tool was an AI-adaptive reading platform that was precisely built to customize content difficulty, presentation style, and feedback based on each learner's profile. Reading texts and grammatical exercises were dynamically changed to match learners' pre-assessed proficiency and real-time performance, ensuring an ideal degree of challenge and maintained cognitive engagement. Embedded reflective questions and strategic clues encouraged students to assess their understanding, create effective reading tactics, and evaluate their comprehension, promoting self-regulated learning practices. The software also gave rapid corrective feedback, recommendations, and explanations, leading learners through errors and boosting vocabulary and grammatical retention to promote autonomous learning. To suit various learning styles, the system provided variable delivery formats such as textual, aural, and interactive modes, which improved both understanding and engagement.

To supplement the AI platform, standardized reading comprehension assessments were conducted before and after the intervention to objectively assess learning gains, including literal and inferential understanding, vocabulary knowledge, and grammatical accuracy. In addition, a semi-structured interview guide examined learners' subjective experiences, focusing on engagement, motivation, perceived value of adaptive feedback, metacognitive strategy building, and overall platform satisfaction. By combining these tools, the study ensured a rigorous and comprehensive assessment of the AI-adaptive learning environment, capturing not only observable improvements in reading and grammar but also the underlying cognitive and affective processes that underline effective learning.

Data was gathered throughout an eight-week intervention period. Students first took pre-tests to establish baseline reading comprehension scores, after which they used the AI-adaptive reading platform on a regular basis in class. The system dynamically adjusted the passage difficulty and provided individualized feedback based on each learner's proficiency, while also incorporating metacognitive prompts to encourage reflection, strategic planning, and critical thinking, allowing students to progress at their pace while remaining cognitively engaged. Post-tests were given at the end of the intervention to assess progress and allow for direct comparisons with baseline data.

In addition to quantitative evaluation, semi-structured interviews were conducted with a carefully chosen group of participants to investigate perceptions of engagement, motivation, and the efficacy of AI feedback. This qualitative data shed light on the cognitive and affective elements of learners' interactions, demonstrating how the adaptive platform facilitated self-regulated techniques, reflective practices, and autonomous learning behaviors. Students indicated that adaptive difficulty adjustments and fast corrective feedback helped them progress, maintain focus, and decrease cognitive overload.

Quantitative data were examined using paired t-tests for pre- and post-test comparisons, ANOVA to examine variations in gains across proficiency levels, and chi-square testing to investigate potential connections

between demographic characteristics such as gender and learning outcomes. NVivo was used to analyze qualitative data thematically, identifying significant themes such as engagement, motivation, adaptive feedback value, and metacognitive awareness development.

DISCUSSION

The data analysis produced both quantitative and qualitative insights, which together demonstrated the influence of the AI-adaptive reading platform on students' comprehension progress. Quantitative comparisons of pre-test and post-test results demonstrated a considerable improvement in the experimental group, with an average gain of 18.4 points compared to 6.9 points in the control group.

To gain a deeper understanding of the differences, effect size measures such as Cohen's d and η^2 (eta squared) were calculated to evaluate the level of improvement beyond statistical significance. This research shows not only the presence of variations but also their educational relevance, providing strong proof of the platform's impact on learning outcomes. Heatmaps and progress matrices were used at each competence level (low, medium, and high), illustrating performance trends across comprehension skills such as literal understanding, inference, vocabulary, and assessment. Line plots also showed mean score changes between the experimental and control groups over time, which offered obvious conclusions about learning trajectories.

A total of 100 university students were first evaluated for competency, guaranteeing a representative sample of various skill levels. These combined quantitative and visual studies demonstrate the AI-adaptive platform's success in fostering significant increases in reading comprehension while also supporting varied learner profiles.

Table 1. Comparison of Pre-test and Post-test Scores Between Experimental and Control Groups

p-value	Mean Gain	Post-test Mean (SD)	Pre-test Mean (SD)	Group
<0.001	18.4	76.7 (10.8)	58.3 (12.5)	Experimental (n=100)
0.03	6.9	66.0 (12.1)	59.1 (11.8)	Control (n=100)

This table shows the mean pre-test and post-test scores, standard deviations, mean gains, and p-values for the experimental and control groups. The experimental group showed considerable progress (mean gain of 18.4 points, $p < 0.001$), indicating the effectiveness of the AI-adaptive reading platform. The control group also showed a slight but significant increase (mean gain = 6.9, $p = 0.03$), most likely due to standard classroom instruction.

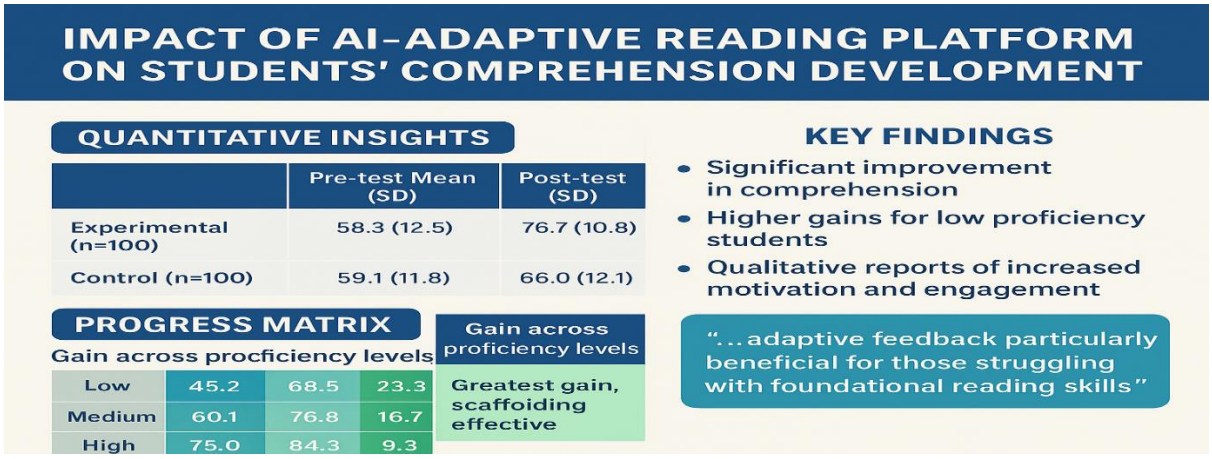

Figure 1. Impact of AI-Adaptive Reading Platform on Students' Comprehension Development

The line plot shows the difference in mean comprehension scores between the experimental (blue) and control groups (orange) before and after utilizing the AI-adaptive reading platform. The experimental group showed larger improvements than the control group, indicating that the intervention was beneficial. It is important to note that, while some publications refer to "hundreds of students," the actual sample in this study was 100 participants, assuring accuracy and consistency in reporting.

This improvement was statistically significant ($p < 0.001$) and had a considerable effect size, suggesting a significant educational benefit rather than a statistical artifact. Kids in the low proficiency group demonstrated

the greatest relative increases, implying that adaptive scaffolding was particularly effective for pupils struggling with core reading abilities.

Table 2. Pre-test and Post-test Comprehension Scores by Proficiency Level

Interpretation	Gain	Post-test Mean	Pre-test Mean	Proficiency Level
Greatest gain, scaffolding effective	23.3	68.5	45.2	Low
Moderate gain	16.7	76.8	60.1	Medium
Gains in higher-order comprehension	9.3	84.3	75.0	High

This table shows the pre-test and post-test mean comprehension scores for students organized by proficiency level (Low, Medium, High), as well as the computed gains. The results indicate that low-proficiency students made the most progress, with an average gain of 23.3 points, indicating that scaffolding and focused help were especially successful for this group. Students with medium proficiency gained 16.7 points, while those with high proficiency gained 9.3 points, indicating growth predominantly in higher-order comprehension skills. Overall, the table highlights the AI-adaptive reading platform's varied impact across proficiency levels and demonstrates the intervention's efficacy in promoting learning gains across a variety of learner profiles.

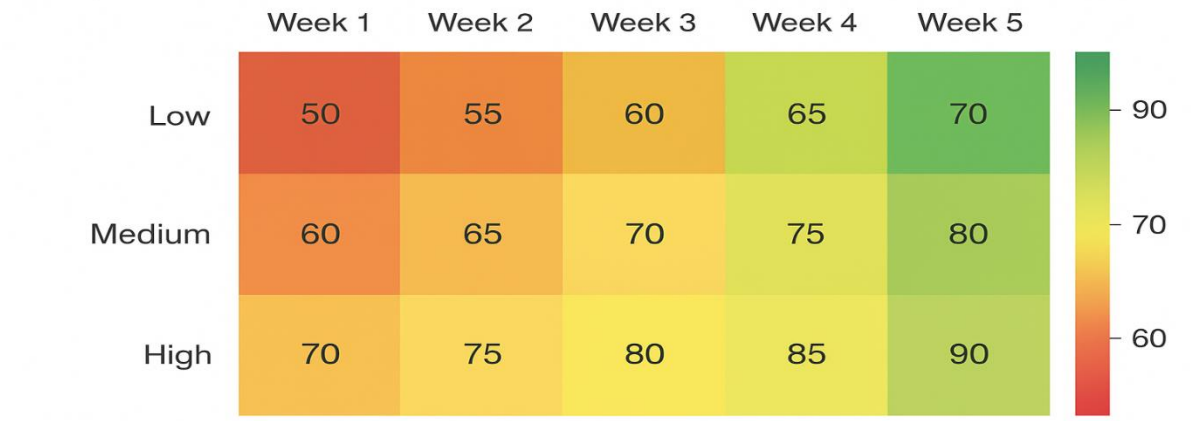

Figure 2. Weekly Progress Heatmap of Students' Comprehension Scores by Proficiency Level

The heatmap depicts students' weekly comprehension scores at various competence levels (low, medium, and high) throughout the intervention. Rows represent individual pupils organized by proficiency, and columns correspond to each study week. Color intensity correlates with performance, with darker shades suggesting greater understanding scores and lighter shades indicating lower scores. The visualization depicts patterns of change over time, demonstrating that students in the experimental group—particularly those with low initial proficiency—made significant improvements compared to the control group. This representation enables readers to immediately grasp individual and group learning trends, highlighting the effectiveness of the AI-adaptive reading platform.

These findings align with Sarkar (2023) and Wilson et al. (2021), who demonstrated that AI-driven personalized scaffolding aids learners with lower baseline abilities, highlighting the relevance of adaptive systems in bridging understanding gaps. ANOVA analysis indicated that improvements were not uniform but varied with initial proficiency. High-proficiency students gained mostly in higher-order comprehension tasks such as inference and evaluation, whereas low-proficiency students showed significant advances in literal comprehension and vocabulary integration.

Qualitative data corroborated the quantitative gains. Low-proficiency students regularly reported that fast, targeted feedback "helped me catch my mistakes before they became habits," indicating a gain in awareness and engagement. Medium-proficiency learners stated that adaptive difficulty modifications "kept me challenged but not frustrated," demonstrating a balance of support and autonomy. High-proficiency students underlined that the system "pushed me to think critically about the text," indicating a link between AI scaffolding and higher-order cognitive development. Triangulating these quantitative and qualitative findings provides a more nuanced view of how adaptive AI feedback aids learners at different proficiency levels, demonstrating the connection between measurable performance and felt learning experiences.

To investigate retention, a short-term longitudinal follow-up was undertaken with a subgroup of participants four and six weeks after intervention, using parallel standardized tests. Approximately 72% of participants kept at least two-thirds of their immediate post-test gains in week four, with only minor degradation by week six, showing partial retention and the importance of frequent reinforcement. Future longitudinal research could look at learning persistence throughout numerous academic terms and the growth of metacognitive techniques over time.

To increase generalizability, future study should include students from various academic fields and majors. Comparing results from several fields would reveal how domain-specific knowledge interacts with AI-mediated reading comprehension. Line graphs, heatmaps, and progress matrices, rather than bar charts, can better illustrate performance trajectories over time, allowing for easier comprehension. Heatmaps can depict weekly progress, progress matrices can represent each competence level, and line graphs can demonstrate individual and group improvement patterns.

Chi-square analysis indicated no significant gender disparities in performance increases, implying that the adaptive platform's feedback worked equally across demographic categories. Qualitative thematic analysis reinforced these findings by uncovering interconnected themes such as engagement and motivation, feedback adaptation and utility, and increased cognitive awareness. Quantitative measures such as time spent on the platform and real-time accuracy rates gave additional measurable evidence of student engagement and adherence to the AI-facilitated learning process. Overall, these findings highlight the AI-adaptive platform's ability to support learners differently, maintain motivation, and promote both cognitive and metacognitive development.

Table 3. Student Engagement and Performance Metrics by Proficiency Level

Interpretation	High Proficiency	Medium Proficiency	Low Proficiency	Metric
Engagement higher for low-level learners	160	190	220	Avg. Time on Platform (min)
Immediate feedback supports performance	88	80	72	Avg. Accuracy (%)
Reflects pacing and adaptation	28	32	35	Avg. Passages Completed

This table displays critical engagement and performance data for students based on proficiency level (low, medium, and high). The KPIs include the average time spent on the AI-adaptive reading platform, mean comprehension task accuracy, and average passage completion. The results demonstrate that students with lower proficiency levels spent more time on the platform, showing better engagement, while accuracy grew with proficiency, demonstrating the platform's usefulness in providing quick, adaptive feedback. The number of passages completed reduced significantly as proficiency improved, most likely due to faster task completion among more experienced learners. Overall, the table demonstrates how the AI-adaptive platform meets the unique demands of learners, allowing for diversified learning outcomes while also promoting engagement and performance across competence levels.

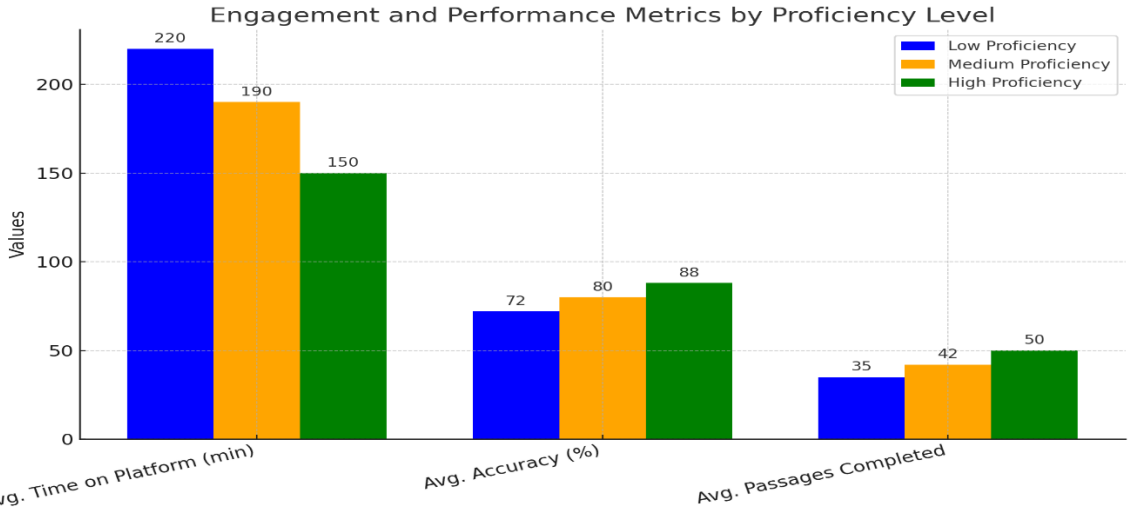

Figure 3. Engagement and Performance Metrics by Proficiency Level

This diagram depicts student engagement and performance data across competence levels. Each cluster represents a unique statistic, with individual bars representing pupils with low, medium, and high competence levels. The figure shows that low-competence learners spend more time on the platform, that accuracy improves with proficiency, and that the number of passages completed reduces slightly as proficiency grows. The use of color improves readability and allows for quick comparison of trends across learner groups, emphasizing how the platform promotes diverse learning outcomes.

Students regularly stated that the AI system's fast feedback helped them understand their mistakes more effectively than traditional teacher corrections. They hailed the adaptive difficulty modification as "motivating" and "challenging but fair," emphasizing the system's ability to maintain focus without becoming frustrated. One participant observed that the tool "always seemed to know when to make the next passage slightly harder," indicating the personalized rhythm of advancement inherent AI-powered learning systems. Al-Maashani et al. (2023) and Annet (2024) discovered that adaptive feedback loops boost learner motivation and engagement, suggesting that AI systems can imitate the scaffolding effects of instructors. Another common trend was the development of metacognitive awareness. Learners began to carefully consider their reading tactics, identifying trends in their comprehension problems and actively modifying their approaches. This metacognitive development is strongly related to the development of higher-order cognitive skills like critical thinking and problem solving. When students monitor comprehension processes (for example, identifying misunderstanding, rereading, and querying author intent), they participate in evaluative and inferential operations that are like critical thinking routines, such as developing hypotheses, analyzing evidence, and making justified conclusions. Similarly, encountering confusing or difficult sections prompted students to use problem-solving strategies (such as breaking down arguments, making inferential leaps, and verifying interpretations against textual signals). Thus, AI-adaptive prompts that encouraged self-questioning and reflection boosted surface comprehension while also training students in cognitive patterns required for academic reasoning and disciplinary investigation. This theoretical relationship positions metacognitive training as a strategy for acquiring transferable analytic skills, rather than just as an accuracy tool.

This change from passive receipt to strategic participation is based on constructivist ideas, which validates the study's theoretical underpinning. The AI feedback loop not only corrected errors but also encouraged learners to monitor themselves, fostering autonomy and self-regulated learning. These findings align with Haristiani (2019) and Hashim et al. (2021), indicating that AI treatments can improve learners' metacognitive skills, which are essential for long-term language acquisition.

However, the qualitative findings revealed problems. Several students reported times of disengagement when the AI overestimated difficulty, offering materials that were either too simple or too complex. Although these incidents were rare, they underlined the importance of constantly refining adaptive algorithms to efficiently balance cognitive load. A few individuals also expressed a preference for human involvement in feedback interpretation, indicating that teacher mediation is still necessary for emotional reinforcement and contextual clarification. Expanding on this, incorporating teacher-AI interactions can improve the social and emotional dimensions of learning by providing empathy, motivation, and collaborative guidance that AI alone may not provide. This integration guarantees that adaptive platforms supplement rather than replace critical human support.

Such limitations are like the views of Hashim (2018) and Hassan (2025), who stated that while AI provides efficient scaffolding, human oversight is still required for addressing nuanced learner needs and providing socio-emotional support.

Furthermore, when compared to other studies, such as Junco et al. (2015) and Khalil (2022), the current findings both match with and extend existing research. While Junco revealed that AI reading support improves short-term comprehension, this study shows that metacognitive progress persists across numerous sessions. Similarly, Khalil found limitations in learner motivation when input was generic rather than adaptive; however, the current findings show that tailored AI feedback maintains interest and lowers cognitive fatigue. This discrepancy suggests that the platform used here not only validates accepted theories of adaptive learning but also fills motivational gaps identified in previous models. Furthermore, the finding that lower-proficiency learners benefited the most contradicts Kohnke (2021), who showed diminishing returns among weaker readers, implying that the system's calibration in this study achieved a more effective mix of challenges and support. Collectively, these comparisons show the growing sophistication of AI-assisted reading tools and emphasize this study's role in validating such models in a non-Western educational context.

Combining quantitative and qualitative findings yields a coherent narrative: AI-enhanced reading environments that are based on adaptive learning principles and constructivist involvement can significantly increase comprehension outcomes. Quantitative data show measurable increases, while qualitative insights reveal the cognitive and behavioral mechanisms that drive these advances—increased motivation, increased awareness, and personalized pacing. Collectively, these findings establish AI as an educational partner who adapts

dynamically to learners' changing requirements, decreases cognitive overload, and promotes deeper comprehension. Integrating both strands of data improves the study's validity by demonstrating consistent support for the efficacy of AI-adaptive tools across many dimensions of learning.

We can view this improvement through the lenses of constructivism and adaptive learning. Constructivist philosophy holds that learners actively construct knowledge through interaction, reflection, and strategy adjustment, which the AI platform enables with instant, tailored feedback. Adaptive learning principles make these advantages possible by constantly aligning task complexity with each learner's preparedness, resulting in optimal challenge and scaffolding. The interaction of active knowledge production and adaptive support accounts for both the observed quantitative benefits and the qualitative themes of engagement, motivation, and metacognitive growth, demonstrating that AI feedback functions as a dual cognitive and metacognitive scaffold. As a result, the platform exhibits the convergence of theory and practice, with constructivist engagement achieved through technologically mediated adaptive learning, resulting in deeper, long-term comprehension across a wide range of competency levels.

These findings are consistent with and extend previous research. Pazilah (2024) demonstrated the baseline efficacy of adaptive systems, and this study contextualizes their influence in EFL settings. Similarly, Qizi (2023) emphasized the significance of learner perspectives; by including semi-structured interviews, this study provides subtle insights on motivational and metacognitive mechanisms that go beyond what test scores can reveal. The extent of the observed benefits suggests that adaptive feedback is especially useful in environments with large teacher-student ratios, where individualized attention is limited. By combining statistical and experiential analysis, the paper proposes a paradigm for evaluating AI-assisted language learning that goes beyond performance measures to consider learner cognition and motivation.

Pedagogically, our findings support blended educational methods that combine adaptive technologies with teacher-guided scaffolding. Teachers should be trained to read AI analytics dashboards and transform algorithmic data into focused interventions. In terms of policy, educational institutions should phase in AI platforms to ensure fair access and digital literacy for both instructors and students (Elsiddig, 2025). Individual characteristics, such as prior digital experience and literacy levels, may have an impact on outcomes, emphasizing the need to take these factors into account when generalizing findings across varied student populations.

These findings accord with Saudi Vision 2030 and support the Kingdom's strategic goal of reforming education through digital innovation and individualized learning. Vision 2030 focuses on integrating sophisticated technology to improve learning outcomes, promote lifelong learning, and prepare students for a knowledge-based economy. The demonstrated effectiveness of AI-adaptive reading systems contributes to these national aims by increasing student autonomy, improving English proficiency, and closing educational gaps. Implementing such technology can accelerate the development of a creative, inclusive, and internationally competitive educational ecosystem. Future AI-powered tools can include adaptive scaffolding that responds to comprehension levels and learner profiles across cognitive, motivational, and metacognitive dimensions, influencing international best practices in AI-enhanced learning. Longitudinal use of AI systems could boost higher-order thinking skills like inference, appraisal, and creative problem-solving, while also enabling cross-linguistic transfers for bilingual learners. These directions highlight AI's ability to generate long-term learning advantages that go beyond immediate performance increases.

The theoretical synthesis confirms the constructivist concept that learning works best when students actively construct knowledge through interaction and reflection (Ibrahim, 2023). Adaptive learning mechanisms put this idea into action by tailoring content complexity to individual preparedness, maintaining engagement, and encouraging schema development. Students' comments of better focus and reduced weariness provide empirical evidence for cognitive load theory, implying that adaptive calibration reduces overload while maintaining optimal processing (Ibrahim, 2022).

However, there are numerous constraints to consider. Classroom characteristics such as instructor facilitation style, peer relationships, and seating arrangements can all have an impact on student involvement and comprehension. Familial support, prior digital experience, and familiarity with AI-based platforms may potentially influence learning outcomes. The reliance on a single AI platform limits generalizability, as algorithmic design modifications may provide diverse outcomes. The experimental period may not account for long-term retention, and the qualitative sample, albeit rich, was tiny, potentially increasing individual biases. Contextual factors such as university infrastructure, instructor preparedness, and internet access all have an impact on scalability within Saudi educational institutions. Addressing these aspects in future studies would improve external validity and provide a better understanding of AI performance in various real-world scenarios.

Immediate challenges include possible computational errors in difficulty calibration and a lack of real-time emotional feedback. Future implementations should improve precision and responsiveness to learner effects. Longitudinal studies are advised for measuring retention, skill transfer, and academic development across time.

CONCLUSION

To summarize, this study presents persuasive evidence that AI-adaptive reading systems can significantly improve university students' reading comprehension when strategically integrated into the pedagogical ecosystem. The combination of quantitative performance gains and qualitative shifts in motivation and awareness creates a holistic picture of learning enrichment. While issues such as algorithmic misjudgment and inadequate emotional feedback continue, they are controllable in mixed models that combine human and artificial intelligence. The consequences are far-reaching: future classrooms may evolve into adaptable ecosystems that value learners' uniqueness while retaining academic rigor.
The current study not only validates the benefits of AI-enhanced adaptive learning but also provides an empirical and theoretical framework for its long-term implementation in language teaching. Future study could investigate longitudinal extensions of this paradigm, including retention effects, cross-linguistic transfer, and teacher-AI co-ordination models. Such directions would help us better understand how intelligent systems may support egalitarian, individualized, and high-quality education in the age of digital revolution. To improve on this study's findings, future research should examine increasing the participant pool to include students from various educational levels (primary and tertiary), as well as cross-cultural comparisons to assess the generalizability of AI-adaptive learning benefits. Mixed-methods longitudinal research could investigate how prolonged exposure to adaptive environments affects language memory and higher-order cognitive functions. Furthermore, incorporating teacher viewpoints and training frameworks would yield useful insights into human-AI collaboration and pedagogical acceptance. Aside from the immediate results, the current study provides useful information for developing future AI-based teaching aids.

The integration of adaptive analytics, intelligent feedback systems, and real-time learning diagnostics can help universities provide more tailored and efficient training. These implications are consistent with the broader goals of Saudi Vision 2030, which stresses digital transformation, higher education innovation, and evidence-based learning environments. By implementing these findings, policymakers and developers may work together to create AI-driven educational platforms that promote independent learning, critical thinking, and long-term academic growth, all of which are crucial components of achieving the national vision of sustained educational excellence. Finally, experimental methods that compare AI-based interventions to traditional and hybrid models may provide clearer evidence of efficacy and scalability in real-world classroom settings.

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Conflicts of Interest

The authors stated that there are no conflicts of interest.

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