A Quasi-Experimental Study on AI-Supported Informal Learning Intervention: Cultivating Digital Competence, Academic Enjoyment, and Engagement among Saudi EFL Learners

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Received: 06/06/2025 Revision: 28/08/2025 Accepted: 15/09/2025 Online: 31/12/2025

ABSTRACT

While the application of artificial intelligence (AI) technologies in English as a Foreign Language (EFL) instruction is on the rise, there is still a scarcity of empirical research investigating their effects on learners' digital competence, engagement, and emotional experiences, especially within informal, conversation-oriented learning environments. The lack of evidence is especially evident in the high-stakes, rapidly changing EFL environment of Saudi Arabia, which poses distinct challenges for genuine conversational practice. This study aimed to fill a significant gap by employing a quasi-experimental design with a non-equivalent control group. It explored the impact of an AI-supported informal learning intervention on 140 intermediate-level female EFL learners within a university context in Saudi Arabia. Participants were methodically allocated to an experimental group (EG; n = 64) that engaged in AI-integrated conversational practice throughout eight units of the mandated curriculum Connect Book 3, or a control group (CG; n = 65) that experienced traditional teacher-led instruction utilizing the same curriculum material. Data were gathered through three validated self-report instruments that assess learners' self-perceived digital competence, academic enjoyment, and engagement. The research aimed to address three questions regarding the impact of the intervention on these significant outcomes. Multivariate Analysis of Covariance (MANCOVA) indicated notable enhancements in the experimental group relative to the control group concerning academic enjoyment, engagement, and digital competence. The intervention demonstrated a significant overall multivariate effect (Wilks' Lambda = .80, $F(3,122) = 9.86$, $p < .001$, partial $\eta 2 = .19$), affirming the beneficial influence of the AI intervention. The findings present important, practical considerations for curriculum developers and EFL teachers in Saudi Arabia concerning the incorporation of conversational AI tools to enhance digital literacy and emotional involvement.

Keywords: AI-Supported Informal Learning Intervention, Quasi-experimental Study, Digital Competence, Academic Enjoyment, Engagement, Saudi EFL Learners

Introduction

The swift rise of artificial intelligence (AI) is fundamentally reshaping educational practices,

urging institutions globally to incorporate digital tools into teaching and learning (Huang et al., 2022; Hutson, 2025; Tikiz-Erturk & Kurt-Taspinar, 2023). In the realm of English as a Foreign Language (EFL), tools powered by AI present remarkable possibilities for tailored feedback, customized content, and, importantly, limitless conversational practice (Huang & Zou, 2024; Jiang, 2022; Xu & Liu, 2025). The transition to AI-enhanced language learning necessitates a comprehensive viewpoint, recognizing that effective execution depends not just on access to technology but also on the abilities and emotional conditions of learners. This study assumes that the effective incorporation of AI in EFL depends on three interrelated foundations: learners' self-assessed Digital Competence, their academic enjoyment of the learning experience, and their resulting engagement (Yuan & Liu, 2025).

Digital competence, characterized as the capability to utilize technology effectively and ethically for academic endeavors, influences a student's ability to harness AI tools for educational purposes (Chen et al., 2024; Niu et al., 2022). The concept of academic enjoyment refers to a positive emotional state marked by pleasure and interest while engaging in study (Hammad Al-Rashidi & Çakmak, 2024; Wang, 2022). This state serves as an essential affective filter that influences persistence and effort (Zhang et al., 2024). Engagement, which includes behavioral, emotional, and cognitive involvement, serves as the fundamental mechanism propelling academic achievement in environments enriched with technology (Suharti et al., 2021; Wang et al., 2025). This study contends that, rather than examining these outcomes separately, it is crucial to integrate them. AI interventions should aim to develop digital skills while also promoting positive emotional experiences, thereby enhancing the cognitive engagement required for effective language learning.

The need for this comprehensive approach is especially pressing and distinctive in the context of EFL in the Kingdom of Saudi Arabia. According to Alghamdi (2024), the Kingdom of Saudi Arabia is experiencing significant educational reform as part of Vision 2030, emphasizing the importance of digital transformation and global competence. Nonetheless, this technological aspiration must contend with established academic limitations, particularly the gender-segregated educational framework. Female university students frequently encounter social and infrastructural obstacles that restrict their chances for unsupervised, genuine, and repeated conversational practice beyond the formal classroom setting (Alasmari, 2020). Informal learning supported by AI, which is accessed privately and allows for non-judgmental repetition, presents a vital and culturally aware approach to this issue, serving as an important complement to formal education. Consequently, the context of Saudi Arabia serves not just as a backdrop, but as a crucial factor that enhances the likelihood of AI addressing a real educational issue, thereby validating the need for a targeted exploration.

The importance of this study lies in its strong theoretical foundations and practical implications that can be applied effectively. Theoretically, the findings enhance the Socio-constructivist framework (Vygotsky, 1978), illustrating how AI-mediated interaction serves as a digital representation of the Zone of Proximal Development (ZPD), offering support for intricate conversational skills without the need for direct human involvement. Additionally, Deci and Ryan (2013) presented Self-Determination Theory (SDT), and this research empirically expands on SDT by demonstrating how AI tools fulfill learners' psychological needs for autonomy and competence while developing digital skills, resulting in increased intrinsic

motivation. This study offers essential, evidence-supported recommendations for stakeholders in Saudi Arabia. The reported effect sizes provide measurable support for the investment in AI tools for the Connect Book 3 curriculum, establishing a clear framework for blending informal conversational practice with formal content. For educational policymakers in KSA, the findings highlight the importance of combining investments in digital infrastructure with targeted digital literacy training to achieve fair and effective results for female learners in this distinctive academic setting.

Literature Review and Integrated Theoretical Foundation

Digital Competence is defined as the collection of knowledge, skills, and attitudes necessary for the critical, collaborative, and ethical use of digital technologies to accomplish particular learning or work objectives (Chen et al., 2024; Rahimi, 2024). Alrawashdeh et al. (2024) argue that within the realm of AI-enhanced EFL, this competence should go beyond mere tool utilization to encompass advanced interaction management, data interpretation, and the ethical application of generative AI in language production. The significance for learners in Saudi Arabia is considerable, as cultivating this skill is essential for successfully engaging with the nation's digital transformation initiatives.

Academic enjoyment is a distinct, affirmative academic emotion marked by sensations of pleasure, satisfaction, and interest that emerge during learning activities (Zhang et al., 2024). In the context of EFL acquisition, enjoyment serves as a significant motivational factor. Enferad et al. (2025) demonstrated that elevated enjoyment levels correlate with reduced affective filters and an increased readiness to engage in communication. The use of AI conversational partners is believed to increase enjoyment by providing non-judgmental, instant feedback, thus fulfilling the psychological need for competence and making practice seem less daunting compared to high-pressure human interactions (Wu et al., 2025; Xu & Liu, 2025).

Engagement is acknowledged as a complex construct that includes the quality of a student's investment and participation in their learning (Namaziandost & Hwang, 2025; Wang et al., 2025). The components include behavioral engagement, which encompasses effort and participation frequency; emotional engagement, characterized by interest and attitude; and cognitive engagement, involving strategic thinking and self-regulation (Deng et al., 2020; Martin & Borup, 2022). Yuan and Liu (2025) contended that AI-supported informal learning has a substantial effect on three dimensions: behaviorally, by promoting more frequent, unscheduled practice; emotionally, by enhancing interest stemming from enjoyment; and cognitively, by enabling deeper processing of linguistic input through adaptive feedback.

This research employs a comprehensive conceptual framework that combines three well-established models to thoroughly substantiate the processes underlying the AI intervention. This unified perspective transcends disjointed theoretical discourse to establish a strong justification for the observed phenomena. Initially, the Socio-cultural Theory (SCT) (Vygotsky, 1978) positions the AI tool as a sophisticated digital artifact. The focus on social interaction and scaffolding offers a philosophical foundation, positioning the AI conversational partner as a more knowledgeable other (MKO). Aladini et al. (2025) expanded upon this framework, contending that AI establishes a digital version of the ZPD, enabling learners to engage with and assimilate intricate conversational structures that they would be unable to navigate on their own. Additionally, Cognitive Load Theory (Sweller, 1988) offers a cognitive rationale for the

effectiveness of the intervention. Given that language learning, especially in conversation, naturally entails a significant intrinsic cognitive load, AI systems are developed to handle extraneous cognitive load effectively. Kaur et al. (2023) demonstrated that through adaptive content presentation and personalized pacing, AI reduces distracting or irrelevant cognitive load. The decrease in unnecessary load allows for an increase in working memory capacity, permitting learners to concentrate on meaning creation and schema development, both of which are crucial for enhancing germane load. Third, SDT (Deci & Ryan, 2013) offers the emotional and motivational rationale. SDT posits that intrinsic motivation reaches its peak when learners' fundamental psychological needs for Autonomy (control over their practice), Competence (achieving success through personalized feedback), and Relatedness (engaging in non-threatening, interactive communication) are fulfilled. The personalized and flexible characteristics of the AI tool effectively meet the requirements for independence and skillfulness within the Saudi context, resulting in increased academic enjoyment and ongoing learner involvement (Xu & Liu, 2025).

Current empirical research supports the overall benefits of AI in L2 learning (Huang et al., 2022; Rezai et al., 2024; Yuan & Liu, 2025). Xu and Liu (2025) demonstrated that AI tools enhance motivational outcomes such as enjoyment and autonomy, while Alrawashdeh et al. (2024) identified a correlation between the use of AI tools and self-efficacy, a concept closely linked to digital competence. Nevertheless, a significant research gap remains in the existing literature: there are limited studies that have utilized a robust quasi-experimental design to evaluate a structured AI intervention, specifically aimed at enhancing conversation skills from a standard, mandatory EFL curriculum like Connect Book 3, in a high-stakes, culturally distinct EFL context such as Saudi Arabia. The current body of research largely consists of correlational or qualitative studies, lacking the quantifiable, causal evidence necessary to guide significant curriculum choices. This research is carefully structured to fill this significant void by offering causal evidence regarding the effectiveness of the AI-supported intervention on three essential outcomes: technological, affective, and behavioral, all within the context of the Saudi Arabian higher education system. In light of the aforementioned considerations, this research seeks to address the following research questions:

1. To what extent does the AI-supported informal learning intervention enhance the digital competence of Saudi EFL learners?
2. Does the AI-supported informal learning intervention significantly enhance the academic enjoyment of Saudi EFL learners?
3. To what extent does the AI-supported informal learning intervention significantly improve engagement among Saudi EFL learners?

Methods

Context of the Study

The research took place in the EFL department of a prominent, state-supported public university in the KSA, in alignment with the national educational directives established by Vision 2030. This directive propels the institution's dedication to swift digital evolution and the development of international skills among its learners. The particular group of students consists of female intermediate-level learners, functioning within a high-stakes, performance-oriented academic

environment that is fundamentally marked by gender segregation. The primary issue in this scenario is the limited availability of genuine, low-pressure, and unsupervised conversational practice, which is an essential element of fluency development frequently hindered by cultural and infrastructural constraints (Peláez-Sánchez et al., 2023). As a result, the intervention employing an AI-supported tool was crafted not just as a technological addition, but as a culturally relevant, private, and accessible educational solution aimed at closing the divide between formal teaching and the practical necessity for conversational skills, specifically catering to the distinct needs of the Saudi environment.

Research Design

The research employed a quantitative, quasi-experimental design featuring a pre-test/post-test non-equivalent control group framework. This design was selected based on practical considerations, as the scheduling and ethical constraints present in the academic setting of the participating Saudi university hindered the possibility of true random assignment of individual students, a necessity for conducting a Randomized Controlled Trial (RCT) (Creswell, 2009). The intervention was implemented in intact, pre-existing conversation classes, designated as the experimental group (EG) and the control group (CG). This non-equivalent control group design is widely acknowledged for its strong ecological validity in educational contexts, facilitating the exploration of causal relationships within the constraints of naturalistic institutions (Tabachnick et al., 2007). The possible risks to internal validity due to non-randomization were carefully addressed by using the pre-test scores as covariates in a Multivariate Analysis of Covariance (MANCOVA), which statistically controlled for any initial differences that existed between the groups.

Participants

The initial sample consisted of 151 female intermediate-level EFL students who were enrolled in the Conversation Skills course. The method of sampling used was convenience sampling, a non-probability approach chosen for its practicality, selecting participants who are easily accessible and fulfill the designated criteria (Creswell, 2009). The inclusion criteria were specifically defined: participants needed to be female EFL learners aged 18 to 22 years, currently enrolled in the second-year English program, and confirmed to possess an intermediate (B1) proficiency level according to the university's standardized placement test results. The average age of the participants was 19.8 years, with a standard deviation of 1.3. The participants primarily hailed from non-STEM disciplines and had minimal previous experience with generative AI tools for academic discussions. The researchers conducted recruitment by formally presenting the study to the pre-selected intact classes, providing a clear explanation of the study’s purpose, the voluntary nature of participation, and the confidentiality protocols in place. Eleven participants were excluded after the intervention because of irregular attendance or their inability to provide complete and consistent responses on the post-test survey. The ultimate effective sample size reached was 140, with the EG comprising 64 participants and the CG also consisting of 65 participants. To enhance participant retention, the research team ensured weekly communication through the university's Learning Management System, providing ongoing engagement and responding to any technical inquiries concerning the AI tool. The results of Levene's test on pre-test means indicated that the final groups did not show significant differences, implying that the low attrition rate of 7.8% did not lead to

considerable bias.

Ethical Considerations

The research was carried out with strict compliance to ethical guidelines. Every participant submitted written informed consent, which outlined the study's procedures, emphasized the voluntary nature of participation, and highlighted the right to withdraw at any time without facing academic penalties. A definitive pledge was established to eliminate any type of coercion from academic personnel. In accordance with data privacy regulations, all data produced by the AI conversational platform were automatically anonymized, devoid of any personally identifiable information, and securely stored on the researcher's institutional, password-protected server. This measure was especially important to tackle issues related to the privacy of informal conversational practice and the management of AI-related digital footprints.

Instruments

Data were collected using three self-report instruments, each administered on a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree), which ensured consistency across the scales.

1. The Digital Competence Scale (DCS): This scale has been adapted from the framework established by Chen et al. (2024). The assessment comprises 15 items distributed among three dimensions: Technical Operations, Information Literacy, and Digital Communication. The selection was made due to its ability to assess the particular digital competencies necessary for the effective and ethical utilization of AI tools in language learning. An example of an item is: "I am able to effectively utilize the features of the AI tool, including voice recognition and corrective feedback, for my conversation practice."
2. Academic Enjoyment Scale (AES): This tool was adapted from the Foreign Language Enjoyment Scale (Dewaele & MacIntyre, 2016). The assessment includes 12 items that evaluate positive emotional states throughout the learning experience. The choice was based on its proven dependability in capturing the emotional aspects of language learning, which serve as essential affective filters. An example of a statement could be: "I experience enjoyment and fulfillment when engaging in conversation practice with the AI tool rather than solely conversing with my instructor."
3. Learner Engagement Scale (LES): This scale was adapted from the work of Wang et al. (2025). The assessment includes 18 items that address three critical dimensions: Behavioral Engagement, Emotional Engagement, and Cognitive Engagement. The scale was selected for its ability to encompass the multifaceted aspects of learner engagement in the intervention. An example of an item is: "I make a conscious effort to utilize the feedback from the AI tool to grasp my grammatical mistakes (Cognitive)."

The authors affirm that the instruments underwent structural modifications to fit the AI-assisted environment. Items were reworded to clearly indicate "AI tool interactions" and "AI feedback" instead of the more general "teacher-led instruction," thereby addressing an important validity issue. The appropriateness of this was verified through a review conducted by a panel of three experts, thereby ensuring strong content validity. Moreover, all instruments underwent a thorough translation process from English to Arabic (the participants' L1) employing a careful double-blind translation and back-translation method to ensure full semantic and cultural equivalence for the Saudi student population.

Before the main study, a thorough pilot test was carried out on a distinct sample of 35 female intermediate EFL learners from the same university to ensure the psychometric validity of the instruments within the Saudi context. The pilot study confirmed that the language and content of the translated and modified instruments were fully suitable and understandable for the target population. The preliminary psychometric evaluation demonstrated the robust reliability of the modified tools. The reported Cronbach's alpha coefficients were as follows: DCS (α=.91), AES (α=.92), and LES (α=.90). Additionally, a Confirmatory Factor Analysis (CFA) was performed on the pilot data, yielding the necessary information to establish construct validity, with all factor loadings affirming that the proposed dimensional structure of the instruments was valid within the local context.

Data Collection Procedures

In order to examine the effects of the AI-assisted informal learning intervention, 140 intermediate-level female EFL learners in Saudi Arabia were randomly divided into two groups: an EG and a CG. Both groups participated in pretesting with three validated self-report instruments to determine baseline scores for digital competence, academic enjoyment, and engagement prior to the intervention. The intervention, utilizing eight conversation-based lessons from Connect Book 3, functioned as the central curriculum for both groups, guaranteeing uniformity in content. Nonetheless, the methods of instruction and the tools utilized varied greatly between the EG and CG to illustrate the contrast between AI-supported and traditional approaches.

The EG underwent an AI-assisted informal learning intervention aimed at improving conversational skills, digital literacy, and engagement within the gender-segregated EFL setting in Saudi Arabia. The intervention employed a range of AI-powered platforms designed to promote engaging and self-directed learning experiences. Students actively utilized speech recognition software, including Elsa Speak and Google’s Speech-to-Text API, to enhance their pronunciation, intonation, and fluency skills. These tools offered prompt corrective feedback on phonetic precision and prosody, allowing learners to enhance their speaking abilities in real time. Furthermore, the EG engaged in digital conversation simulations utilizing AI platforms such as Replika and Duolingo’s conversational modules. These experiences immersed students in contextualized scenarios, including ordering food in a restaurant, arranging travel accommodations, or discussing future plans. The simulations utilized natural language processing to tailor dialogue complexity according to each learner’s proficiency level, thereby guaranteeing personalized and genuine language practice.

To further enhance digital competence, the group engaged in collaborative digital assignments using tools such as Google Workspace and Canva to create multimedia dialogues and presentations. These activities necessitated those students handle digital content, including the sourcing of genuine online resources (e.g., travel blogs or restaurant menus) to support their conversational tasks, in accordance with the Digital Content Management aspect of the digital competence framework. Reflective exercises, conducted via platforms such as Padlet, prompted students to engage in discussions about digital empathy and safe online communication practices, focusing on the aspects of Digital Empathy and Digital Security. For example, learners examined case studies regarding responsible online conduct and developed protocols for safe digital interactions, enhancing essential digital literacy competencies. Interactive

listening and speaking exercises, enhanced by AI-driven platforms such as LingQ, offered adaptive input customized to learners' proficiency, strengthening the Use of Digital Media dimension. The activities aimed to foster independence, enabling learners to engage with the material at their own speed while benefiting from AI-generated feedback to support their educational journey.

The CG, on the other hand, experienced conventional teacher-directed teaching devoid of AI incorporation. Conversational training utilized traditional approaches, featuring clear teacher explanations of grammar and vocabulary from Connect Book 3, succeeded by dialogues based on the textbook. Role-plays were facilitated in pairs or small groups, with the instructor offering manual feedback on pronunciation and fluency via repetition and drilling activities. Instruction employed printed materials and in-class speaking activities, including teacher-modeled dialogues and supervised discussions, without the inclusion of digital or adaptive elements. This method focused on instructor-led education, restricting chances for individualized feedback or self-directed inquiry.

It is important to highlight that both groups finished the eight lessons within the same timeframe to maintain comparability. The intervention by the EG was notable for its incorporation of AI technologies, which provided adaptive feedback, facilitated multimodal interactions, and promoted learner-driven activities. This approach created a dynamic and engaging learning environment specifically designed to meet the needs of Saudi female EFL learners. Post-testing was carried out for both groups utilizing the identical instruments as the pretest to assess variations in digital competence, academic enjoyment, and engagement.

Data Analysis

The gathered data underwent analysis through the SPSS, Version 26. Initial calculations of descriptive statistics were performed to provide a summary of the demographics and outcome measures of the final sample. Independent samples t-tests were conducted to verify that there were no significant pre-existing differences between the groups regarding the demographic variables. The main statistical examination utilized a MANCOVA. It was chosen as the suitable statistical test due to the study's inclusion of one independent variable (i.e., AI-supported intervention vs. conventional instruction) and three closely related dependent variables (i.e., digital competence, academic enjoyment, and engagement). This approach enabled us to manage the associated pre-test scores as covariates (Tabachnick et al., 2007).

Before conducting the MANCOVA, all necessary assumptions were thoroughly examined. The assessment of normality involved a visual inspection of histograms alongside the Kolmogorov-Smirnov test, which confirmed an acceptable distribution. Multicollinearity was assessed by analyzing tolerance and Variance Inflation Factor (VIF) values, which remained comfortably within acceptable thresholds. The essential assumption for MANCOVA, Homogeneity of Covariance Matrices, was assessed through Box's M Test, yielding a non-significant result ($p>.001$), thereby affirming the approximate equality of the covariance matrices. Furthermore, the assumption of Homogeneity of Variances for each dependent variable was validated through Levene's Test, where all p-values exceeded the significance threshold. Ultimately, the assumption of Homogeneity of Regression Slopes was validated by examining the non-significant interaction term between the covariate and the independent variable, thereby confirming that the relationship between the pre-test and post-test scores remained consistent

across both groups.

Results

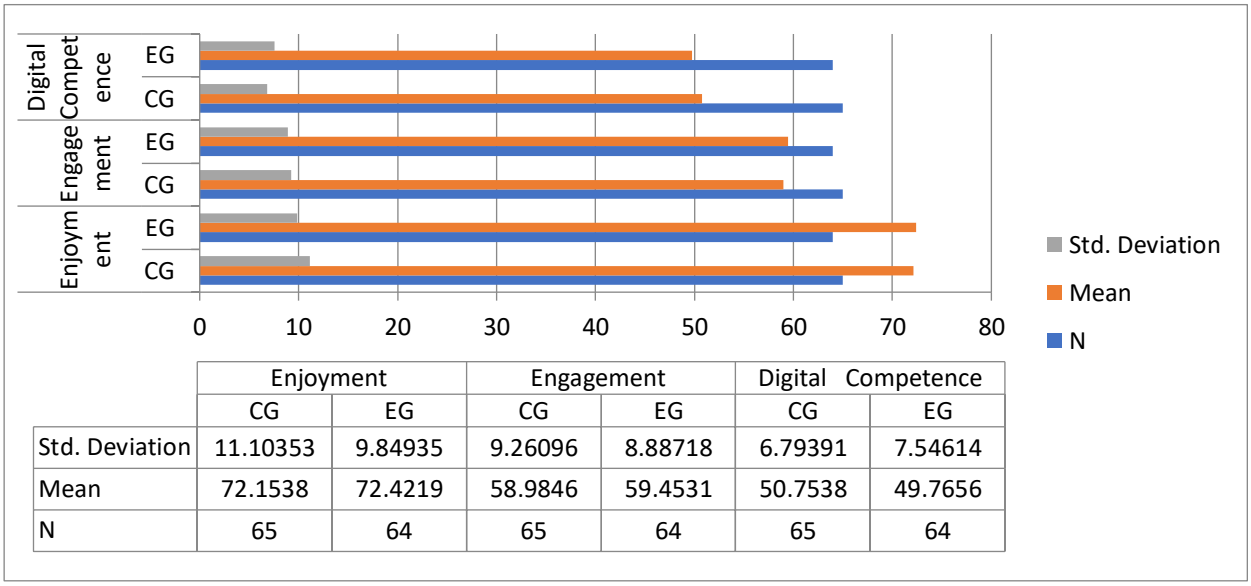
The findings are illustrated in the subsequent tables and figures.

Table 1

Group Statistics for Pretest of Three Variables

Variable	Group	N	Mean	Std. Deviation	Std. Error Mean
Academic Enjoyment	CG	65	72.15	11.10	1.37
	EG	64	72.42	9.84	1.23
Engagement	CG	65	58.98	9.26	1.14
	EG	64	59.45	8.88	1.11
Digital Competence	CG	65	50.75	6.79	0.84
	EG	64	49.76	7.54	0.94

Table 1 displays the pretest mean scores, standard deviations, and standard errors for academic enjoyment, engagement, and digital competence for both the CG and the EG. The average scores for academic enjoyment (CG: M = 72.15, SD = 11.10; EG: M = 72.42, SD = 9.84), engagement (CG: M = 58.98, SD = 9.26; EG: M = 59.45, SD = 8.88), and digital competence (CG: M = 50.75, SD = 6.79; EG: M = 49.76, SD = 7.54) showed a strong similarity between the groups. The slight variations observed suggest that the EG and CG were comparable at the outset, reinforcing the premise of uniformity prior to the intervention. The small standard errors, which range from 0.84 to 1.37, indicate that the estimates of the means are precise, thereby enhancing the reliability of the baseline comparison.



	Enjoyment		Engagement		Digital Competence	
	CG	EG	CG	EG	CG	EG
Std. Deviation	11.10353	9.84935	9.26096	8.88718	6.79391	7.54614
Mean	72.1538	72.4219	58.9846	59.4531	50.7538	49.7656
N	65	64	65	64	65	64

Figure 1

Pretest Statistics

Figure 1 displays the pretest mean scores for academic enjoyment, engagement, and digital competence, with green bars indicating the CG and EG. The closely aligned means for academic

enjoyment (CG: 72.15 vs. EG: 72.42), engagement (CG: 58.98 vs. EG: 59.45), and digital competence (CG: 50.75 vs. EG: 49.76) visually affirm the baseline equivalence between the groups, guaranteeing that any differences observed in the posttest can be ascribed to the intervention rather than to pre-existing differences.

Table 2

Independent Samples t-Test for Pretest Variables

Variable	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Academic Enjoyment	0.21	0.64	-0.14	127	0.88	-0.26	1.84
			-0.14	125.64	0.88	-0.26	1.84
Engagement	0.09	0.75	-0.29	127	0.77	-0.46	1.59
			-0.29	126.91	0.77	-0.46	1.59
Digital Competence	0.41	0.51	0.78	127	0.43	0.98	1.26
			0.78	125.19	0.43	0.98	1.26

Table 2 presents the findings from independent samples t-tests that compare the pretest scores of the CG and the CG regarding academic enjoyment, engagement, and digital competence. No statistically significant differences were observed: academic enjoyment ($t(127) = -0.14$, $p = .88$), engagement ($t(127) = -0.29$, $p = .77$), and digital competence ($t(127) = 0.78$, $p = .43$). The non-significant F-tests for equality of variances (academic enjoyment: $F = 0.21$, $p = .64$; engagement: $F = 0.09$, $p = .75$; digital competence: $F = 0.41$, $p = .51$) indicate that the assumption of equal variances was satisfied. These findings support baseline equivalence, demonstrating that the groups were similar at the beginning of the study, with mean differences (from -0.46 to 0.98) and small standard errors of the difference (1.26 to 1.84) indicating minimal pre-intervention variations.

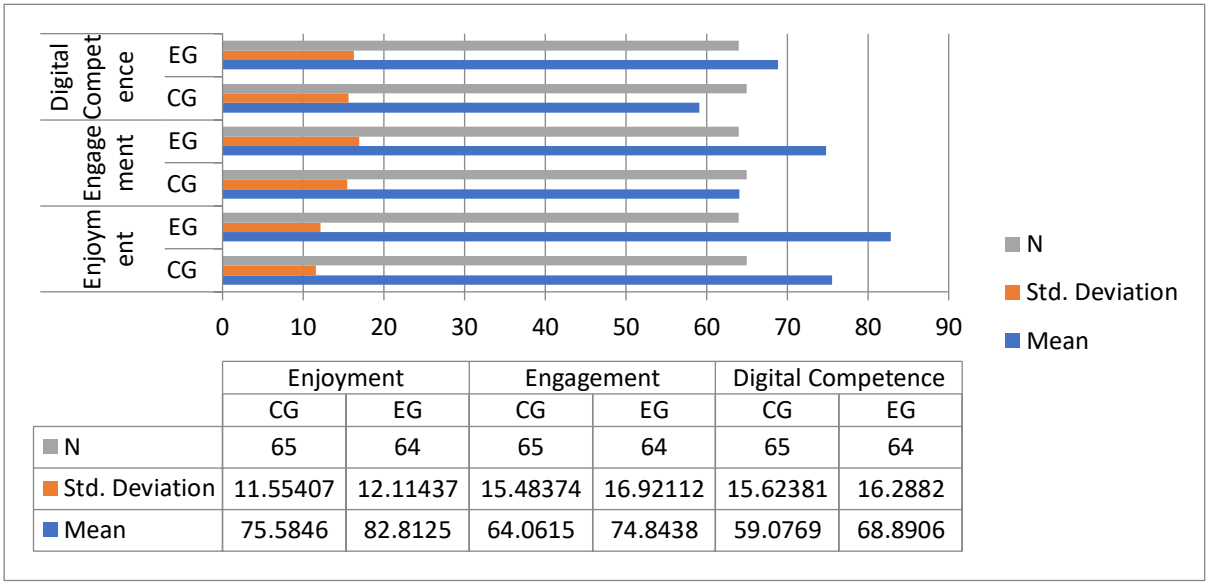
Table 3

Group Statistics for Posttest of Three Variables

Variable	Group	Mean	Std. Deviation	N
Academic Enjoyment	CG	75.58	11.55	65
	EG	82.81	12.11	64
Engagement	CG	64.06	15.48	65

	EG	74.84	16.92	64
Digital Competence	CG	59.07	15.62	65
	EG	68.89	16.28	64

Table 3 presents descriptive statistics for posttest scores related to academic enjoyment, engagement, and digital competence. The EG demonstrated superior performance compared to the CG in all measured variables: academic enjoyment (EG: M = 82.81, SD = 12.11; CG: M = 75.58, SD = 11.55), engagement (EG: M = 74.84, SD = 16.92; CG: M = 64.06, SD = 15.48), and digital competence (EG: M = 68.89, SD = 16.28; CG: M = 59.07, SD = 15.62). The elevated mean scores in the EG indicate that the AI-supported intervention positively influenced learners' emotional experiences, active participation, and digital skills when contrasted with conventional teaching methods. The standard deviations reveal a moderate level of variability in the responses, with the EG exhibiting slightly greater variability, which may suggest a range of reactions to the AI intervention.



	Enjoyment		Engagement		Digital Competence	
	CG	EG	CG	EG	CG	EG
N	65	64	65	64	65	64
Std. Deviation	11.55407	12.11437	15.48374	16.92112	15.62381	16.2882
Mean	75.5846	82.8125	64.0615	74.8438	59.0769	68.8906

Figure 2

Posttest Statistics

Figure 2 illustrates the posttest mean scores for academic enjoyment (EG: 82.81 vs. CG: 75.58), engagement (EG: 74.84 vs. CG: 64.06), and digital competence (EG: 68.89 vs. CG: 59.07), with green bars highlighting the differences between the groups. The elevated means in the EG across all variables visually affirm the intervention's effectiveness, with significant differences indicating that AI-supported learning improved outcomes in contrast to the CG's conventional

instruction. The persistent trend of elevated EG scores highlights the influence of the intervention on all assessed constructs.

Table 4

MANCOVA for Posttest Scores

Effect	Test	Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Intercept	Pillai's Trace	0.35	22.22	3.00	122.00	.00	0.35
	Wilks' Lambda	0.64	22.22	3.00	122.00	.00	0.35
	Hotelling's Trace	0.54	22.22	3.00	122.00	.00	0.35
	Roy's Largest Root	0.54	22.22	3.00	122.00	.00	0.35
Academic Enjoyment (covariate)	Pillai's Trace	0.05	2.39	3.00	122.00	.07	0.05
	Wilks' Lambda	0.94	2.39	3.00	122.00	.07	0.05
	Hotelling's Trace	0.05	2.39	3.00	122.00	.07	0.05
	Roy's Largest Root	0.05	2.39	3.00	122.00	.07	0.05
Engagement (covariate)	Pillai's Trace	0.00	0.38	3.00	122.00	.76	0.00
	Wilks' Lambda	0.99	0.38	3.00	122.00	.76	0.00
	Hotelling's Trace	0.00	0.38	3.00	122.00	.76	0.00
	Roy's Largest Root	0.00	0.38	3.00	122.00	.76	0.00
Digital Competence (covariate)	Pillai's Trace	0.01	0.68	3.00	122.00	.56	0.01
	Wilks' Lambda	0.98	0.68	3.00	122.00	.56	0.01
	Hotelling's Trace	0.01	0.68	3.00	122.00	.56	0.01
	Roy's Largest Root	0.01	0.68	3.00	122.00	.56	0.01
Groups	Pillai's Trace	0.19	9.86	3.00	122.00	.00	0.19
	Wilks' Lambda	0.80	9.86	3.00	122.00	.00	0.19
	Hotelling's Trace	0.24	9.86	3.00	122.00	.00	0.19

	Roy's Largest Root	0.24	9.86	3.00	122.00	.00	0.19

Table 4 displays the multivariate findings from the MANCOVA, investigating the overall impact of group affiliation (EG vs. CG) on the posttest outcomes for academic enjoyment, engagement, and digital competence, while accounting for pretest scores. The primary effect of the group was found to be statistically significant (Wilks' Lambda = 0.80, $F(3, 122) = 9.86$, $p < .001$, partial $\eta^2 = 0.19$), suggesting that the intervention supported by AI had a notable impact on the overall results. The partial eta squared ($\eta^2 = 0.19$) indicates a moderate to large effect size, suggesting that around 19% of the variance in the combined dependent variables can be linked to the intervention. The covariates (pretest scores) for academic enjoyment (Wilks' Lambda = 0.94, $F(3, 122) = 2.39$, $p = .07$, partial $\eta^2 = 0.05$), engagement (Wilks' Lambda = 0.99, $F(3, 122) = 0.38$, $p = .76$, partial $\eta^2 = 0.00$), and digital competence (Wilks' Lambda = 0.98, $F(3, 122) = 0.68$, $p = .56$, partial $\eta^2 = 0.01$) were not significant, indicating that the differences observed in the posttest were primarily attributable to the intervention rather than the baseline scores. The significant effect of the intercept (Wilks' Lambda = 0.64, $F(3, 122) = 22.22$, $p < .001$, partial $\eta^2 = 0.35$) demonstrates that the model explained a considerable amount of variance in the outcomes.

Table 5

Tests of Between-Subjects Effects for Each Posttest Variable

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	Academic Enjoyment	5818.69	4	1454.67	13.20	.00	0.29
	Engagement	8861.37	4	2215.34	9.71	.00	0.23
	Digital Competence	3582.95	4	895.73	3.48	.01	0.10
Intercept	Academic Enjoyment	4028.65	1	4028.65	36.58	.00	0.22
	Engagement	1489.92	1	1489.92	6.53	.01	0.05
	Digital Competence	12102.07	1	12102.07	47.10	.00	0.27
Academic Enjoyment (covariate)	Academic Enjoyment	661.36	1	661.36	6.00	.01	0.04
	Engagement	361.41	1	361.41	1.58	.21	0.01
	Digital Competence	14.56	1	14.56	0.05	.81	0.00

Engagement (covariate)	Academic Enjoyment	50.82	1	50.82	0.46	.49	0.00
	Engagement	24.86	1	24.86	0.10	.74	0.00
	Digital Competence	77.91	1	77.91	0.30	.58	0.00
Digital Competence (covariate)	Academic Enjoyment	14.26	1	14.26	0.13	.72	0.00
	Engagement	42.97	1	42.97	0.18	.66	0.00
	Digital Competence	451.19	1	451.19	1.75	.18	0.01
Groups	Academic Enjoyment	1495.50	1	1495.50	13.58	.00	0.09
	Engagement	3633.65	1	3633.65	15.93	.00	0.11
	Digital Competence	2428.01	1	2428.01	9.45	.00	0.07
Error	Academic Enjoyment	13655.54	124	110.12			
	Engagement	28269.85	124	227.98			
	Digital Competence	31859.66	124	256.93			
Total	Academic Enjoyment	828043.00	129				
	Engagement	658636.00	129				
	Digital Competence	562931.00	129				
Corrected Total	Academic Enjoyment	19474.24	128				
	Engagement	37131.22	128				
	Digital Competence	35442.62	128				

Table 5 presents the findings from univariate ANCOVAs conducted for each dependent variable, with pretest scores accounted for. The group variable demonstrated a significant influence on academic enjoyment ($F(1, 124) = 13.58$, $p < .001$, partial $\eta^2 = 0.09$), engagement ($F(1, 124) = 15.93$, $p < .001$, partial $\eta^2 = 0.11$), and digital competence ($F(1, 124) = 9.45$, $p = .003$, partial $\eta^2 = 0.07$). The results demonstrate that the EG achieved statistically significant improvements over the CG, with effect sizes indicating that 9%, 11%, and 7% of the variance in academic enjoyment, engagement, and digital competence, respectively, can be linked to the intervention. Among the covariates, only the academic enjoyment pretest emerged as a

significant predictor of posttest academic enjoyment scores ($F(1, 124) = 6.00$, $p = .01$, partial $\eta^2 = 0.04$). In contrast, engagement ($F(1, 124) = 0.10$, $p = .74$, partial $\eta^2 = 0.00$) and digital competence ($F(1, 124) = 1.75$, $p = .18$, partial $\eta^2 = 0.01$) pretests did not serve as significant predictors of their respective outcomes. The notable intercept effects (e.g., academic enjoyment: $F(1, 124) = 36.58$, $p < .001$, partial $\eta^2 = 0.22$) suggest that the model explained a considerable amount of variance in each outcome. The findings validate the effectiveness of the AI-supported intervention in improving all three constructs, with the most significant impact noted for engagement.

Discussion

The initial research inquiry examined if an AI-assisted informal learning intervention notably enhances the digital competence of Saudi EFL learners. The discovery of a notable positive effect ($F(1,124) =9.45, p=.003$), accompanied by a modest-to-medium effect size ($\eta2=.071$), validates that the execution of structured conversational practice effectively fostered the essential technological skills. This finding aligns with the broader literature that emphasizes the importance of engaging with intelligent systems to enhance digital literacy (Chen et al., 2024). Nonetheless, our research offers distinctive, causal insights within a non-Western framework, illustrating that the enhancement arose not from direct computer science instruction, but rather as a secondary effect of language utilization. The modest nature of the effect size indicates an important consideration for Saudi institutions: although the tool enhances functional skills, there may be a need for a dedicated, broader component that emphasizes ethical use and advanced information literacy to adequately meet the comprehensive digital competence required by Vision 2030. The theoretical basis for this effect is grounded in SCT (Vygotsky, 1978), where the AI system acts as a Digital More Knowledgeable Other (MKO), guiding learners into their ZPD for technology utilization. To effectively accomplish the communicative tasks from Connect Book 3, participants were required to interpret automated phonetic feedback, navigate the parameters of the dialogue system, and employ voice recognition technology, thus facilitating the internalization of these digital procedures as essential tools for reaching their language objectives.

The second research question inquired if an AI-supported informal learning intervention notably enhances the academic enjoyment of Saudi EFL learners. The notable finding ($F(1,124) =13.58, p<.001$), along with a medium effect size ($\eta2=.090$), provides strong evidence that the AI environment improved positive affective experiences. This outcome aligns positively with the broader motivational literature presented by Xu and Liu (2025), which connects the use of AI to enhanced autonomy and academic enjoyment. The essential aspect of our discovery is its contextual significance: the AI offered a private, non-judgmental conversational space, which is crucial for female learners who frequently face heightened anxiety concerning public performance and peer evaluation in the formal, gender-segregated classroom environment (Alasmari, 2020; Peláez-Sánchez et al., 2023). The elimination of the affective filter transformed the practice into a source of academic enjoyment instead of anxiety. The core theoretical rationale for this effect is rooted in SDT (Deci & Ryan, 2013). The capacity to manage the rhythm of the conversation, start discussions at their convenience, and endlessly reiterate phrases fulfilled the learners' desire for independence (Xia et al., 2022). At the same

time, obtaining immediate, precise, and corrective feedback, which validated advancements in the conversational frameworks from Connect Book 3 strongly bolstered the psychological requirement for competence. The combination of fulfilling two essential psychological needs serves as the catalyst that changed a compulsory curriculum requirement into a lasting source of academic enjoyment.

The third research question inquired if an AI-supported informal learning intervention significantly boosts engagement among Saudi EFL learners. The analysis revealed a highly significant effect ($F(1,124)=15.93$, $p<.001$), indicating the largest effect size ($\eta 2=.110$). This strong result aligns with the findings of Yuan and Liu (2025) and underscores the motivating potential of AI; however, our study distinctly offers causal evidence for engagement in the crucial area of informal, self-directed practice beyond class hours. This holds significant relevance in the context of Saudi Arabia, where opportunities for high-frequency practice are constrained. The positive result demonstrates that the AI successfully encouraged the essential behavioral, emotional, and cognitive engagement needed for extensive practice of the Connect Book 3 material. The rationale for this enhanced engagement is based on Cognitive Load Theory (Sweller, 1988). The flexible characteristics of the AI tool reduced the unnecessary cognitive burden linked to anxiety, fear of making mistakes in public, and unclear input that often obstructs participation in traditional environments. Through the careful presentation of linguistic input and feedback (Kaur et al., 2023), the AI enhanced the learners' mental capacity for engaging in deep processing, strategic learning, and schema development (i.e., germane load). This enhanced cognitive setting enabled students to dedicate more sustained effort, which directly resulted in the highest levels of engagement observed. Nonetheless, institutions should heed the cautions expressed by Zhai et al. (2024) concerning the risks associated with excessive dependence on AI systems, as this may result in a diminished cognitive effort necessary for effective language production if not properly overseen.

Conclusion

This quasi-experimental study revealed a notable positive multivariate impact of an AI-supported informal learning intervention on digital competence, academic enjoyment, and engagement among intermediate-level female EFL learners in Saudi Arabia. The study offers essential empirical support for the effectiveness of AI in tackling the specific challenges present in Saudi Arabia's gender-segregated EFL environment, where female learners encounter socio-cultural and infrastructural obstacles to frequent, unsupervised conversational practice. Xu and Liu (2025) emphasize that AI tools provide a culturally relevant and private approach, allowing learners to participate in genuine language practice free from the limitations of conventional classroom environments. The strong evidence supports that AI-driven platforms not only promote vital digital and language skills but also improve positive emotional outcomes, tackling a fundamental teaching challenge in the female-only educational setting of Saudi Arabia. The findings correspond with the directives of the national Vision 2030, highlighting the importance of digital transformation and fair access to education.

This study theoretically enhances two fundamental frameworks in AI-assisted language learning. Initially, the notable enhancements in academic enjoyment and engagement offer compelling evidence that aligns with SDT (Deci & Ryan, 2013). The personalized feedback and self-paced learning environment provided by the AI intervention addressed learners'

psychological needs for autonomy, enabling them to take charge of their learning journeys, and competence, by affirming their progress through immediate feedback. This dynamic acted as a significant intrinsic motivator for language acquisition. Additionally, the improved digital skills and ongoing involvement build upon the principles of SCT as proposed in 1978. The AI conversational partner acted as a digital More Knowledgeable Other (MKO), offering customized support that helped learners maneuver through intricate communication frameworks and technical interfaces within their ZPD. This supports the idea that AI plays a crucial role in enhancing both language and digital skills, further developing Vygotsky's theories within contemporary digital education environments.

The findings provide practical recommendations for stakeholders within Saudi Arabia's EFL system to incorporate AI in a manner that is both effective and ethical, in line with the emphasis on digital innovation outlined in Vision 2030. For those involved in EFL curriculum design and administration, it is crucial to incorporate conversational AI tools that align with the curriculum, such as specialized dialogue chatbots, into intermediate courses like Connect Book 3. This method guarantees frequent, low-stress conversational practice, addressing socio-cultural obstacles for female learners. Additionally, assessment frameworks ought to acknowledge self-directed, AI-logged practice to highlight its established significance for engagement and fluency. University policymakers and IT departments ought to allocate resources towards acquiring licenses for AI dialogue platforms that feature advanced speech recognition and tailored feedback in both Arabic (L1) and English (L2). Moreover, it is essential to finance extensive, gender-inclusive digital training programs aimed at equipping female learners with advanced skills in AI, such as data analysis and effective communication. This approach addresses the modest effect size ($\eta^2 = .071$) related to digital competence and promotes equitable access for all. EFL instructors ought to shift from being the main providers of conversational practice to becoming mentors and facilitators in AI-assisted learning environments. Training programs ought to prepare educators to assist learners in utilizing AI feedback for language improvement and self-reflection, as well as in developing intricate prompts to enhance cognitive involvement, thereby establishing educators as facilitators who promote independent learning.

Limitations and Suggestions for Further Studies

Despite these contributions, the research encountered constraints stemming from the academic setting. The quasi-experimental design with a non-equivalent control group, required due to institutional policies that prevent random assignment of pre-existing classes, could lead to unmeasured differences that were present before the study began. The sample, composed exclusively of intermediate-level female learners from one Saudi university, restricts the applicability of the findings to male groups, different proficiency levels, or various regional settings within Saudi Arabia. Furthermore, dependence on self-report tools for assessing digital competence, academic enjoyment, and engagement, while having undergone psychometric validation, could be influenced by social desirability bias, which may lead to an overestimation of reported engagement or digital skill levels. To overcome these constraints, subsequent studies ought to explore novel avenues of investigation. Longitudinal, mixed-methods studies spanning at least one academic year should monitor the sustainability of engagement and academic enjoyment while evaluating the impact of frequent AI use on cognitive processes,

especially cognitive offloading (Zhai et al., 2024), to ascertain whether dependence on AI feedback influences independent recall of grammar and pronunciation in high-stakes communication. Comparative studies that investigate the varying effects of AI interventions within gender-segregated groups (female-only versus male-only) in Saudi Arabia would offer valuable insights into the ways socio-cultural factors influence technology adoption and learning outcomes. Furthermore, creating interventions that leverage AI to replicate culturally authentic social scenarios in Saudi Arabia, including dialogues that necessitate deference or politeness strategies, would evaluate the effectiveness of AI in fostering socio-pragmatic competence, thereby broadening its application from mere grammatical correction to enhancing cultural communication fluency.

Funding

The authors acknowledge the Deanship of Scientific Research at King Faisal University, Saudi Arabia for financial support under annual research grant number Grant KFU252826.

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