

Article

Leveraging AI to Mitigate Learning Poverty in the Digital Era: The Impacts of Integrated AI Educational Tools on Students' Literacy Skills

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Abstract

Technological innovation plays a crucial role in improving educational quality worldwide. In Ethiopia, however, literacy skills face significant obstacles, worsening the problem of learning poverty. This study aimed to analyze the effects of integrated AI educational tools on students' literacy development. It also explored how learners perceived the use of these tools in reading and writing instruction. A quasi-experimental single-group time series design, combining both quantitative and qualitative approaches, was used. A total of 46 students from the Information Technology department at Injibara University were selected through a comprehensive census sampling method. For a period of three months, participants received reading and writing lessons supported by AI tools (NoRedInk, Rewordifyv2.1.0, and LanguageTool 9.5.0) to assess their impact on literacy skills. Data collection included pre- and post-tests, focus group discussions, and reflective journals. Quantitative data were analyzed with ANOVA, and qualitative data underwent thematic analysis using thematic techniques. Results revealed that the integration of AI educational tools significantly enhanced students' literacy skills, including grammar, vocabulary, comprehension, content organization, and writing style. Students also expressed positive perceptions of using these tools in their reading and writing lessons. Therefore, this study encourages scholars, educators, and learners to adopt integrated AI educational tools to improve literacy development.

Keywords: AI educational tools; digital era; literacy skills; mitigating learning poverty; reading and writing skills



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1. Introduction

Education is widely acknowledged as a fundamental driver of societal growth and individual development. It contributes not only to economic progress but also to social well-being, enabling citizens to navigate both routine and complex aspects of daily life effectively. Through education, individuals acquire critical thinking, problem-solving, decision-making, and analytical skills, all of which are essential for participating meaningfully in societal processes. Scholars emphasize that education extends beyond knowledge transfer to include character formation, civic responsibility, and social preparedness,

highlighting its role in fostering holistic development, social inclusion, and sustainable growth [1]. Education is therefore not only an individual benefit but a societal imperative, shaping the intellectual and moral capacities of citizens and supporting the advancement of communities and nations. This is particularly relevant in multilingual societies, where English as a Foreign Language (EFL) serves as a medium for academic instruction, global communication, and professional opportunities.

Within the broader framework of education, the possession of basic literacy skills in English as a Foreign Language is essential for academic achievement and lifelong learning. EFL literacy, encompassing reading, writing, listening, and comprehension, is a prerequisite for acquiring knowledge in all disciplines and is central to effective communication, critical thinking, and problem-solving. Research demonstrates that literacy skills in EFL enable learners to analyze, synthesize, and evaluate information, and to articulate their ideas clearly, both in academic and social contexts [2,3]. Reading comprehension supports understanding of English texts, integration of information, and critical engagement with content, while writing skills allow students to express ideas coherently, reflect on societal and global issues, and participate meaningfully in scholarly discourse [4]. Early literacy skills, such as print awareness, phonological recognition, and vocabulary acquisition, form the foundation for advanced reading and writing abilities. Parental literacy, home environment, and prior exposure to English further influence the development of these skills [5,6]. Without mastery of EFL literacy, students encounter barriers to academic progress, limited learning opportunities, and reduced capacity to participate fully in higher education and professional life. This underscores the need for structured pedagogical interventions, targeted literacy programs, and continuous support for EFL learners at all levels of education.

Despite the acknowledged importance of EFL literacy, Ethiopia faces persistent challenges that hinder the full realization of educational benefits. Learning poverty, defined as the inability of learners to read, write, and comprehend texts in English, remains widespread, affecting learners from early childhood through higher education [7,8]. According to recent reports, approximately 90% of Ethiopian children under the age of ten cannot read texts correctly, indicating a severe literacy deficit from the earliest stages of formal education. This foundational gap carries forward into higher education, where students continue to struggle with EFL reading and writing tasks. The causes of this literacy gap are multifaceted. A shortage of qualified teachers, inadequate instructional materials, outdated curricula, and insufficient integration of technology into classrooms significantly contribute to low literacy outcomes [9,10]. Socioeconomic disparities, gender inequalities, and geographical barriers further exacerbate the problem, particularly affecting girls, children with disabilities, and rural learners. Additionally, recurrent socio-political disruptions, inflation, and other systemic challenges have intensified the difficulties faced by students, leading to widespread learning poverty and limited opportunities for academic, social, and professional advancement [11–15].

The consequences of low EFL literacy in Ethiopia are profound. Students who cannot read fluently or express themselves effectively in English encounter obstacles in academic performance, critical engagement, and higher education completion. This deficiency perpetuates cycles of poverty and social inequity, as learners unable to access and process information in English are disadvantaged in employment, international communication, and lifelong learning. Higher education students, in particular, struggle with integrating literacy into complex tasks such as research, academic writing, and professional communication, thereby undermining their overall educational outcomes [16–22]. Furthermore, the lack of EFL literacy skills restricts learners' ability to benefit from emerging digital and

technological tools, limiting opportunities for innovative learning experiences that could otherwise enhance comprehension and expression.

Addressing EFL literacy deficits in Ethiopia requires a holistic approach that targets the enhancement of literacy skills. Adequate teacher training, curriculum reform, equitable access to resources, and the strategic integration of appropriate technological tools are essential for empowering learners and improving literacy outcomes. By fostering English reading and writing skills from early childhood through higher education, Ethiopia can enhance the quality of education, promote social equity, and prepare students for meaningful participation in the global knowledge economy. Digital interventions, including audio-visual aids, interactive learning platforms, and AI-supported writing tools, can provide personalized learning experiences, immediate feedback, and opportunities for skill development tailored to local languages and cultural contexts [23–28]. Tools like Grammarly, QuillBot, and other AI-supported software have demonstrated effectiveness in improving vocabulary, reading comprehension, and writing fluency. However, their use remains limited within Ethiopian higher education, highlighting a critical area for policy focus and institutional support [29–32].

Based on the above discussion, this study seeks to address the following research questions:

1. What are the impacts of integrated AI educational tools on the development of students' EFL literacy skills?
2. How do learners perceive the use of integrated AI educational tools in reading and writing instruction?

Answering these questions, the research will contribute several theoretical and practical insights. First, it investigates the impacts of integrated AI educational tools on the development of students' EFL literacy skills, with particular attention to reading and writing proficiency in higher education. By examining changes in learners' performance, the study evaluates the effectiveness of AI-supported instruction as a pedagogical means to enhance EFL literacy. Second, the study explores learners' perceptions of the use of integrated AI educational tools in reading and writing instruction. This dimension focuses on students' attitudes, engagement, and perceived usefulness of AI-assisted activities in supporting their learning processes. Together, these research questions position the study as a focused investigation into how AI tools can both improve EFL literacy outcomes and shape learners' perceptions toward technology-enhanced language learning, contributing evidence-based insights to EFL pedagogy and digital education in higher education contexts, contributing to sustainable improvements in educational quality and student outcomes.

2. Review of Literature

2.1. Learning Poverty

Learning poverty refers to the inability to read and understand a simple text [13] and is closely linked to household and socio-economic factors [33]. Field studies show that children from lower-income households with parents of low educational attainment face higher rates of learning poverty. In Ethiopia, this manifests as failure to achieve minimum proficiency in reading and mathematics, compounded by poverty, health issues, and inadequate living conditions [34,35]. High dropout rates, delayed enrollment, and early school leaving underscore the need for targeted interventions to improve literacy access and retention. The COVID-19 pandemic further worsened the situation, as students advanced grades without adequate learning, negatively impacting their reading and writing skills.

2.2. Literacy Skills

Literacy encompasses reading, writing, and communication skills that are essential for meaningful participation in society [36]. In the context of English as a EFL, literacy

extends beyond basic decoding skills to include the ability to comprehend, interpret, and produce academic and functional texts in English. For this study, literacy is conceptualized as both an end in itself and a means to academic success. In the end, EFL literacy represents a fundamental life skill that enables learners to engage in social interaction, access information, and participate in global and local communicative practices. As a means, EFL literacy underpins students' academic achievement, as reading and writing skills develop interactively and are central to learning across disciplines delivered through English as the medium of instruction [37].

In Ethiopia, the development of EFL literacy is constrained by poor teaching conditions, socio-political instability, and limited educational resources, particularly in the Amhara, Tigray, and Afar regions. These challenges undermine students' ability to acquire functional proficiency in English, which in turn affects their academic performance and broader educational trajectories. Reading and writing skills in EFL are therefore foundational not only for cognitive development and academic success, but also for social integration and lifelong learning, reinforcing their dual role as both a prerequisite for educational attainment and a necessary competence for life beyond formal schooling [38–40].

2.3. Challenges in Literacy Skills

Barriers to literacy exist across all education levels. Globally, limited parental knowledge, complex academic texts, and insufficient vocabulary hinder literacy acquisition [41,42]. In Northern Ethiopia, conflicts, school disruptions, and destroyed infrastructure further limit learning opportunities. Overcrowded classrooms, lack of teaching personnel, and insufficient materials exacerbate these challenges, contributing to persistent learning poverty [43–46].

2.4. Strategies for Mitigating Learning Poverty

Mitigating learning poverty requires a multifaceted approach, combining educational strategies and community engagement [47]. Key measures include increasing school resources, enhancing teacher training, and addressing socio-economic barriers. Collaboration among educators, parents, and government agencies creates supportive learning environments, enabling students from disadvantaged backgrounds to succeed academically [48].

2.5. Education in the Digital Era

Technological advances are transforming education, offering opportunities and challenges [49–52]. In Ethiopia, higher education institutions face limited infrastructure, unreliable internet, and insufficiently skilled staff, hindering digital integration [20,22,53,54]. Enhancing teachers' digital competencies, providing administrative support, and integrating AI and e-learning platforms can improve learning quality and reduce literacy-related learning poverty [55–57].

2.6. Integrating Digital Devices to Improve Literacy Skills

Digital devices create personalized learning experiences that enhance reading and writing skills, engagement, and academic success. Effective integration depends on curriculum design, teaching strategies, and alignment with students' needs [58,59]. In EFL contexts, AI-powered tools such as NoRedInk, Rewordify, and LanguageTool have been shown to provide adaptive support for literacy development. Rewordify simplifies complex texts to improve vocabulary acquisition and reading comprehension, enabling learners to engage meaningfully with challenging material. NoRedInk provides individualized grammar and writing exercises, allowing students to receive real-time feedback and target specific areas for improvement, while LanguageTool supports self-editing and writing coherence through automated suggestions for grammar, punctuation, and style. Studies indicate that these AI

tools can also increase learner motivation, autonomy, and confidence, demonstrating that technology-enhanced instruction can bridge gaps in EFL literacy acquisition [60–64].

2.7. Theoretical Framework

This study is guided by Constructivist Learning Theory (CLT), which emphasizes active knowledge construction through experience, social interaction, and reflection. CLT suggests that learners develop understanding most effectively when engaged in meaningful tasks, collaborate with peers, and receive scaffolding from instructors. Applying CLT to EFL literacy, students enhance reading, writing, and comprehension skills by interacting with authentic language materials and constructing knowledge through practice and collaboration. Integrating AI tools within this framework provides interactive, adaptive, and personalized learning experiences that align with constructivist principles. AI platforms offer immediate feedback, scaffolded exercises, and opportunities for self-directed learning, supporting iterative skill development while fostering engagement.

Furthermore, using AI in a constructivist environment can positively shape students' perceptions of technology-assisted learning. By experiencing the benefits of AI—such as real-time correction, vocabulary support, and adaptive challenges—learners develop confidence, motivation, and openness toward technology in language acquisition. Thus, combining CLT with AI tools not only improves EFL literacy but also encourages students to perceive AI activities as meaningful, supportive, and integral to their learning process [60,61]. Figure 1 illustrates how AI-supported literacy learning enables students to actively construct reading and writing skills through guided, learner-centered engagement.

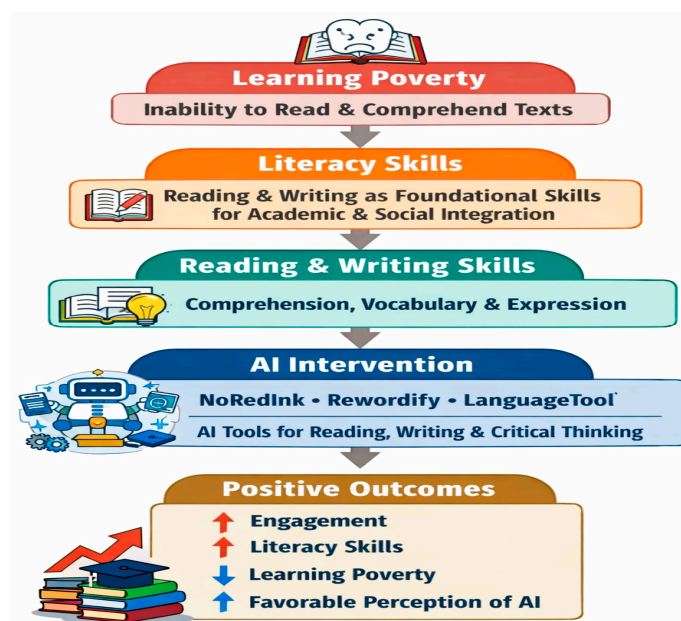


Figure 1. Conceptual Framework.

3. Methodology

3.1. Research Design

The bottom line of the study is to alleviate learning poverty of literacy skills by improving students' reading and writing literacy skills through combining the AI tools, and to identify how students perceive using AI tools in advancing their literacy skills. Hence, in accomplishing this primary research objective, a quasi-experimental time series single-group research design supported by test and focus group discussion instruments was employed to gather data from students and teachers at multiple times before and after

the intervention. The study in [62] states that a quasi-experimental research design is ideal to assess the impacts of the intervention implemented in a real-world setting.

3.2. Population

Focusing on mitigating learning poverty, particularly reading and writing literacy in higher education, this study involved students. The total number of participants in this study was 46 second-year Information Technology (IT) students enrolled during the study period. And, they were attending Communicative English Language Skills II, providing a relevant context for EFL literacy development. The cohort, aged 19–22, and representing both genders from diverse socio-economic backgrounds. All students belonged to the same academic cohort and were taking the course in which the intervention was implemented. Given the small and clearly defined nature of the group, the study adopted a non-probabilistic sampling approach, specifically a comprehensive census sampling technique, whereby all eligible students in the population were included. To ensure the suitability of participants, students were included if they were officially registered as second-year IT students, attended the course regularly, and provided consent to participate in the study. A non-probabilistic comprehensive census sampling technique was appropriate because the total population size was small and easily accessible, making it practical to involve every student rather than drawing a sample. Including the entire cohort helped minimize selection bias and ensured that the findings reflected the real classroom context, and this could reduce variability that could be caused by sampling differences. Furthermore, as the study employed a technology-mediated intervention, the results may have been influenced by their relatively high digital literacy and familiarity with technology-enabled tasks. The homogeneity of this group may also have contributed to the consistency of the findings. However, these results may not be transferable to educational contexts such as primary and secondary schools, where formal IT training is limited. The findings are more likely to be transferable to learners in higher education, particularly those enrolled in communicative English language courses. Finally, maximizing participant inclusion increased the robustness of the data, which is particularly important in educational research settings where the number of available participants is often limited.

3.3. Instruments

To gather quality data, the following data collection tools: tests, focus group discussions, and student reflective journals, were necessarily employed. These self-prepared instruments focus on improving participants' literacy skills, mitigating learning poverty of EFL literacy skills using AI tools (NoRedInk, Rewordifyv2.1.0, and LanguageTool 9.5.0), and examining their perceptions on the use of integrated AI educational tools in reducing literacy skills poverty. For example, the pre- and post-test achievement tests consisted of closed-ended questions, (What is the main purpose of using AI tools in reading and writing?), assessed literacy sub-skills, such as reading comprehension (the ability to understand and interpret texts), vocabulary (accurate and context-appropriate word use), grammar and mechanics (syntax, punctuation, and spelling), sentence structure (syntactic accuracy and variety), coherence (logical flow of ideas), and overall writing quality (effective integration of these elements to produce clear and communicative texts). And, reflective journals and focus group discussions provided insights into students' perceptions of using AI tools in improving reading and writing literacy skills by forwarding questions (Describe how AI tools assisted you in organizing your ideas and improving coherence in your essays). The instruments were reviewed by two PhD holders and one MA-level researcher to ensure the validity. They carefully reviewed each item to ensure it was relevant, clear, and meaningful for assessing EFL literacy skills and aligned with the study's goals. Based on their sug-

gestions, the questions were refined to improve clarity, confusing wording was removed, and insured they directly addressed the research questions. A pilot study confirmed the reliability of the tools, with a Cronbach's alpha of 0.89 for the entire achievement test, indicating that all items consistently measured the intended literacy skills.

3.4. Data Collection Procedures

There was a treatment group to gather relevant and sufficient data in a multiple time series. After obtaining the consent from students, the pre-test was administered to them to establish a baseline before the intervention. And then, the experimental group took part within three-months AI-supported intervention that was built into their regular classroom lessons to strengthen their reading and writing skills. During this period, students used NoRedInk to practise grammar and mechanics with personalised feedback, Rewordify to make difficult reading texts easier to understand and to build vocabulary, and LanguageTool to support idea generation, text organisation, and revision while working on writing tasks. Together, these activities created regular opportunities for feedback and active engagement with reading and writing.

After the intervention, a post-test whose question items are the same as the pre-test was administered to identify the impact of AI tools, track trends and patterns in the data, and measure changes over time in students' EFL literacy skills. Besides the test, qualitative data regarding participants' perception of the AI tools applied in the intervention were collected through focus group discussions with 10 participants for 62 min and students' reflective journals. The responses were recorded and transcribed.

3.5. Data Analysis Techniques

Quantitative data underwent a thorough analysis using an inferential statistical method, a one-way repeated measures ANOVA using the statistical software of SPSS version 27. And, the qualitative data obtained from focus group discussions and students' journal reflections were analysed using the thematic analysis technique. The analysis involved repeated reading, initial coding to identify recurring patterns, and the clustering of codes into broader themes related to literacy development, learner engagement, and AI-supported instruction. These themes complemented and contextualized the quantitative findings.

4. Results and Discussions

4.1. Impacts of Integrated AI Educational Tools on Students' Literacy Skills

The students were given three reading and essay writing pretests and three reading and essay writing posttests to measure their literacy skills before and after the AI-supported intervention. This section outlines the test outcomes derived from both the pretests and posttests, analyzed through One-Way Repeated Measures ANOVA. Table 1 shows that the students' Mean scores for Pretest-1, Pretest-2, and Pretest-3 were 33.07, 33.93, and 34.48, respectively. Additionally, the students' Mean scores for Posttest-1, Posttest-2, and Posttest-3 were 44.50, 44.76, and 45.35. These results indicate that the students' pretest Mean scores were consistent, and similarly, their posttest Mean scores were also consistent. A comparison between the pretest and posttest Mean scores reveals statistically significant differences. In other words, the students' posttest Mean scores exceeded those of the pretests. This suggests that students' literacy performance improved markedly following the intervention period. Overall, it can be inferred that using AI tools in reading and writing instruction positively influenced students' literacy performance.

Table 1. Descriptive statistics.

Tests	Mean	Std. Deviation	N
M Pretest 1	33.07	1.890	46
M Pretest 2	33.93	2.407	46
M Pretest 3	34.48	3.082	46
M Posttest 1	44.50	2.631	46
M Posttest 2	44.76	2.938	46
M Posttest 3	45.35	2.331	46

Before conducting the repeated-measures ANOVA, the assumptions underlying the analysis were examined. Normality of the dependent variable (students' literacy scores) was assessed using the Shapiro–Wilk test for each measurement point, and the results indicated no severe deviations from normality ($p > 0.05$). The dependent variable in this analysis was students' overall literacy test scores, while time (Pretest 1, Pretest 2, Pretest 3, Posttest 1, Posttest 2, and Posttest 3) served as the within-subjects factor. In addition, repeated-measures ANOVA is considered robust to moderate violations of normality, particularly when sample sizes exceed 30 and group sizes are equal, as in the present study ($N = 46$). Therefore, the use of repeated-measures ANOVA was deemed appropriate for addressing the study's research objectives.

Moreover, the results suggest that the integrated application of AI-powered educational tools in reading and writing instruction enhanced students' literacy skills across both reading and writing domains. Consistent with this finding, earlier studies [58,59] demonstrated that combined AI tool usage in literacy instruction positively impacts students' skills by fostering engagement and personalized learning experiences. Through the AI-enhanced intervention using tools such as NoRedInk, Rewordify, and LanguageTool, students exhibited notable improvements in grammar, vocabulary, comprehension, idea generation, content organization, and writing style.

Table 2 presents the within-subject effects of the repeated-measures analysis. Under the sphericity assumed condition, the analysis yielded $F(5, 225) = 1194.446$, $p < 0.001$, partial $\eta^2 = 0.964$, indicating a statistically significant and very large effect of time on students' literacy scores. Importantly, this finding reflects systematic changes across all six measurement points rather than a simple pre–post contrast. While statistically significant differences were detected across successive phases, closer inspection of the descriptive statistics and post hoc comparisons suggests that score changes during the pre-intervention phase were relatively small and gradual, whereas substantially larger gains occurred following the introduction of the AI-supported instructional intervention. Taken together, the pattern of results supports the interpretation that the observed improvements are closely associated with the AI-supported instructional intervention, while acknowledging that time-related factors may have contributed marginally to performance changes before the intervention.

To determine the specific differences between each test score, a post hoc analysis was conducted. For a repeated-measures variable, the post hoc analysis utilized paired-sample t -tests. Table 3 shows that minor but statistically significant differences were observed among the three pretests; however, the magnitude of these differences was small, suggesting limited score progression before the intervention. Similarly, no meaningful differences were observed among the three posttests, indicating a relative stabilization of performance following the intervention. In contrast, substantial and statistically significant differences were found between all pretest and posttest comparisons, with gains that were markedly larger than those observed within either phase. This pattern suggests that, although maturation or repeated exposure may have contributed to small variations

over time, the magnitude and consistency of the pretest–posttest differences are closely associated with the implementation of the AI-supported instructional intervention rather than solely with measurement variability or practice effects. Therefore, it can be concluded that the integrated use of AI-powered instructional tools, including NoRedInk, Rewordify, and LanguageTool, was associated with meaningful improvements in students' literacy skills, such as grammar, vocabulary, comprehension, idea generation, content organization, and writing style. Consistent with this interpretation, prior research has noted that, despite recognized challenges, the integration of AI offers substantial opportunities to transform the educational landscape [56].

Table 2. Tests of within-subject's effects.

	Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Time	Sphericity Assumed	8479.217	5	1695.843	1194.446	0.000	0.964
	Greenhouse-Geisser	8479.217	3.557	2383.608	1194.446	0.000	0.964
	Huynh-Feldt	8479.217	3.900	2174.031	1194.446	0.000	0.964
	Lower-bound	8479.217	1.000	8479.217	1194.446	0.000	0.964
Error (Time)	Sphericity Assumed	319.449	225	1.420			
	Greenhouse-Geisser	319.449	160.079	1.996			
	Huynh-Feldt	319.449	175.510	1.820			
	Lower-bound	319.449	45.000	7.099			

Table 3. Paired samples test.

	Paired Differences	Mean	Std. Deviation	Std. Error Mean	t	df	Sig. (2-Tailed)
Pair 1	M Pretest 1 – M Pretest 2	−0.870	1.276	0.188	−4.624	45	0.000
Pair 2	M Pretest 1 – M Pretest 3	−1.413	1.833	0.270	−5.229	45	0.000
Pair 3	M Pretest 1 – M Posttest 1	−11.435	2.040	0.301	−38.014	45	0.000
Pair 4	M Pretest 1 – M Posttest 2	−11.696	2.086	0.308	−38.034	45	0.000
Pair 5	M Pretest 1 – M Posttest 3	−12.283	1.882	0.277	−44.272	45	0.000
Pair 6	M Pretest 2 – M Pretest 3	−0.543	1.456	0.215	−2.531	45	0.015
Pair 7	M Pretest 2 – M Posttest 1	−10.565	1.500	0.221	−47.758	45	0.000
Pair 8	M Pretest 2 – M Posttest 2	−10.826	1.780	0.262	−41.246	45	0.000
Pair 9	M Pretest 2 – M Posttest 3	−11.413	1.892	0.279	−40.904	45	0.000
Pair 10	M Pretest 3 – M Posttest 1	−10.022	1.653	0.244	−41.116	45	0.000
Pair 11	M Pretest 3 – M Posttest 2	−10.283	1.361	0.201	−51.250	45	0.000
Pair 12	M Pretest 3 – M Posttest 3	−10.870	1.759	0.259	−41.913	45	0.000
Pair 13	M Posttest 1 – M Posttest 2	−0.261	1.512	0.223	−1.170	45	0.248
Pair 14	M Posttest 1 – M Posttest 3	−0.848	1.619	0.239	−3.552	45	0.001
Pair 15	M Posttest 2 – M Posttest 3	−0.587	1.359	0.200	−2.929	45	0.005

Although the paired-sample comparisons revealed statistically significant differences among some pretest scores and among some posttest scores, the magnitude of these differences was small and is unlikely to be educationally meaningful. In contrast, all comparisons between pretest and posttest scores demonstrated large and consistent differences, indicating that the observed gains were primarily attributable to the intervention rather than to measurement variability or repeated testing effects. Therefore, while statistical significance was observed in several pairwise comparisons, the substantive and pedagogical significance of the results is most evident in the contrast between pre-intervention and post-intervention performance.

It should be noted that the quantitative findings reported in this section reflect students' overall literacy performance rather than separate domain-specific scores. Consequently, conclusions drawn from the statistical analysis pertain to general improvements in literacy skills as measured by the composite reading and writing assessments.

Although statistically significant differences were observed across all measurement points, the educational significance of these differences varied considerably. The relatively small gains observed during the pre-intervention phase likely reflect normal developmental progression, increased familiarity with test formats, or short-term learning consolidation. In contrast, the substantially larger and more consistent gains observed following the introduction of the AI-supported instructional intervention suggest a meaningful improvement in literacy outcomes. While the repeated-measures design does not fully eliminate alternative explanations such as maturation or practice effects, the timing, magnitude, and consistency of the post-intervention gains provide strong evidence that the integrated AI educational tools contributed substantially to enhancing students' literacy performance.

These findings are consistent with prior research demonstrating the positive impact of AI-supported instruction on literacy development [58,59]. They also align with qualitative insights from student reflections and focus group discussions, which highlighted improvements in grammar, vocabulary, comprehension, idea generation, content organization, and writing style following the AI intervention. Taken together, the quantitative and qualitative evidence support the conclusion that the integrated AI tools facilitated notable advancements in students' literacy skills, while still recognizing that small pre-intervention changes may partly reflect normal learning progression.

4.2. Students' Perceptions Towards AI Educational Tools in Reading and Writing Instruction

The findings derived from the focus group discussions conducted with participants reveal compelling insights regarding the impacts of integrated AI-powered educational tools on enhancing students' literacy skills, particularly in the domains of reading and writing. Focus group discussions revealed compelling insights into the impacts of integrated AI-powered educational tools on students' literacy skills. Participants described substantial improvements in reading comprehension, grammar, vocabulary, idea generation, content organization, and writing style following the intervention. A focus group discussion that consisted of 10 participants was conducted for 62 min. Discussions were guided by semi-structured questions covering literacy challenges, AI tool usage, and perceived learning outcomes. The qualitative data obtained from focus group discussions and students' reflective journals were analyzed using a thematic analysis approach. The analysis involved repeated readings of the transcripts and written reflections, followed by initial coding to identify recurring patterns. These codes were then grouped into broader themes related to perceived improvements in literacy skills, learning engagement, and instructional support provided by AI tools. This analytic process enabled the identification of dominant themes that complemented and contextualized the quantitative findings.

A significant portion of the participants shared their experiences of grappling with various deficiencies in their reading and writing abilities prior to their engagement with these innovative AI educational resources. Many expressed challenges in comprehending complex English texts and in crafting coherent, effective essays that could convey their thoughts clearly and persuasively. However, following their exposure to these advanced AI tools, students reported remarkable improvements across a broad spectrum of literacy skills. For instance, one participant vividly articulated her journey, noting that her literacy skills had seen a substantial transformation after utilizing the integrated AI-powered educational tools. She highlighted how these resources played a pivotal role in her development in several critical areas, including grammar, vocabulary enhancement, reading comprehension,

idea generation, content organization, and writing style. This participant expressed a sense of newfound confidence, stating that she is now capable of reading and comprehending English language texts with much greater efficacy than before. Furthermore, she shared that she can produce written works that are not only coherent but also engaging and relevant to her intended audience. For instance, one of the students stated: “My reading and writing skills have been significantly enhanced due to the use of the AI instructional tool. I feel like I’ve gained a deeper understanding of grammar and vocabulary, which has positively influenced my comprehension skills.”

Another participant contributed to the discussion by recounting his personal experience with the integrated AI instructional tools. He noted that these resources significantly empowered his literacy skills and provided him with the necessary support to overcome previous struggles he faced with reading performance. He candidly reflected on how his written texts often fell short of effectively communicating his ideas to his audience. However, after undergoing the intervention involving AI tools, he reported enhanced abilities in reading comprehension and text production. He specifically mentioned improvements in grammar usage, vocabulary selection, comprehension of complex texts, idea generation for writing assignments, content organization in essays, and overall writing style.

Moreover, a third student shared her insights regarding her improved reading and writing capabilities as a direct result of engaging with the integrated AI instructional tools. She enthusiastically remarked, “My reading and writing skills have been significantly enhanced due to the use of the AI instructional tool. I feel like I’ve gained a deeper understanding of grammar and vocabulary, which has positively influenced my comprehension skills.” She elaborated on how these enhancements allowed her to generate ideas more effectively, organize her content logically, and refine her writing style to better connect with her audience. This participant expressed gratitude for the instruction provided through these AI-enhanced educational tools, crediting them for elevating her overall literacy competencies.

In addition to these individual accounts, another respondent emphasized that his literacy skills were significantly augmented following his learning experiences with the AI-powered instructional tools. He noted that he has become proficient in English reading and writing compared to his prior performance. This improvement was not just limited to academic tasks; he felt equipped to tackle real-world reading and writing challenges that he might encounter outside of the classroom setting.

The discussions also revealed a common theme among participants regarding the applicability of the literacy skills they developed during the instructional process to real-life contexts involving reading and writing. One focus group discussion participant poignantly remarked, “Every university graduate, including those specializing in English language studies, benefits from improving literacy skills through AI-powered educational tools.” This statement reflects a broader understanding of the significance of literacy in various professional and academic settings. The participant expressed a personal aspiration to become an expert in the English language, which necessitates a high level of proficiency in professional reading and writing. She emphasized that excelling in grammar, vocabulary, comprehension, idea generation, content organization, and writing style are all key components of literacy skills that are essential for success.

As part of their reflections on their learning experiences, many participants acknowledged that the literacy skills they cultivated through integrated AI-powered tools would be invaluable throughout their academic journeys and beyond. They recognized that these skills would not only aid them in their current studies but also serve as foundational competencies that would support their future endeavors in various fields. The reflective journals corroborated these findings, highlighting improvements in grammar usage, vocabulary, comprehension, idea generation, content organization, and writing style across multiple

dimensions. The combined application of AI tools such as NoRedInk, Rewordify, and LanguageTool was instrumental in facilitating these improvements.

In conclusion, the focus group discussions provided rich qualitative data that underscores the transformative impact of integrated AI-powered educational tools on students' literacy skills. Paired samples tests indicated significant differences between pre- and post-intervention scores across all literacy domains ($p < 0.05$), supporting the observed improvements. Participants reported significant improvements in their reading and writing abilities across multiple dimensions, including grammar, vocabulary, comprehension, idea generation, content organization, and writing style. In line with this finding, Refs. [49–51] reported the importance of leveraging technology in educational settings to enhance students' learning experiences and outcomes. As students continue to navigate an increasingly complex information landscape, equipping them with robust literacy skills through innovative instructional methods will contribute to their academic success and prepare them for future challenges in both professional and personal contexts.

The data collected from students' reflective journals provide compelling insights into the significant role that integrated AI educational tools play in enhancing various literacy skills among learners. These tools have been shown to effectively improve essential competencies such as grammar, vocabulary, comprehension, idea generation, content organization, and writing style. Participants in this study reported that their engagement with AI tools specifically designed for educational purposes has led to notable advancements in their reading and writing capabilities. The combination of AI applications like NoRedInk, Rewordify, and LanguageTool has proven to be particularly beneficial in fostering these skills across the aforementioned domains.

The findings of this study are well-supported by existing literature. For instance, research conducted by [58,59] provides robust evidence that the integration of AI instructional tools into language pedagogy significantly bolsters students' literacy abilities. Furthermore, additional studies carried out by [52–55] have also highlighted the critical importance of enhancing literacy skills among higher education students, especially in the areas of reading and writing, through the thoughtful incorporation of AI educational tools into the teaching and learning framework. This integration is not merely beneficial; it is essential for fostering crucial skills that will serve students well in their future academic and professional endeavors.

The qualitative data collected through student reflective journals and focus group discussions further corroborate these findings. Students consistently expressed that their literacy skills improved through the application of integrated AI educational tools. They noted specific enhancements in their grammar usage, expanded vocabulary, better comprehension of texts, more effective idea generation, improved content organization, and a more refined writing style. These improvements were not just superficial; they reflected a deeper engagement with the learning material and a more profound understanding of the language itself.

Moreover, the implications of these findings extend beyond individual skill enhancement. The study suggests that the use of integrated AI educational tools in reading and writing instruction can lead to a more comprehensive development of students' overall literacy capabilities. When students actively engage with these tools, they are not just passively receiving information; they are participating in an interactive learning process that encourages exploration, creativity, and critical thinking. This active engagement is crucial for developing lifelong learners who can adapt to the ever-evolving demands of the modern world.

In contrast to some previous studies, such as [63,64], which posited that the effectiveness of AI educational tools in developing students' literacy skills was limited due to

over-reliance on AI tools and reduced critical thinking, reduced human interaction, and the deceptive nature of AI, the present study provides a more positive perspective. While acknowledging the potential limitations of certain AI applications, this research distinctly elucidates the positive impact that integrated AI educational tools can have on English as a Foreign Language (EFL) students' literacy skills. It contributes to the existing body of literature by revealing the specific effects of these tools on literacy development among EFL learners.

Furthermore, this study offers valuable insights into English as a foreign language education by demonstrating how integrated AI educational tools can enhance literacy skills within a specific local context where such integration has been previously underutilized. By focusing on the unique needs and challenges faced by EFL learners in this particular setting, the research highlights the potential for tailored AI applications to address these issues effectively.

In conclusion, the findings of this study not only align with a majority of prior research but also provide a fresh perspective on the integration of AI educational tools in language learning. The evidence gathered from student reflective journals indicates that these tools can significantly enhance literacy skills, thereby equipping students with the necessary competencies for their future academic and professional pursuits. The study's limitations include a relatively small sample size drawn from a specific academic and geographic context, as well as variability in participants' prior exposure to technology and English proficiency, which may limit the generalizability of the results. As educational institutions continue to explore innovative teaching methods, the integration of AI educational tools represents a promising avenue for fostering improved literacy outcomes among students in an increasingly digital world. Therefore, by embracing these technologies, educators can create more engaging and effective learning environments that empower students to achieve their full potential.

5. Conclusions and Implications

The findings of this study revealed the significant role of integrated AI educational tools in enhancing literacy skills among students in EFL learning environments. The systematic incorporation of AI tools such as NoRedInk, Rewordifyv2.1.0, and LanguageTool 9.5.0 has demonstrated a positive Impact on various dimensions of literacy, including grammar, vocabulary, comprehension, idea generation, content organization, and writing style. The findings provide converging evidence that the integrated use of AI educational tools was strongly associated with improvements in EFL learners' literacy skills. Tools such as NoRedInk, Rewordify, and LanguageTool improved grammar, vocabulary, comprehension, idea generation, content organization, and writing style. Students' engagement with these tools led to measurable improvements in both reading and writing competencies. Specifically, the use of these integrated AI educational tools in academic reading and writing contexts facilitated the development of essential literacy competencies, which will, in turn, mitigate learning poverty among students.

Through their engagement with these tools, students exhibited notable improvements in their understanding of sentence structure and punctuation, thereby enhancing their grammatical proficiency. Additionally, the tools contributed to an expanded repertoire of vocabulary, allowing students to refine their word choice and usage effectively. The comprehension skills of the learners were also strengthened; they displayed an increased ability to interpret and analyze texts critically. Furthermore, the integration of these AI resources enabled students to generate and articulate ideas more effectively, thereby fostering creativity in their writing. The logical organization of thoughts was enhanced

as students learned to present their ideas coherently, while the refinement of their unique voice and writing style became evident through sustained practice with these tools.

The integrative application of NoRedInk, Rewordifyv2.1.0, and LanguageTool 9.5.0 has proven to be instrumental in boosting students' literacy skills. NoRedInk's adaptive exercises specifically targeted grammar, usage, and style, while Rewordifyv2.1.0 simplified complex texts to enhance readability and foster vocabulary acquisition. LanguageTool 9.5.0 further supported learners by assisting in various writing tasks, including idea generation, content structuring, and editing processes. The cumulative effect of these tools demonstrates that their integrative use is beneficial for the overall enhancement of literacy skills among students. The integrative use of these tools is recommended for academic reading and writing instruction, with instructors encouraged to embed AI-supported activities in curricula. Developers should consider AI tool integration when designing language teaching materials. Awareness among teachers and students of AI's role in reducing learning gaps is essential. In addition, the majority of students believe that utilizing artificial intelligence is really advisable to hone the literacy skills, including reading and writing skills, although they encounter a technology skills gap.

Given these findings, it is recommended that the integrated use of AI educational tools be adopted as a strategic approach to improve EFL students' literacy skills. This recommendation highlights the necessity for educators to promote the utilization of AI-powered educational tools within academic reading and writing classes. EFL instructors are encouraged to incorporate these tools into their curricula to facilitate the development of critical literacy skills among their students. Material developers should also consider the integration of AI educational tools when designing language teaching resources to ensure that students are equipped with the necessary skills for effective communication. Furthermore, creating and growing awareness among both students and teachers about the critical importance and impacts of AI tools-powered activities in reducing learning poverty is suggested.

While the study yielded promising results regarding the impact of AI educational tools on literacy skills, it is important to acknowledge certain limitations. Additionally, the participants were drawn from a single academic institution within a specific linguistic and geographical context, which may influence the transferability of the findings to other settings. Differences in institutional resources, students' prior exposure to AI technologies, and variations in language learning environments may yield different outcomes. Therefore, caution should be exercised when generalizing the results beyond contexts with similar academic and sociolinguistic characteristics. Limitations include a small sample size and a short intervention period. The sample size was relatively small, and the duration of the intervention was limited. Nonetheless, this does not diminish the representativeness of the findings because the selected participants shared common characteristics with a broader student population. Additionally, the repeated practice with NoRedInk, Rewordifyv2.1.0, and LanguageTool 9.5.0 indicates that the intervention had a meaningful effect on student learning. However, it is acknowledged that a larger participant pool and an extended intervention period could have yielded more robust and generalizable results.

Future research endeavors should aim to explore the potential effects of AI-powered educational tools on other aspects of language acquisition, particularly speaking and listening skills within EFL instruction. Subsequent studies should explore the effects of AI tools on other language skills such as speaking and listening, using larger, diverse samples and extended intervention durations. Such investigations would contribute significantly to the existing body of knowledge surrounding educational AI and its applications in language learning contexts. As the field continues to evolve, it is imperative that researchers further

examine how these innovative tools can be leveraged to enhance various facets of language proficiency among learners.

In summary, the findings of this study demonstrate that integrated AI educational tools play a significant role in enhancing EFL students' literacy skills. Their systematic use led to substantial improvements in grammar, vocabulary, comprehension, idea generation, content organization, and writing style, underscoring their pedagogical value. Although limited by sample size and intervention duration, the evidence suggests that AI tools offer a promising approach to improving literacy outcomes and mitigating learning gaps. Strategic integration of these tools in curricula, along with capacity-building for teachers and students, is recommended to maximize their impact.

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