PAPER

Assessing the Efficacy of AI-Driven Corrective Feedback via WhatsApp Application to Improve ESL Learners' Writing Skills: An Experimental Study

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ABSTRACT

Writing in English poses challenges due to the intricacy of its grammatical rules; however, these challenges may be effectively overcome through artificial intelligence (AI)-driven technologies. As there is insufficient research on AI-enabled WhatsApp for English language learning and instruction, this study examines how WhatsApp's AI system enhances ESL learners' writing skills. To deal with these gaps, the study aims to assess how AI-driven corrective feedback through the WhatsApp application enhances ESL learners' writing skills by reducing grammatical errors within the framework of the interactionist theory of second language learning. The present research study utilized a quasi-experimental design involving two groups—an experimental group and a control group—to experiment. The experimental group was subjected to treatment involving AI-driven corrective feedback via WhatsApp application, whereas the control group did not receive such feedback. Data were collected from 112 undergraduate participants in India at two intervals: a pre-test and a post-test. The participants' written submissions were assessed and scored using ChatGPT 4.0. The method of statistical analysis, *repeated measures analysis of variance* (RM-ANOVA), was applied to analyze the score. The results of the study showed that ESL learners who received AI-driven corrective feedback via WhatsApp performed better than those who received traditional feedback, particularly in correcting complex grammatical errors related to subject-verb agreement errors, tense errors, pronoun errors, fragment errors run-on sentences, comma splices, misplaced modifiers, apostrophe errors, capitalization errors, word choice errors/lexical errors, and preposition errors in their writing. The study found that augmented feedback systems and AI-driven corrective comments in ESL classrooms could enhance writing skills.

KEYWORDS

WhatsApp artificial intelligence (AI), corrective feedback, misplaced modifiers, social contacts and interactions, writing errors

1   INTRODUCTION

Language learning experts have long predicted that artificial intelligence (AI)-powered technology will open up fresh possibilities for language teaching and learning. Today, we see how technology in education has changed conventional means of instruction and learning, offering novel techniques to learn languages that satisfy today's requirements [1] [2]. AI stands out among technological innovations because it offers very tailored and responsive educational opportunities. AI innovations, especially in second language acquisition, have pushed recent educational framework reorganizations. As AI continues to transform education, institutions become more adaptable and responsive in customizing language curriculum and instruction to individual learners and teachers [3].

As teaching and instruction become learner-centered, AI's ability to address individual student concerns offers several benefits in ESL/EFL classrooms. Conventional teaching is unable to offer today's tech-savvy learners tailored instruction based on their specific skills. Developing students' skills while offering an enriching educational atmosphere becomes a prerequisite for language teaching and learning [4]. Multiple studies have emphasized the role of customized instruction and corrective feedback in ESL/EFL classrooms. For example, Liu and Feng [5] examined both theoretical and empirical evidence to describe learners' engagement with correction in EFL/ESL lessons. The results revealed that corrective feedback was inefficient without learner engagement, so offering corrective feedback is crucial for helping EFL/ESL learners. Kamalov et al. [6] investigated the impact of AI on language instruction and learning. The study found how AI offered personalized learning, reduced administrative tasks, and provided immediate feedback in education.

There is not enough WhatsApp study notwithstanding the seeming potential of AI-driven corrective feedback in the work environment and education. The impact of WhatsApp on AI-driven corrective feedback has not been examined, even though it is widely used for communication purposes, including instruction and feedback. The vast majority of research on feedback delivery has disregarded WhatsApp in preference for conventional approaches. Researchers remain unsure whether the conversational tone and lack of formality in WhatsApp enhance or hinder AI-driven corrective feedback. Academics might fill this gap by investigating how WhatsApp users receive, comprehend, react, and respond to AI-driven corrective feedback. Building understanding about these factors will help enhance feedback mechanisms on this frequently utilized messaging platform, which in turn will increase user engagement and learning. Therefore, this study focuses on the effects of AI, specifically through integrating Meta AI tools within WhatsApp, in improving ESL students' writing.

2   LITERATURE REVIEW

2.1   Theoretical framework

The social cognitive theory (SCT) assists AI chatbots in learning since they can provide immediate advice and assistance for independent learning. This offers a framework for comprehending WhatsApp corrective feedback because it examines how people learn in social contexts, how they regulate what they are learning, and how psychological, emotional, and social factors affect their learning.

Based on Vygotsky's [7] sociocultural theories, the interactionist theory of second language learning stresses social interactions, negotiation, and scaffolding. This theory says that active and meaningful interactions with target language practitioners affect the growth of languages. This suggests that both input and output influence learning. Students require more than language skills. These theories provide a theoretical framework to assess the efficacy of AI-driven corrective feedback transmitted via WhatsApp to improve ESL students' writing. This approach emphasizes interaction in learning, particularly in the context of meaningful conversations with fluent speakers. This work proposes the use of AI to recreate this interactive dynamic and provide learners with immediate, comprehensible feedback within their zone of proximal development (ZPD). By providing prompts and corrections, this automated feedback imitates human interactions and engages learners in an endless loop of generating, receiving, and editing language output [8] [9].

2.2   AI-driven corrective feedback via WhatsApp application

Meta AI, previously Facebook AI, is an accomplishment in Meta Platforms' incorporation of AI-powered technology into WhatsApp and other apps. This integration aims to transform WhatsApp into a multifaceted tool that may improve user engagement through advanced AI functions, especially for learning a language. Meta AI serves a multifunctional role in WhatsApp by enhancing user interactions, automating responses, and offering immediate language assistance. Its main feature is its ability to offer AI-driven corrective feedback. As the AI reads through human documents, finds errors in grammar, syntax, and writing, and corrects them immediately in a logical and useful way, this is an invaluable tool for ESL learners. This feedback system helps students understand and solve their errors immediately, making the learning process ongoing and centered on what they need to communicate in daily life. Adding Meta AI not only helps identify and correct grammatical errors, but it also helps users learn more about language rules and how to use them by offering them explanations and ideas that help them get better at writing over time. In the meantime, this may considerably enhance learners spoken, reading, and writing skills, as well as their general language proficiency. This has the potential to transform ordinary conversations into valuable educational experiences. Thus, embedding Meta AI into WhatsApp could constitute an enormous breakthrough forward in utilizing popular messaging applications for educational purposes. As it allows for collaborative and immediate feedback, this technology may provide ESL students an advantage and make proficiency in English more accessible. This innovative approach democratizes language learning and embeds it into users' daily digital interactions, making language improvement an integral part of their communication habits.

2.3   Studies on the impact of AI on educational learning

The impact of AI in learning is multifaceted and transformative, influencing various aspects of education, from higher education to specialized fields such as programming and STEM. Multiple studies have investigated the efficacy of AI learning in educational situations. For example, Castelló et al. [10] argued that AI-enhanced

educational practices by transforming teaching methodologies, assessment procedures, and personalized learning. This bibliometric evaluation used VOS Viewer 1.6.18 and Word Stat 2023.1 to evaluate 254 high-impact JCR research publications. Four subject areas and twelve significant concepts were chosen by normalized impact per document (NID) and per year from this field's internal research structure. This study offered implications for researchers, lawmakers, and SoTL. Similarly, Cronje [11] examined the findings of an archived desk study that evaluated worksheets developed by four ChatGPT-coached students. For graduation, fourth-year IT students were asked to compose a 3000-to-5000-word research report. It was revealed that well-designed questions and encouraging students to reflect on their AI experience were essential. The study suggests that beginners should learn how to respond to feedback, provide helpful suggestions, and reflect. Osunde et al. [12] investigated E-learning game creation for young learners and gaming representations' goals and attractiveness through an experimental study. It was found that AI significantly increases engagement and interest in computer science among young female students, demonstrating AI's capability to address underrepresentation in STEM fields. The study implies that e-learning games could be used to motivate learners. Future studies should investigate the impact of e-learning games featuring appealing characters. Rusli et al., [13] evaluated pre-service ESL instructors' opinions on utilizing social media for writing instruction, emphasizing both its benefits and disadvantages. The study utilized a qualitative method and chose 34 public institution ESL pre-service instructors. The findings revealed that ESL pre-service teachers had mixed opinions regarding social media in writing schooling as beneficial and disadvantageous.

Castro et al. [14] carried out an extensive literature review to discuss AI's reinforcement of personalized learning drivers. PRISMA-based searches of major peer-reviewed journals discovered 102 relevant publications during 2013–2022. A mixed-method approach was used to reveal literary structures and insights through classification and frequency analysis. The study revealed multiple drivers of customized learning's effectiveness in education and e-learning. The study suggests that AI with appropriate pedagogy can personalize learning to maximize digital economy relevance. Future studies should focus on overcoming ethical challenges such as data privacy and discrimination.

Hmoud et al. [15] sought to develop and validate an approach to assess AI chatbot work efficiency, especially for education. Statistical analysis is used to assess internal consistency and reliability, as well as substantive validity. The findings substantially supported the rubric's reliability and accuracy, promoting AI robot performance assessment in education. The study offers pedagogical implications as it provides chatbot designers and evaluators with a complete and proven performance analysis approach. It suggests that additional validation research with varied activities and AI chatbots validate these findings. Usama et al. [16] examined whether the rotation model (RM) and grammar translation method (GTM) improved 12th-grade inflectional morpheme errors. GTM and RM were taught to 41 experimental and control groups. With SPSS 22, treatment data was analyzed before and after the test. RM instruction significantly reduced mean error levels for each category compared to GTM. It may enhance academic and real-world language education. Future research should include other linguistic disciplines to better understand language trends. Watanabe [17] assessed the theoretical applicability of multiple artificial intelligence technologies to the educational philosophy ideal of maturity. It was found that intelligent methods of instruction such

as ChatGPT impeded student maturity, but AI-supported research tools assisted them. The article suggests lowering student maturity-related AI application risk. Alam et al. [18] carried out a study to reduce inflectional morpheme-related mistakes in the writing of Madrasa ESL students. One group used Grammarly for grammar instruction, whereas the other group got communicative language training. Before and after treatment, every individual underwent an assessment. Data was analyzed quantitatively. These findings showed that using 'Grammarly' as an e-tool could help ESL writers, particularly those who struggle to write well in English. Future studies could add vocabulary characteristics to English writing instruction.

2.4   Studies on the effect of AI on writing skills

The potential of AI, particularly ChatGPT, for enhancing writing skills across disciplines has attracted attention to its application to education. In recent years, Song and Song [19] explored whether AI-assisted learning of a language enhanced Chinese EFL students' writing and engagement. Pre- and post-tests evaluated quantitative writing. Equally competent 50 EFL students were assigned randomly to experimental (AI-assisted ChatGPT training) or control (conventional instruction) groups. It was found that AI-assisted schooling enhanced writing and motivation more than the control group. The study highlights AI's potential for transforming education, encompassing its advantages and disadvantages, and its impact on learning languages for practitioners and scholars. Shaikh et al. [20] explored both positive and negative aspects of AI in the workplace, focusing on the mental health and wellness of employees. The data was obtained from 184 doctors and nurses at Pakistan's major hospitals. The findings of partial least squares (PLS) revealed an evident correlation between AI and employee productivity. The study suggests further research and novel approaches. Naz and Robertson [21] assessed ChatGPT-3's effectiveness in providing customized, beneficial feedback, pedagogical frameworks, accuracy, and AI integration in language instruction. The findings revealed that social cognitive theory (SCT) assisted AI chatbots in learning since they can provide immediate advice and assistance for independent learning. This study will assist instructors in developing AI-assisted e-learning by offering the data required for developing effective AI feedback based on sound pedagogical principles. Escalante et al. [22] examined two longitudinal studies. Study 1 contrasted ChatGPT (GPT-4) with a human tutor's writing comments for 48 university ENL students. Study 2 examined 43 ChatGPT and tut-receiving ENLs. Study 1 revealed no difference in learning across groups. Study 2 revealed that individuals were practically evenly divided on whether they favored AI or human input. These findings imply that AI-generated feedback could be utilized for assessing ENL essays without affecting learning outcomes. Evmenova et al. [23] studied artificial intelligence system instructor feedback and data-based instructional recommendations. Students with and without impairments composed essays utilizing technology. Eight responses were generated from two four-question ChatGPT versions of the essays. Inductive thematic analysis analyzed data. The findings showed that ChatGPT versions and prompts responded differently. The study implies that the engagement of instructors with AI may be advanced to enhance the instruction of writing. Morsidi et al. [24] examined students' perspectives on WhatsApp utilization in classrooms, the frequency of WhatsApp usage in schools, and its impact on

students' communication skills. This quantitative study chose 400 UTM students to participate in online surveys using basic randomization. The results demonstrated that numerous UTM students utilize WhatsApp for school and that it enhanced their speaking skills.

Steiss et al. [25] analyzed human and AI feedback on secondary student texts to assess ChatGPT's efficacy. 200 human- and AI-generated formative comments for similar essays were used. It was examined if there were any differences in quality between English language learners and native speakers, compositions of different quality, and ChatGPT and human feedback for the entire sample. It was revealed that human assessors offered learners more effective feedback in all categories except criteria-based. The study suggests that innovative AI might help with early writing or when an instructor is unavailable. Imran and Almusharraf [26] utilized a systematic review of the best 30 papers for assessing ChatGPT's academic writing assistance. Using specified criteria for searching 550 papers published between December 2022 and May 2023—the time immediately after ChatGPT's launch—were thoroughly examined. The findings revealed that ChatGPT as a writing assistant in education has both positive and negative aspects, particularly for academic writing. The study suggests understanding chatbots' role as facilitators for students and instructors to simplify and aid academics. Bašić et al. [27] assessed learners' essay-writing skills and competency both with and without ChatGPT. ChatGPT helped the control group (n = 9), and experimental group (n = 9) write essays with an average grade of C. Despite low essay similarity, the experimental group had higher text inauthenticity. No evidence was found to show ChatGPT students wrote more quickly, more accurately, or more accurately. ChatGPT-assisted writing may confuse beginners, reducing essay quality. Seo [28] analyzed the educational efficacy of ChatGPT-assisted narrative writing in college-level L2 writing through an examination of student-initiated prompts. South Korean university students (44 participants) were examined to evaluate the effects of ChatGPT on narrative writing. It was revealed that requests for language, correction, and information were highest. ChatGPT found trivial mistakes in most language questions. It was also found that narrative writing fluency and performance increased after using ChatGPT. In terms of pedagogical implications, the study helps students acquire creative thinking and writing skills. Future studies should focus on learners' skills and synthetic complexity in AI-assisted storytelling.

2.5 Research question

Q. 1. What are the differences in writing performance between ESL learners who receive AI-driven corrective feedback via WhatsApp and those who rely on WhatsApp only?

3 DESIGN OF THE STUDY

The study's research framework is shown in Figure 1. The investigation employed a quasi-experimental design over 20 weeks, engaging two cohorts of undergraduate ESL students in India. The methodology used in this study is detailed in the subsequent sections:
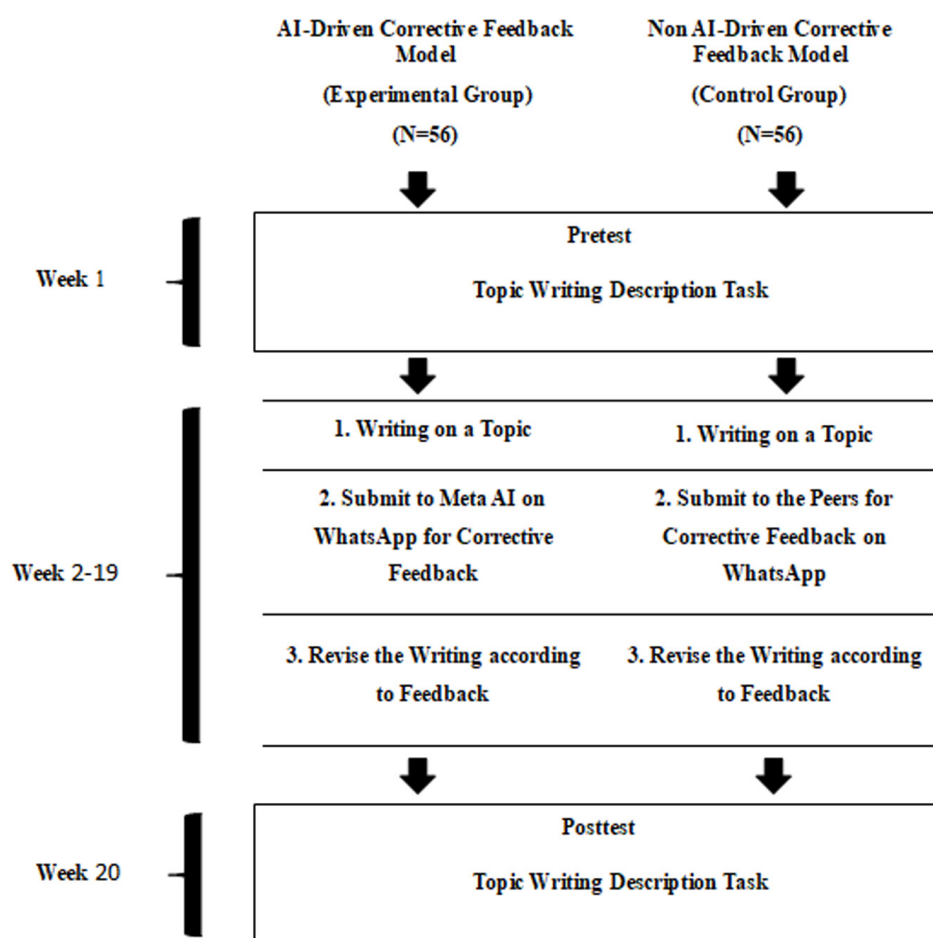
Fig. 1. Presentation of the research design

3.1 Participants and sampling

The study involved 112 undergraduate students randomly selected from two existing English-speaking classes taught by the same instructor. These students, ages 20 to 23, pursued degrees in non-English major programs. Native Hindi speakers from India learning English as a second language were randomly assigned to the AI-Driven Corrective Feedback Model (N = 56) or the Non-AI-Driven Model. All participants were given details about the study.

3.2 Treatment

The study adopted a quasi-experimental design involving two distinct groups: the AI-Driven Corrective Feedback Model (Experimental Group) and the Non-AI-Driven Corrective Feedback Model (Control Group), each comprising 56 participants. The participants in the experimental group were required to undertake a topic description task, which they had to complete within a 30-minute timeframe in a language lab from the second day of the intervention. They used a word processing file with the auto-correction feature disabled to ensure the authenticity and accuracy of their writing abilities. This setting allowed the researchers to capture the participants'

accurate writing skills without the influence of automated corrections. Once the task was completed, participants logged into WhatsApp on a laptop and submitted their written work directly to Meta AI for corrective feedback. Upon receiving the AI-generated feedback, the participants were instructed to revise their original texts per Meta AI's suggestions. This feedback loop was designed to correct their immediate mistakes and reinforce learning through active revision. Participants were encouraged to engage with Meta AI by requesting detailed explanations of each error, including the relevant grammatical rules, to deepen further their understanding of the errors identified by the AI. This additional step was intended to enhance the educational value of the feedback by providing context and rationale, helping participants to internalize the corrections and apply them in future writing tasks.

In contrast, the control group followed a parallel process where participants were tasked with completing the same topic description task under identical conditions. However, instead of submitting their work to Meta AI, they submitted their written tasks to peers for feedback via WhatsApp. Participants used feedback and concepts to improve their work after peer assessment. After correction, the control group engaged in a discussion regarding their grammar issues and areas for improvement. The discussion aimed to clarify grammar through peer learning and introspection.

The entire process for both groups was repeated three times a week over 20 weeks, allowing participants to engage with the feedback mechanisms and refine their writing skills. This methodological approach allowed for a thorough and nuanced comparison between the effectiveness of AI-driven corrective feedback and traditional peer feedback in enhancing writing skills and reducing errors.

3.3   Topic writing description tasks

At the commencement of the study, specifically on the first and last day of the first and last week, both a pre- and a post-test were administered to assess the participant's proficiency in English writing of both groups, focusing particularly on grammatical accuracy. For each test, participants were provided with distinct topics for a topic description task, which they were required to complete within a 30-minute timeframe. Two different topics were assigned to ensure that participants could not remember details from one task while completing the next, promoting a genuine assessment of their writing skills for each test [17]. The tasks were to be written using Microsoft Word with the auto-correction feature disabled, ensuring that the participants' genuine writing abilities were accurately evaluated without automated assistance. Participants were instructed to communicate their files directly to the teacher (first author) upon completing each task. This procedure was established to facilitate a systematic evaluation of each participant's progress in terms of grammatical proficiency. Pre-tests and post-tests were administered to the study participants to assess baseline skills before and after interventions. This method allowed for an effective assessment of the participants' writing skills at two critical points and ensured that the same instructor handled the evaluation consistently and fairly.

3.4   Data analysis

Both groups were given pre- and post- tests, and their written responses were analyzed using ChatGPT 4. The written submissions were evaluated specifically for grammatical accuracy, a key aspect of the study's focus. In the context of the present

study, ChatGPT analyzed the types of common grammatical errors (1. Subject-Verb Agreement Errors; 2. Tense Errors; 3. Pronoun Errors; 4. Fragment Errors; 5. Run-On Sentences and Comma Splices; 6. Misplaced Modifiers; 7. Apostrophe Errors; 8. Capitalization Errors; 9. Word Choice Errors/Lexical Errors; and 10. Preposition Errors) and scored them based on the grammatical accuracy of writing. This methodological approach leverages AI's advanced analytical capabilities to ensure a thorough and precise evaluation of each participant's writing skills, aligning with assessing improvements throughout the study. The scores obtained from the pre- and post-test for each group were analyzed using the repeated measures analysis of variance (RM-ANOVA) test. This statistical method was chosen for its capability to assess changes within groups across multiple time points, aligning perfectly with the study's design of repeated measurements on the same subjects. RM-ANOVA facilitates a comprehensive evaluation of participants' writing skills progression during the intervention, offering a statistically sound assessment of the effectiveness of the AI-driven corrective feedback.

4 RESULTS OF THE STUDY

In the study, a two-way ANOVA was employed to analyze the impact of group and assessment timing (pre-test, post-test) on the scores. The analysis revealed a significant main impact of the group factor ($F_{(1, 55)} = 16.513$, $p < .001$, $\eta p^2 = .231$), demonstrating significant score variance caused by group differences. Specifically, participants in the experimental group, who received AI-driven corrective feedback via WhatsApp, achieved higher scores than the control group (see Figure 2). The feedback was given to enhance writing and reduce grammatical issues related to 1. Subject-Verb Agreement Errors; 2. Tense Errors; 3. Pronoun Errors; 4. Fragment Errors; 5. Run-On Sentences and Comma Splices; 6. Misplaced Modifiers; 7. Apostrophe Errors; 8. Capitalization Errors; 9. Word Choice Errors/Lexical Errors; and 10. Preposition Errors, demonstrating its effectiveness. Conversely, the control group, which received traditional non-AI-driven feedback, exhibited lower scores. This contrast highlights the potential advantages of integrating AI technology in educational feedback mechanisms to improve learning outcomes.
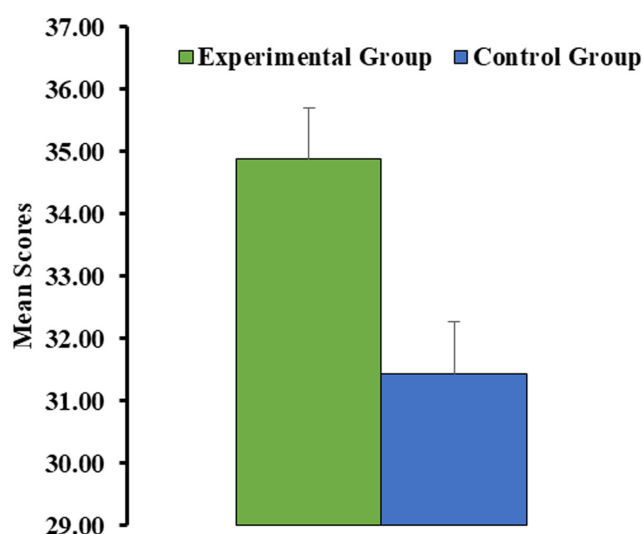

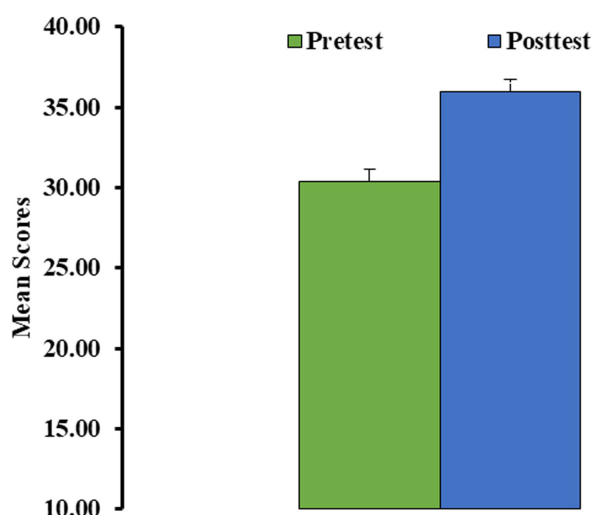**Fig. 2.** Variations of scores between experimental and control groups

Fig. 3. Variations of scores across assessments

Furthermore, our analysis demonstrated a pronounced main effect of the assessments on participant scores, with significant results of $F_{(1, 55)} = 53.538$, $p < .001$, $\eta p^2 = .493$. This result indicates a substantial improvement in scores from the pretest (conducted before the intervention) to the post-test (after the intervention) (see Figure 3). The significant partial eta squared value shows that pre- and post-test differences explain approximately half of the score variance. This significant increase in post-test scores illustrates intervention effectiveness in enhancing the participants' abilities to reduce grammatical errors, highlighting the positive impact of the corrective feedback employed during the period.
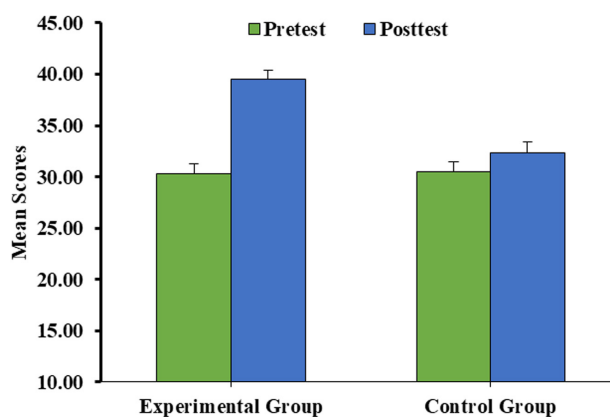

Fig. 4. Variation in scores of assessments across groups

Additionally, our analysis identified a significant two-way interaction between the groups and assessments, with $F_{(1, 55)} = 27.793$, $p < .001$, $\eta p^2 = .336$. The experimental group had a greater improvement in assessment results from the pre-test to the post-test than the control group (see Figure 4). Experimental group participants who got WhatsApp-based, AI-driven corrective feedback enhanced their writing skills more than control group participants who did not.

This improvement was particularly evident in their ability to reduce grammatical errors across various categories, including 1. Subject-Verb Agreement Errors, 2. Tense Errors, 3. Pronoun Errors, 4. Fragment Errors, 5. Run-On Sentences and Comma Splices, 6. Misplaced Modifiers, 7. Apostrophe Errors, 8. Capitalization Errors,

9. Word Choice Errors/Lexical Errors, and 10. Preposition Errors. The targeted intervention using AI-driven feedback effectively helped participants in the experimental group enhance their command over these grammatical aspects, leading to a higher score post-intervention than their friends in the control group. This outcome underscores the efficacy of utilizing advanced technology such as AI to support and improve educational processes, particularly in enhancing language skills.

Table 1. Comparative analysis of pre-test to post-test gains in two groups

	AI-Driven Corrective Feedback			Non-AI-Driven Corrective Feedback		
	Pre-Test	Post-Test	Gained	Pre-Test	Post-Test	Gained
Mean	30.28	39.05	9.22	30.48	32.37	1.89
SD	0.944	0.876	0.07	1.003	1.063	0.06

The comparative analysis of gains from the pre-test to the post-test between the two groups highlighted a marked disparity in their improvements (refer to Table 1). The participants assigned to the experimental group, who benefited from AI-driven corrective feedback, exhibited significant progress, evidenced by an average gain of 9.22 scores, and maintained a low variability with a standard deviation of 0.07. Conversely, the control group, which relied on non-AI-driven corrective feedback, achieved much more modest improvements, with an average gain of just 1.89 scores and a similarly low standard deviation of 0.06. This pronounced difference illustrates the substantial impact of utilizing AI-driven feedback mechanisms in educational interventions and emphasizes their effectiveness in substantially enhancing writing skills. The findings indicate that AI-driven feedback can expedite learning and enhance learning outcomes more than traditional feedback.

5 DISCUSSION

The findings from the study clearly illustrate that ESL learners who received AI-driven corrective feedback via WhatsApp exhibited significantly superior performance in their writing skills compared to those who only received traditional feedback through the same platform. This enhanced performance was particularly evident in the substantial improvements these participants made across various aspects of grammar. The grammatical errors they addressed were wide-ranging, encompassing irregular tenses, misplaced pronouns, and issues with sentence fragments, among many others. The pronounced improvement in their ability to construct clear and correct sentences underscores the potent impact of AI-driven feedback. This feedback approach, being immediate and precisely tailored to individual errors, facilitates an effective learning process, enabling real-time correction and understanding of mistakes. The study findings, highlighting the effectiveness of AI-driven corrective feedback in enhancing ESL learners' writing skills, resonate with an expanding body of recent research that supports the integration of advanced technologies in education. The significant performance improvement observed in ESL learners receiving AI feedback compared to those who used traditional methods aligns with multiple studies [29–33].

All these studies highlighted ChatGPT's capability to evaluate and score grammatical precision in writing reliably. Chang et al. [34] emphasized how AI technologies could provide personalized, immediate feedback that adapted to individual learning

paces and preferences, thereby enhancing overall learning outcomes. In addition, Jia et al. [35] demonstrated that systems powered by AI could identify and correct complex grammatical problems instantaneously, contrasting human-based evaluations, which are delayed and inconsistent. Jiang [36] observed that interaction with AI feedback systems bolstered grammatical accuracy and enhanced learner confidence and autonomy. Their study suggested that learners engaging with AI were more likely to seek further clarification and actively engage with learning materials, fostering a more inquisitive and autonomous learning environment. This proactive engagement was critical for effective language learning, as it encouraged continual learning and application of new skills. Moreover, a meta-analysis by Meng et al. [37] corroborated these findings by demonstrating how AI-enhanced feedback systems significantly reduced educators' time on routine grading, freeing resources for more focused and strategic instruction. These efficiency gains improved educational outcomes and enhanced instructional quality by allowing teachers to dedicate more time to personalized teaching approaches and complex problem-solving discussions. Similarly, Altinay et al. [38] found that AI tools for language acquisition substantially enhanced the frequency and quality of interactions between students and instructors by providing teachers with precise data on student errors and misunderstandings, enabling more targeted instructional strategies. Their study showed how AI could make classrooms more engaging and responsive, revolutionizing education. However, these findings are inconsistent with many studies [39–41], which noted certain concerns related to the accuracy, consistency, and intelligibility of ChatGPT responses.

The findings from this study underscored how ESL learners receiving AI-driven corrective feedback via WhatsApp significantly outperformed their peers who only received traditional feedback, especially in complex areas of grammar such as subject-verb agreement, tense inconsistencies, and pronoun alignments. This finding is corroborated by Vygotsky's [7] interactionist theory, which argues that learning and knowledge are gained through social interactions.

According to Vygotsky, the ZPD defines a student's achievement versus with guidance. AI-driven feedback effectively serves within this zone, providing tailored assistance that helps learners tackle challenging grammatical rules beyond their current ability, thus facilitating deeper linguistic and cognitive development. This personalized feedback mirrors the scaffolding that Vygotsky deemed essential for learning, where support is adjusted based on the learner's performance, fostering autonomy and competence [38]. Vygotsky [7] also stressed the significance of language acquisition in cognitive development, as it is a prerequisite for intellectual development and communication. The immediate, corrective feedback provided by AI on WhatsApp not only aids in language acquisition but also enhances cognitive processes by allowing learners to reflect on and correct their mistakes in real time [39]. Furthermore, the use of WhatsApp as a feedback tool reflects Vygotsky's idea of cultural tools mediating learning. Technological advancements, such as AI and mobile platforms, have become modern tools that mediate educational processes, extending the learning environment beyond traditional settings and incorporating real-time data exchange [40–41]. Fundamentally, AI-driven corrective feedback via WhatsApp exemplifies Vygotsky's educational theories, showcasing how technological interventions can substantially improve language learning. This approach delivers prompt, precise, and situation-specific assistance attuned to learners' developmental requirements. Consequently, it facilitates the learning of grammatical skills. It harmonizes with the cognitive and interactive learning principles advocated by Vygotsky, thus transforming the nature of educational interactions in the digital era.

6 CONCLUSION

The study assessed how AI-driven corrective feedback transmitted via the WhatsApp application enhanced ESL learners' writing skills by reducing grammatical errors within the interactionist theory of second language learning. It was demonstrated that ESL learners who received AI-driven corrective feedback via WhatsApp significantly outperformed their peers who received traditional feedback, especially in addressing complex grammatical errors such as subject-verb agreement, tense inconsistencies, and pronoun misalignments. This finding confirms that technologically enhanced feedback mechanisms can offer more substantial educational benefits than conventional approaches. These findings imply that integrating AI-driven technologies, such as Meta AI, which relates to WhatsApp, in educational environments significantly enhances learning efficiency and efficacy. Artificial intelligence's immediate evaluation complements Vygotsky's theories on social knowledge generation and context-specific scaffolding in the learner's zone of proximal growth. This method improves ESL students' grammar and language. However, the study has limitations. WhatsApp might not work in conventional or illiterate environments. Participant demographics and study duration may restrict generalizability. Thus, future research should examine Meta AI-driven WhatsApp feedback in different educational contexts and demographics of learners. The long-term impacts of such treatments on language retention and cognitive development should be examined.

In conclusion, WhatsApp-based AI-driven corrective feedback advances educational technologies. This immediate information processing approach enhances learning a language significantly. As educational paradigms change, such technologies have become crucial for learners' success across disciplines.

7 ACKNOWLEDGMENT

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