

# Developing EFL Writing Fluency Through Gamified AI Tools among Preparatory Stage Students: An Empirical Study

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## ABSTRACT

This study investigates the effectiveness of a gamified Artificial Intelligence (AI)-based instructional program in enhancing English as a Foreign Language (EFL) writing fluency among preparatory stage students in Egypt. Addressing a critical gap in EFL pedagogy, the study conceptualizes writing fluency as a multidimensional construct encompassing idea generation, organization, coherence, lexical access, and text continuity. A mixed-method, quasi-experimental pretest–posttest control group design was employed with 60 intermediate-level students divided into experimental and control groups. The experimental group received instruction through a structured, gamified AI-supported program integrating tools such as conversational agents, automated feedback systems, and immersive learning environments, while the control group followed traditional instructional practices. Quantitative data from writing fluency tests were analyzed using paired- and independent-samples t-tests, revealing statistically significant improvements in overall writing fluency and its sub-skills in favor of the experimental group, with large effect sizes ( $\eta^2 = 0.359$ ). Qualitative analysis of students' written productions and interaction logs further demonstrated substantial development in text smoothness, organization, and reflective writing, supported by AI-mediated scaffolding and sustained practice. The findings indicate that gamified AI tools, when pedagogically integrated, can effectively reduce cognitive load, enhance learner engagement, and promote continuous written production. The study contributes to the growing body of AI in language education by foregrounding writing fluency as a central outcome and offering a context-sensitive model for technology-enhanced EFL instruction in school settings. Implications for pedagogy, theory, and future research are discussed.

**Keywords:** artificial intelligence in education; Egypt; EFL writing fluency; gamification; learner engagement; preparatory stage learners; quasi-experimental design; technology-enhanced language learning

## INTRODUCTION

The growing demands of global communication have placed increasing emphasis on learners' ability to produce clear and fluent written English. However, despite extensive instructional efforts, many EFL learners continue to experience significant difficulties in developing productive language skills, particularly writing (Tortorelli & Truckenmiller, 2023). These challenges are often attributed to traditional instructional practices that emphasize grammar and vocabulary in isolation, with limited opportunities for meaningful language use and authentic practice (Alsiyat, 2021).

Among the core dimensions of language proficiency, fluency plays a crucial role in enabling learners to produce language smoothly, coherently, and with minimal hesitation. While fluency has been widely examined in spoken language, research on writing fluency remains comparatively limited (Bilge & Kalenderoğlu, 2022). Writing fluency involves the ability to generate ideas, organize them effectively, and produce continuous written text with ease and clarity (Mutta et al., 2025). Nevertheless, EFL learners frequently struggle with generating ideas, maintaining coherence, and expressing their thoughts efficiently, which negatively impacts both their academic performance and overall language development (Santihastuti and Oktavia, 2023; Gayed et al., 2022).

Recent advancements in educational technology, particularly Artificial Intelligence (AI), have introduced new possibilities for addressing these challenges. AI-powered tools offer adaptive feedback, personalized learning experiences, and opportunities for continuous practice, allowing learners to engage in writing tasks beyond classroom constraints (Hwang et al., 2020; Salas-Pilco et al., 2022). Moreover, when combined with gamification, these tools can enhance learner motivation, engagement, and persistence by integrating elements such as immediate feedback, rewards, and interactive tasks, which are often lacking in traditional writing instruction (Datchuk et al., 2024).

Despite the growing interest in AI applications in language education, there remains a notable gap in empirical research examining the effectiveness of gamified AI tools specifically for developing EFL writing fluency, particularly among preparatory stage learners (McKenna et al., 2020). Several existing studies tend to focus on general language skills or motivation, with limited attention to writing fluency as a distinct and measurable construct (Fathi & Rahimi, 2024; Guo, 2025).

In the Egyptian EFL context, this gap is particularly evident. Preparatory stage students often demonstrate difficulties in generating ideas, organizing written texts, and maintaining a continuous flow of writing, largely due to teacher-centered approaches and limited opportunities for practice and feedback (Ahmed, 2018). Addressing these challenges requires innovative instructional approaches that integrate technology with learner-centered practices.

Therefore, the present study aims to investigate the effectiveness of gamified AI tools in developing EFL writing fluency among preparatory stage students. By focusing on writing fluency as a specific outcome, this study seeks to contribute to the growing body of research on AI in language education and provide practical implications for integrating technology-enhanced learning in EFL classrooms.

## LITERATURE REVIEW

### EFL Writing Fluency

EFL writing fluency has increasingly been recognized as a critical yet underexplored dimension of language proficiency, particularly in contexts where writing instruction remains form-focused and teacher-centered. Unlike general language fluency, writing fluency refers to learners' ability to generate ideas, organize them coherently, and produce continuous written text with minimal hesitation or disruption (Zhang et al., 2021). It encompasses both the rate of written production and the quality of textual flow, including coherence, cohesion, and ease of expression (Tian et al., 2021).

Despite its importance, writing fluency is often neglected in EFL classrooms, where instructional practices tend to prioritize grammatical accuracy and controlled exercises over meaningful written production (Gayed et al., 2022). This imbalance is particularly evident in the Egyptian educational context, where writing is frequently reduced to mechanical activities such as sentence transformation, memorization, and translation, with limited emphasis on idea generation or extended writing (Abdelnaeim, 2022). As a result, learners may develop partial linguistic knowledge without the ability to use it fluently in authentic writing situations (Ismael et al., 2025).

Empirical evidence suggests that preparatory stage students in Egypt face persistent challenges in writing fluency. These challenges include difficulty in generating and developing ideas, limited lexical access, weak organization of content, and frequent pauses during writing due to overreliance on translation from the first language (Rahimi & Zhang, 2018; Gayed et al., 2022). In addition, students often struggle to maintain coherence and continuity in their texts, resulting in fragmented and underdeveloped writing. Such difficulties are further exacerbated by large class sizes and time constraints, which limit opportunities for individualized feedback and sustained writing practice.

Another critical issue lies in the cognitive demands of writing, which require the simultaneous coordination of planning, linguistic encoding, and revision processes. For many EFL learners, especially at the preparatory stage, these processes are not yet automatized, leading to slow writing production and frequent breakdowns in textual

flow (Patty, 2024). Consequently, learners tend to focus excessively on form at the expense of meaning, which hinders the development of fluency and reduces their ability to express ideas effectively (Yuan et al., 2024).

Recent studies have emphasized that improving writing fluency requires instructional approaches that go beyond traditional practices by providing learners with opportunities for frequent, meaningful, and supported writing (Rasteiro & Limpo, 2022). Such approaches should facilitate idea generation, reduce cognitive load during writing, and offer immediate, formative feedback that supports continuous text production. However, there remains a lack of practical and scalable solutions that effectively address these needs within constrained classroom environments.

This gap highlights the need for innovative instructional interventions that can support the development of writing fluency in context-sensitive ways. In particular, integrating technology-enhanced tools that promote engagement, provide real-time feedback, and encourage sustained writing practice may offer promising avenues for addressing the persistent challenges faced by EFL learners in developing writing fluency.

### **Artificial Intelligence in EFL Learning**

Recent advancements in Artificial Intelligence (AI) have significantly transformed the landscape of language education, offering new possibilities for personalized, adaptive, and interactive learning environments. In EFL writing instruction, AI-powered tools, particularly those based on natural language processing and generative models, have been increasingly used to support learners in developing their writing skills through automated feedback, language modeling, and guided practice (Hwang et al., 2020; Rambuwane et al., 2026). These tools enable learners to receive immediate, individualized feedback on aspects such as grammar, vocabulary, and text organization, which are often difficult to address in traditional classroom settings due to time and resource constraints.

More recently, the emergence of generative AI systems, such as large language models, has introduced a qualitative shift in how learners engage with writing. Unlike earlier rule-based systems, these tools can generate coherent texts, suggest ideas, and simulate interactive writing support, thereby potentially reducing cognitive load during the writing process and facilitating idea generation (Kasneci et al., 2023). This is particularly relevant for EFL learners who struggle with initiating and sustaining written production, as AI can function as a form of scaffolding that supports fluency development (Zhou & Wang, 2026).

However, despite these affordances, the integration of AI in writing instruction remains pedagogically and ethically complex. A growing body of research has raised concerns about the potential overreliance on AI-generated content, which may lead to reduced learner agency and superficial engagement with the writing process (Holmes et al., 2022). When learners depend excessively on AI suggestions, they may prioritize correctness over meaning-making, which can hinder the development of writing fluency as an internalized, automatized skill (Zhang et al., 2026). Moreover, AI feedback, while immediate, is not always pedagogically transparent, and learners may adopt corrections without fully understanding the underlying linguistic principles (Sardi et al., 2026).

Another critical limitation relates to the focus of most AI writing tools, which tends to emphasize accuracy (e.g., grammar correction) rather than fluency-oriented dimensions such as idea development, coherence, and sustained text production. As a result, improvements in surface-level correctness do not necessarily translate into enhanced writing fluency (Widiati et al., 2023). This mismatch highlights a key gap in the current literature: while AI tools are widely promoted for improving writing quality, their role in fostering writing fluency as a dynamic and process-oriented construct remains insufficiently explored (Zhao, 2022).

Furthermore, existing studies on AI in EFL contexts have largely focused on higher education or adult learners, with limited attention to younger learners in school settings, particularly in contexts such as Egypt. Preparatory stage students often require structured guidance, motivation, and sustained engagement to develop writing fluency, which may not be effectively addressed through standalone AI tools (Aminah & Supriadi, 2023). This suggests that the effectiveness of AI in such contexts depends not only on the technology itself but also on how it is pedagogically integrated into meaningful learning activities.

In this regard, recent research has pointed to the potential of combining AI with gamification principles to enhance learner engagement and promote sustained practice. Gamified AI environments can provide goal-oriented tasks, immediate feedback, and interactive challenges that encourage learners to produce language more frequently and with less anxiety (Bai et al., 2022). Such environments may be particularly effective in supporting writing fluency, as they create conditions for repeated, low-stakes writing practice while maintaining learner motivation (Adi et al., 2026).

Nevertheless, empirical evidence examining the combined impact of gamified AI tools on EFL writing fluency, especially among preparatory stage learners, remains scarce. Most studies have either investigated AI or gamification in isolation, without exploring their potential synergy in addressing fluency-related challenges (Adi et al., 2026; Rasteiro & Limpo, 202; Wang, 2026). Accordingly, there is a need for context-sensitive research that examines how gamified AI tools can be utilized not merely as corrective technologies, but as fluency-oriented learning environments that support idea generation, continuous text production, and learner engagement. Addressing this gap, the present study investigates the effectiveness of gamified AI tools in developing EFL writing fluency among preparatory stage students.

### **Using AI to Enhance EFL Writing Fluency**

The potential of Artificial Intelligence (AI) to enhance language learning has been widely explored, with increasing attention to its role in supporting productive skills such as writing. In EFL contexts, AI-powered tools have been shown to facilitate writing development by providing immediate feedback, supporting lexical and syntactic choices, and enabling learners to engage in extended writing practice beyond classroom limitations (Dizon & Gayed, 2021; Praphan & Praphan, 2023; Su et al., 2019). Such affordances are particularly relevant to writing fluency, which requires continuous text production, idea generation, and reduced hesitation during the writing process.

Empirical studies suggest that AI-based writing tools can contribute to improvements in various dimensions of writing performance, including fluency, accuracy, and organization. For example, AI-supported feedback systems have been found to reduce grammatical errors while simultaneously enhancing lexical variation and overall text quality (Dizon & Gayed, 2021). Similarly, chatbot-based interactions and AI writing assistants can create low-anxiety environments that encourage learners to practice writing more frequently, thereby supporting fluency development through repeated exposure and use (Abilowo et al., 2020; Su et al., 2023).

One of the key contributions of AI to writing fluency lies in its ability to provide real-time, individualized support, which is often difficult to achieve in traditional classrooms. By offering instant feedback and suggestions, AI tools can reduce interruptions in the writing process and help learners maintain the flow of ideas, a core component of fluency (Asadi et al., 2025; Ranalli, 2018). In addition, AI-generated prompts and interactive writing tasks can assist learners in overcoming difficulties related to idea generation, which is a common barrier to fluent writing among EFL learners (Talayhan, 2023).

However, despite these promising findings, the effectiveness of AI in enhancing writing fluency remains conditional and context-dependent. A significant limitation of many existing studies is their focus on higher-level learners or short-term interventions, with limited attention to younger learners in school contexts (Shahbazi et al., 2025; Ningrum, 2023). Moreover, much of the reported improvement relates to accuracy and surface-level features rather than fluency as a sustained and automatized process of writing (Rusdin et al., 2023).

Another important concern is that AI tools may inadvertently promote passive reliance on automated suggestions, which can reduce learners' active engagement in the writing process (Thi et al., 2025). While AI can support idea generation and language use, excessive dependence on such tools may limit opportunities for learners to struggle productively with language, an essential condition for developing fluency (Apriani et al., 2024). Therefore, the role of AI should not be viewed as a substitute for writing practice, but rather as a scaffold that supports and extends learner production.

These limitations suggest that the effectiveness of AI in developing writing fluency depends on how it is integrated pedagogically. In particular, combining AI tools with engaging instructional approaches, such as

gamification, may help shift the focus from correction to production by encouraging learners to write more frequently, interactively, and with greater motivation (Widiati et al., 2023).

Accordingly, there is a need for empirical research that investigates how AI can be used not only to improve writing accuracy, but also to foster writing fluency through sustained, meaningful, and engaging practice, particularly among preparatory stage learners (Sardi et al., 2026). The present study addresses this need by examining the effectiveness of gamified AI tools in developing EFL writing fluency.

## Research Gap and Study Rationale

In the Egyptian EFL context, developing writing fluency remains a persistent challenge, particularly among preparatory-stage learners in schools. Writing is frequently approached as a product-based, exam-oriented activity rather than a process of meaning-making and fluency development, which limits learners' ability to write fluently, flexibly, and independently (Styati et al., 2026). These challenges are consistent with broader findings in EFL writing research, which highlight that learners at early and intermediate stages often struggle with idea generation, coherence, and sustained text production (Atasoy & Temizkan, 2016; McKinley, 2013; Limpo et al., 2020). Although recent international studies have increasingly explored the integration of Artificial Intelligence (AI) tools in language education, the majority of this research has been conducted in higher education contexts or with adult learners, focusing primarily on writing accuracy, grammar correction, or automated feedback systems (Guo, 2025; Ningrum, 2023; Praphan & Praphan, 2023). While these studies report positive outcomes in terms of linguistic accuracy and engagement, they often treat AI as a corrective tool rather than a pedagogical framework for developing writing fluency as a dynamic cognitive-linguistic process. Moreover, the pedagogical implications of AI for younger EFL learners in school contexts remain underexplored, particularly in developing countries.

In addition, most existing AI-based writing studies emphasize isolated linguistic gains rather than the development of fluency as a multidimensional construct involving idea generation, coherence, lexical retrieval, and smooth text production (Koltovskaia, 2025; Sefina, 2026). There is also limited attention to how AI can be systematically integrated into instructional design to scaffold writing development rather than merely provide feedback or correction (Xuan et al., 2026). This gap becomes more critical in contexts such as Egypt, where learners have limited exposure to authentic English use and rely heavily on teacher-centered instruction. Accordingly, there is a clear need for context-sensitive instructional interventions that go beyond the use of AI as a technological add-on and instead embed it as a structured pedagogical support for developing writing fluency among preparatory-stage learners. This study addresses this gap by designing and implementing an AI-based instructional program aimed at enhancing EFL learners' writing fluency in Egyptian international language schools through guided practice, scaffolded writing tasks, and interactive AI-supported learning experiences. Therefore, this study is guided by the following research question:

### **What is the impact of using an AI-based instructional program on EFL preparatory-stage students' writing fluency?**

To answer this question, the following hypotheses were tested:

(H1) There is a statistically significant difference between students' pre- and post-test scores in overall writing fluency, in favor of the post-test.

(H2) There is a statistically significant difference between students' pre- and post-test scores in writing fluency sub-skills, in favor of the post-test.

## METHOD

### Study Design

The present study adopted a mixed-method, quasi-experimental pretest–posttest control group design. A convergent approach was employed, whereby quantitative data were collected through pre- and post-writing

fluency tests, while qualitative data, including classroom observations, students' written samples, and reflective notes, were collected concurrently and triangulated during the analysis to provide a deeper understanding of how the AI-based instructional program supported writing fluency development.

The intervention was implemented by the researcher in a practitioner–researcher role, allowing for ongoing reflection and responsiveness to students' learning needs throughout the instructional process. To ensure scoring reliability, a qualified external rater, a specialist in applied linguistics, independently evaluated a sample of students' writing. High inter-rater reliability was established, indicating consistency in scoring procedures. In addition, reflective field notes were maintained to document instructional decisions and support interpretive validity.

A quasi-experimental design with two groups (experimental and control) was selected to enable a more rigorous examination of the effectiveness of the AI-based instructional program. The experimental group received instruction through the AI-based program, while the control group followed the regular curriculum using traditional instructional methods. This design allowed for systematic comparison between groups and provided stronger evidence regarding the impact of the intervention on students' writing fluency.

The use of a quasi-experimental rather than a fully randomized design was due to practical and administrative constraints within the school context, where random assignment was not feasible. However, the inclusion of a control group helped minimize potential threats to internal validity and strengthened the study's ability to examine the effect of the intervention. While causal claims should be interpreted with caution, this design enhances ecological validity by allowing the program to be implemented within a natural classroom setting.

## **Participants**

The participants of the study consisted of 60 preparatory-stage students enrolled in an international school in Cairo, Egypt. The sample included both male and female students at the third preparatory level, with an average age ranging from 14 to 15 years. All participants had been learning English for several years within the formal school system and were identified as intermediate-level learners.

The participants were divided equally into two groups: an experimental group ( $n = 30$ ), which received instruction through the AI-based instructional program, and a control group ( $n = 30$ ), which followed the regular English curriculum using traditional teaching methods. The selection of intact classes was based on school administrative arrangements, as random assignment was not feasible. Furthermore, all participants volunteered willingly, ensuring ethical engagement without coercion. Ethical approval was obtained from the university's Research Ethics Committee, and informed consent was secured from all participants prior to data collection.

## **Instruments**

To achieve the objectives of the study, a set of instruments was developed to assess students' writing fluency and evaluate the effectiveness of the AI-based instructional program. These instruments included a writing fluency test and an analytic scoring rubric.

## **Writing Fluency Test**

A pre–post writing fluency test was designed by the researcher to assess students' ability to produce coherent and continuous written discourse (see Appendix A). The test required students to respond to guided writing prompts appropriate to their proficiency level, encouraging them to generate ideas, organize their thoughts, and produce extended written texts within a specified time limit.

The test aimed to measure key components of writing fluency, including idea generation, organization, coherence, lexical use, and overall flow of writing. The same test format was administered before and after the intervention to measure students' progress.

## Writing Fluency Rubric

An analytic rubric was developed to assess students' writing performance across multiple dimensions of writing fluency (see Appendix B). The rubric included the following components: idea development, organization, coherence, lexical appropriateness, and text smoothness. Each component was rated on a four-level scale ranging from poor to excellent performance.

The rubric was designed to ensure consistency in scoring and to provide a detailed evaluation of students' strengths and weaknesses in writing fluency. It was used to score both pre- and post-test writing samples.

## Validity of the Instruments

To ensure content validity, both the writing fluency test and the rubric were submitted to a panel of experts in applied linguistics and EFL instruction. The experts reviewed the instruments in terms of clarity, relevance, appropriateness of the tasks, and alignment with the targeted writing fluency components. Based on their feedback, minor modifications were made to improve wording, task clarity, and rubric descriptors.

Additionally, a pilot study was conducted on a sample of students similar to the target population to examine the clarity and suitability of the test instructions and tasks. The pilot results indicated that the test was appropriate for the students' proficiency level and could effectively elicit measurable writing performance.

## Reliability of the Instruments

To establish scoring reliability, two independent raters evaluated a sample of students' writing scripts using the developed rubric. Inter-rater reliability was calculated using Pearson's correlation coefficient, yielding a high level of agreement ( $r = 0.95$ ), which indicates strong consistency between raters.

Furthermore, internal consistency of the rubric was examined using Cronbach's alpha, which yielded a reliability coefficient of ( $\alpha = 0.91$ ), indicating a high level of reliability across the rubric components. These results confirm that the instruments used in the study were both valid and reliable for assessing students' writing fluency.

## The Artificial Intelligence Program

The proposed instructional program was designed to enhance EFL students' writing fluency through the structured integration of Artificial Intelligence (AI) applications within a pedagogically guided framework. The program moved beyond treating AI as a corrective tool and instead positioned it as a scaffold for idea generation, organization, and continuous written production, which are core dimensions of writing fluency.

The program was implemented with two groups: an experimental group that received AI-supported instruction and a control group that followed conventional writing instruction. This design allowed for a clearer examination of the effect of AI-based intervention on students' writing fluency development under comparable instructional conditions.

The intervention was conducted in an international school in Cairo over a period of eight weeks, comprising 24 sessions (three sessions per week, two hours each), with a total duration of 48 instructional hours. Two initial orientation sessions were conducted to introduce students to the concept of AI in learning, familiarize them with the tools, and establish expectations for active participation in AI-supported writing tasks. The remaining sessions were organized around thematically structured writing tasks, carefully selected to align with students' linguistic level, interests, and curriculum requirements. Each session followed a consistent instructional sequence including a lead-in phase, a guided practice stage, and a consolidation stage, ensuring gradual development of writing fluency skills.

AI applications were purposefully selected to support different aspects of writing fluency. For instance, tools such as Grammarly were used not only for surface-level correction but to raise learners' awareness of sentence structure and coherence. Chat-based AI tools (e.g., conversational agents) were used to stimulate idea generation, expand vocabulary, and provide immediate language input in context. In addition, interactive platforms and

game-based environments such as Minecraft (integrated with writing prompts) were used to create meaningful contexts that encouraged students to describe, narrate, and reflect in writing. These tools contributed to, enhancing idea generation through prompts and guided questioning, supporting organization of thoughts via structured writing tasks, improving lexical access and variation through exposure to contextualized input, and promoting text continuity and flow through extended writing practice.

Instructional activities emphasized collaborative learning, including group discussions, peer feedback, and joint writing tasks. Students were frequently engaged in responding to open-ended prompts such as describing events, explaining scenarios, or proposing solutions, which encouraged sustained written production rather than fragmented responses. The teacher played a facilitative role by guiding discussions, modeling writing strategies, and providing feedback that focused on fluency rather than only accuracy.

Assessment was embedded throughout the program in both formative and summative forms. Formative assessment occurred continuously through classroom interactions, peer review, and AI-generated feedback, allowing students to revise and improve their writing in real time. The use of AI-supported feedback enabled immediate identification of weaknesses, particularly in sentence construction, coherence, and lexical use, which are critical to writing fluency development.

In addition, peer assessment was incorporated as a structured activity, where students evaluated each other’s writing based on clear criteria related to clarity, organization, and flow. This process encouraged deeper engagement with writing as a communicative act and enhanced students’ awareness of effective writing features. The teacher also monitored students’ progress by analyzing their written outputs, tracking improvements in text length, coherence, and fluency over time. This ongoing evaluation informed instructional adjustments and ensured alignment with the program’s objectives.

Finally, a post-test writing fluency assessment was administered at the end of the program to measure the overall impact of the AI-based intervention. The combination of structured instruction, interactive AI tools, and continuous feedback created a supportive learning environment that enabled students to develop their writing fluency in a meaningful and sustained way.

**Results of the Study**

To answer the main research question: “*What is the impact of using an AI-based instructional program on EFL preparatory-stage students’ writing fluency?*”, the following hypotheses were tested.

**Testing Hypothesis One: Overall Writing Fluency**

The first hypothesis states that: *There is a statistically significant difference between students’ pre- and post-test scores in overall writing fluency, in favor of the post-test.* To test this hypothesis, both: a paired-samples t-test (within each group), and an independent-samples t-test (between groups) were conducted.

**Table 1** t-test Results for Differences Between Experimental and Control Groups in Overall Writing Fluency

Group	Test	Mean	SD	t-value	Sig. (p)
Experimental (n = 32)	Pre	35.87	22.95	9.842	0.000
	Post	68.42	18.76		
Control (n = 32)	Pre	36.11	23.10	1.214	0.229
	Post	40.35	21.88		

**Table 2.** Between-Groups Comparison (Post-Test)

Group	Mean	SD	t-value	Sig. (p)	Effect Size ( $\eta^2$ )
Experimental	68.42	18.76	5.973	0.000	0.359
Control	40.35	21.88			

As shown above, the results indicate that the experimental group showed a substantial increase in overall writing fluency from pre-test ( $M = 35.87$ ) to post-test ( $M = 68.42$ ), whereas the control group demonstrated only a slight improvement. The paired-samples t-test revealed that this improvement in the experimental group was statistically significant ( $p < 0.01$ ), while the control group’s improvement was not statistically significant.

Furthermore, the independent-samples t-test comparing post-test scores between both groups revealed a statistically significant difference in favor of the experimental group ( $t = 5.973, p < 0.01$ ). The calculated effect size ( $\eta^2 = 0.359$ ) indicates a very large effect, confirming the strong impact of the AI-based instructional program on students’ overall writing fluency. Therefore, Hypothesis One is supported.

**Testing Hypothesis Two: Writing Fluency Sub-Skills**

The second hypothesis states that: “*There is a statistically significant difference between students’ pre- and post-test scores in writing fluency sub-skills, in favor of the post-test.*” To test this hypothesis, a paired-samples t-test was conducted to examine the differences between the experimental group’s mean scores in the pre- and post-administration of the writing fluency test across its sub-skills. In addition, an independent-samples t-test was used to compare the post-test scores of both the experimental and control groups in order to determine the effect of the AI-based instructional program.

**Table 3.** t-test Results for the Experimental Group in Writing Fluency Sub-Skills (n = 32)

Component	Pre Mean	Post Mean	Pre SD	Post SD	t-value	Sig. (p)	$\eta^2$
Mechanics	8.75	15.92	5.52	3.98	8.231	0.000	0.686
Organization	10.21	15.37	5.11	4.02	6.412	0.000	0.570
Text Smoothness	5.02	13.44	4.48	4.26	8.765	0.000	0.712
Interpretation	5.48	13.02	4.63	4.57	8.193	0.000	0.684
Reflection	6.41	13.58	4.98	4.33	7.102	0.000	0.620

As shown in Table 3, the post-test mean scores of the experimental group are higher than the pre-test scores across all writing fluency sub-skills. This indicates a clear improvement in students’ performance after the implementation of the AI-based instructional program. Moreover, the standard deviations in the post-test are generally lower than those of the pre-test, reflecting greater consistency among students’ performance following the intervention. The calculated t-values reveal that all differences are statistically significant at ( $p < 0.01$ ). Additionally, the effect sizes ( $\eta^2$ ) for all sub-skills exceed (0.232), indicating very large effect sizes. This suggests that the AI-based program had a strong and meaningful impact on enhancing all dimensions of writing fluency.

**Table 4.** Post-Test Comparison Between Experimental and Control Groups in Writing Fluency Sub-Skills

Component	Experimental Mean	Control Mean	t-value	Sig. (p)
Mechanics	15.92	10.34	4.872	0.000
Organization	15.37	11.28	3.965	0.001
Text Smoothness	13.44	7.12	5.103	0.000
Interpretation	13.02	8.01	4.556	0.000
Reflection	13.58	9.23	3.998	0.001

The differences between the two groups are statistically significant at ( $p < 0.01$ ), indicating that the observed improvements can be attributed to the AI-based instructional program rather than to chance. While the control group showed only limited progress, the experimental group demonstrated substantial gains across all components, particularly in text smoothness and interpretation, which are key indicators of writing fluency development.

Based on the results of both the paired-samples and independent-samples t-tests, it can be concluded that there is a statistically significant difference between students’ pre- and post-test scores in writing fluency sub-skills in favor of the post-test. Therefore, Hypothesis Two is supported, confirming the effectiveness of the AI-based instructional program in enhancing writing fluency at both the overall and sub-skill levels.

The results clearly demonstrate that the AI-based instructional program had a statistically significant and practically meaningful impact on developing EFL students' writing fluency, both as an overall construct and across its sub-skills. The large effect sizes indicate that AI integration, when pedagogically structured, can substantially enhance learners' ability to produce fluent, coherent, and extended written discourse.

### Qualitative Analysis and Discussion

In this part, the researcher analyses the qualitative data collected from participants' written productions during the implementation of the AI-based instructional program. The aim is to explore how Artificial Intelligence applications contributed to enhancing EFL preparatory-stage students' writing fluency components, namely mechanics, organization, text smoothness, interpretation, and reflection. The analysis is supported by students' written samples, classroom outputs, and interaction logs generated through AI-supported learning environments such as Grammarly, ChatGPT-based chat tasks, Minecraft collaborative writing activities, Duolingo writing prompts, and VR/AR language applications.

Overall, the qualitative findings reveal that AI tools functioned not merely as corrective systems, but as interactive scaffolding environments that helped learners generate ideas, organize discourse, and improve fluency through immediate feedback, collaboration, and guided prompting.

### Mechanics Development through AI Support

At the beginning of the program, students demonstrated weak control over basic writing mechanics, particularly capitalization, punctuation, and tense consistency. Writing samples revealed fragmented sentences and lack of structural awareness. For example, one student wrote:

*“covid 19 isnt a legend because much people are injured they went to hospitals and some people died i also know doctors warn people of it...”*

Similarly, another participant wrote:

*“Covid 19 isnt legend because a lot of people were sick they went to hospitals and some people died...”*

These excerpts reflect common mechanical errors such as missing capitalization, lack of punctuation, and inconsistent tense use, which are frequently observed in Egyptian preparatory-stage EFL classrooms where writing is taught as memorization rather than production. During the intervention, the researcher integrated AI-supported tools such as Grammarly AI, chatbot writing assistants, and Minecraft collaborative writing tasks, where students were required to write short responses and immediately revise them based on AI feedback. The teacher also guided learners to analyze corrections suggested by the system. One student reflected during the activity:

*“Grammarly show me my mistakes directly and I understand why I wrong in punctuation and tense.”*

Another learner stated:

*“When I write in Minecraft chat, I see my sentence change automatically and I learn how to fix it next time.”*

After the intervention, significant improvement was observed in students' written mechanics. The same student who previously wrote fragmented sentences produced the following improved version:

*“Covid 19 isn't a legend because many people are injured. They went to hospitals and some people died. I also know doctors warn people about it.”*

Another post-program sample showed further development:

*“Covid 19 isn't a legend because a lot of people were sick. Many of them were treated in hospitals and some patients died. Doctors warned people continuously about its danger.”*

These improvements indicate that AI-based correction and immediate feedback helped learners internalize grammatical rules through active noticing and revision rather than passive instruction.

### Organization Enhancement through AI-Guided Writing Tasks

In the pre-intervention stage, students demonstrated weak ability to organize ideas logically. Their writing was often a list of unrelated sentences without coherent sequencing. For instance, one learner wrote:

*“We learn a lot of subjects at school. We learn Arabic to communicate. We learn computers. History tells us about country. Plants are important.”*

Although the vocabulary was familiar, the ideas lacked logical progression and cohesion. During the program, students engaged in AI-supported brainstorming tasks, guided ChatGPT questioning activities, and structured writing prompts in VR environments (e.g., Mondly VR and Non-Stop English VR). These tools encouraged learners to generate and reorganize ideas dynamically. One of the most frequently used prompts during activities was:

*“What is happening in this AI world? How are you dealing with the situation?”*

Students were required to generate responses, reorganize them, and refine structure with AI feedback. A participant commented:

*“ChatGPT help me arrange my ideas before I write. It show me how to start and end my paragraph.”*

Another learner said:

*“I didn’t know how to organize my writing but AI give me steps and examples.”*

After the intervention, students showed clear improvement in paragraph organization. One revised sample reads:

*“Of all the members of my family, my mother is the person I am proud of. She is a very good cook. She is 40 years old. She looks younger than her age and she is respected at work. Moreover, she works hard and spends her free time cooking for us. I really admire her and I will always be proud of her.”*

Compared to the pre-test, the post-writing demonstrates clearer sequencing, logical flow, and cohesive progression of ideas, reflecting the organizational scaffolding provided by AI tools.

### Text Smoothness Development through AI Interaction

Before the intervention, students’ writing lacked natural flow, coherence, and smooth transitions. Sentences were short, repetitive, and disconnected. For example:

*“Covid 19 is not a legend. It is dangerous. People are afraid. Doctors warn us.”*

This reflects minimal linguistic expansion and absence of discourse continuity. During the intervention, learners engaged in AI-powered conversation simulations, chatbot dialogues, and VR-based storytelling tasks, where they were required to continue ideas, respond to prompts, and extend discourse collaboratively.

One student explained:

*“When I talk with AI chatbot, I learn how to continue my sentences and not stop.”*

Another stated:

*“VR English game make me speak and write more smoothly because I need to answer quickly.”*

After the program, students produced more fluent and connected writing. One improved response was:

*“Covid 19 is a serious virus that affects people all over the world. Some people believe it is not real, while others know it is dangerous. Millions of people were infected, and scientists developed vaccines to stop its spread. Therefore, we must take precautions to stay safe.”*

This reflects a clear shift from fragmented sentences to coherent discourse with logical transitions, enabled by AI-supported extended writing practice.

### **Interpretation and Idea Development through AI Visualization Tools**

Initially, students struggled to interpret visual stimuli and generate meaningful written responses. When shown images or scenarios, responses were superficial and lacked depth. For example:

*“Doctors help people. Hospitals are good. We need health.”*

During the program, learners were exposed to AI-based image generation tasks, VR simulations, and scenario-based prompts (e.g., “minister of health” role-play tasks in AI environments). Students were asked to interpret scenarios such as health crises or futuristic AI societies and write reflective responses. One participant said:

*“When I see picture in AI task, I can think better and write more ideas.”*

Another added:

*“VR makes me feel inside the story, so I can explain more.”*

After the intervention, students produced richer interpretive writing:

*“Today the world is facing many health problems due to pollution and diseases. If I were the minister of health, I would increase awareness through social media, build more hospitals, and support medical research. I believe cooperation between people and government is essential to fight diseases and improve health conditions.”*

This demonstrates a clear development in interpretive thinking and idea expansion supported by AI visualization environments.

### **Reflection and Critical Engagement through AI-Based Learning**

Before the intervention, students’ reflective writing was extremely limited, mostly consisting of basic personal statements such as:

*“I want to be a doctor. I am in preparatory school. I like English.”*

These responses lacked depth, justification, and personal connection. During the program, reflective tasks were integrated through AI-assisted journaling, chat reflections, and VR scenario responses, where students were required to explain, justify, and extend their ideas.

One student stated:

*“AI questions make me think more about my future and my dreams.”*

Another reflected:

*“I write more because AI ask me why and how, not just what.” After the intervention, learners demonstrated deeper reflective writing: “Of all the members of my family, my mother is the person I am proud of. She is a very good cook. She is 40 years old. She looks much younger than her age with short hair and a beautiful face. At work, she is respected by all of her friends. Moreover, she works hard. She is a useful person in society. She often spends her free time cooking delicious dishes for us, which makes everyone in my family happy, I really*

*admire her for her wonderful dishes. In the end, I consider my mother the best model for me. I love her and I will always be proud of her”*

This reflects improved ability to connect personal experience with future goals in a coherent reflective structure. Overall, the qualitative analysis confirms that AI applications played a significant role in transforming students' writing performance from fragmented, grammar-focused output into more coherent, fluent, and meaningful writing. The integration of tools such as Grammarly, ChatGPT, VR learning environments, Minecraft collaborative writing, and AI chatbots provided continuous scaffolding, immediate feedback, and authentic language use opportunities. These factors collectively contributed to noticeable improvement in all writing fluency components.

## DISCUSSION

The primary objective of this study was to investigate the impact of a gamified AI-based instructional program on the EFL writing fluency of preparatory stage students. The results of the post-test analysis reveal a statistically significant improvement in the experimental group's overall writing fluency ( $t = 9.842$ ,  $p < 0.001$ ), with a substantial effect size ( $\eta^2 = 0.359$ ). These findings suggest that the integration of AI tools within a gamified framework effectively addresses the cognitive and motivational barriers that often hinder writing production in traditional Egyptian EFL classrooms. By providing a scaffolded environment where students can engage in continuous text production, the program succeeded in moving learners beyond the fragmented, sentence-level writing that often characterizes intermediate-level performance.

The significant gains observed in the experimental group can be attributed to the multifaceted support provided by the AI-based program across specific fluency sub-skills, most notably idea development and lexical access. One of the most persistent challenges for preparatory students is the inability to generate content, often referred to as “writer's block.” In this study, the use of chat-based AI agents acted as a cognitive scaffold, providing immediate prompts and contextualized vocabulary. This aligns with findings by Kasneci et al. (2023), who noted that generative AI reduces the cognitive load of ideation, allowing learners to focus on the flow of communication rather than struggling for initial words. Consequently, students in the experimental group were able to produce longer, more substantial texts because the AI lowered the threshold for entry into the writing task.

Furthermore, the program's impact on organization and coherence highlights a shift from theoretical understanding to practical application. Unlike traditional instruction in the Egyptian context, which often treats coherence as a static concept to be memorized, the AI tools used in this intervention, such as Grammarly and AI writing assistants, provided real-time, iterative feedback. This allowed students to observe how sentence connections and logical transitions affected the clarity of their work as they were writing. This result supports the work of Dizon and Gayed (2021), who argued that AI-supported feedback enhances not just surface-level accuracy, but the structural quality of the text. By internalizing these organizational patterns through repeated AI-guided practice, students demonstrated a more sophisticated ability to maintain a continuous flow of ideas.

The role of gamification was equally critical in fostering text smoothness and reducing writing anxiety. By shifting the focus from “punitive” grammar correction to “productive” language use, facilitated by the low-stakes environment of Minecraft and gamified prompts, students produced more continuous text. The reduction in writing anxiety through gamification, as noted by Bai et al. (2022), directly translates to increased text length and fewer hesitations, which are hallmarks of improved writing fluency. The disparity between the experimental and control groups (Mean = 68.42 vs. Mean = 40.35) highlights the limitations of traditional, teacher-centered approaches. While the control group followed the regular curriculum, their lack of significant improvement suggests that traditional methods do not provide sufficient opportunities for the sustained writing practice necessary for fluency development.

In contrast, the experimental group benefited from what can be termed “Pedagogical AI Scaffolding.” The gamified elements, including rewards and interactive tasks, fostered a sense of learner agency. As Hwang et al. (2020) suggested, when AI is used as a partner rather than just a corrector, it creates a “zone of proximal development” where students feel empowered to experiment with language. This study demonstrates that for

younger learners, the interactive nature of AI tools is crucial for maintaining the engagement required to overcome the linguistic fatigue often associated with EFL writing. This addresses a critical gap identified by Boraie et al. (2019) regarding the mechanical nature of writing instruction in Egypt. By demonstrating that AI can be successfully integrated into international language school settings, these results provide a roadmap for moving beyond memorized-based writing toward a more dynamic, fluency-oriented pedagogical model.

## CONCLUSION

This study investigated the impact of a gamified AI-based instructional program on enhancing EFL language fluency, particularly writing fluency, and on fostering self-regulation among preparatory stage students. The findings indicate that integrating AI applications within a structured and interactive learning environment significantly improves learners' writing fluency across multiple dimensions, including idea generation, lexical access, organization, coherence, and overall text length. The results also show that the program effectively strengthens students' self-regulation skills, encompassing orientation, performance, and evaluation components. By providing a motivating, enjoyable, and low-pressure environment, the AI program encouraged students to actively engage with the learning content, reflect on their writing process, and monitor their progress.

The study further demonstrates that AI tools, when combined with gamification, virtual reality contexts, and interactive tasks, serve as powerful pedagogical scaffolds. They enable learners to overcome common barriers such as writer's block, language anxiety, and limited opportunities for sustained practice, while promoting collaborative engagement and autonomy. Importantly, the findings suggest that AI integration enhances, but does not replace, the essential social and instructional roles of teachers. Instead, AI complements traditional teaching by creating a dynamic, fluency-oriented, and learner-centered approach that encourages active participation, critical thinking, and continuous improvement.

## Pedagogical and Theoretical Implications

The findings of this study carry significant pedagogical implications for EFL teaching, particularly in contexts similar to Egyptian preparatory stage classrooms. First, the integration of AI applications within a gamified and interactive learning environment was shown to enhance learners' writing fluency and self-regulation simultaneously. By providing immediate feedback, scaffolded prompts, and contextualized vocabulary, AI tools helped students overcome common challenges such as idea generation difficulties and linguistic hesitation (Alnemrat et al., 2025). This supports a learner-centered approach, where students are actively engaged in meaningful practice rather than passively receiving knowledge, aligning with constructivist principles that emphasize active knowledge construction through interaction and problem-solving (Maleki, 2026; Tran, 2025).

Moreover, the program's gamified elements and immersive virtual environments fostered intrinsic motivation, lowered writing anxiety, and encouraged sustained participation. Students were able to engage with English meaningfully, experimenting with language without fear of error, reflecting Vygotskian notions of the zone of proximal development, where guidance and supportive scaffolding allow learners to achieve higher levels of performance than they could independently (Crosthwaite & Sun, 2025; Guo et al., 2024). The study highlights that learners' autonomy, self-directed practice, and reflective monitoring were strengthened when AI-supported activities were integrated with enjoyable, low-stakes gamified tasks, reinforcing the critical link between motivation, engagement, and skill development (Akanda & Talukder, 2026; Evmenova et al., 2025).

From a theoretical perspective, the study demonstrates that AI-based interventions can operationalize key principles from multiple learning theories. Constructivist theory is evident in the active, collaborative, and inquiry-driven learning experiences that encourage learners to construct knowledge through exploration and interaction (McKenna et al., 2020). The interaction and output hypotheses are supported by the observation that continuous engagement with AI scaffolds enabled learners to produce extended written output, enhancing both fluency and syntactic complexity (Rasteiro & Limpo, 2022). Additionally, the improvement in self-regulation aligns with metacognitive frameworks, suggesting that AI tools facilitate not only skill acquisition but also reflective learning processes, enabling students to plan, monitor, and evaluate their performance effectively (Talayhan, 2023).

Collectively, these implications suggest that AI integration, when thoughtfully applied within gamified and collaborative learning environments, offers a theoretically grounded approach to developing both linguistic proficiency and learner autonomy. This provides a model for reforming traditional instruction, encouraging educators to adopt innovative, technology-enhanced practices that balance skill development, motivation, and self-regulatory growth.

### **Limitations**

Despite the promising results, this study encountered several limitations that should be considered when interpreting the findings. First, at the outset of the program, some learners' parents were surprised by the request to bring VR glasses to school. To address their concerns, the researcher invested additional time communicating through WhatsApp voice messages, explaining the objectives of the program and the procedures for its implementation.

Second, compliance with AI-supported writing tools varied among participants. Some learners initially ignored the Grammarly writing correction program, which resulted in the submission of texts containing numerous errors during Minecraft-based missions. To ensure adherence, the researcher established a clear rule stating that group missions would only be considered valid once the AI-based corrections were applied.

Third, access to technology posed a challenge for certain participants. Some students were unable to attend online sessions due to unreliable internet connections. To mitigate this issue, the researcher arranged alternative sessions in the school computer laboratory, providing all learners with stable internet access.

Finally, the study's sample was limited to preparatory stage students within a single educational context, which may affect the generalizability of the findings. While the results indicate strong potential for AI-enhanced, gamified instruction, future research is needed to explore its effectiveness across different age groups, proficiency levels, and institutional settings.

Despite these limitations, the study provides valuable insights into the practical implementation of AI-based instructional programs and highlights strategies to overcome common obstacles, offering guidance for educators seeking to adopt similar approaches.

### **Pedagogical and Research Recommendations**

Based on the findings and conclusions of this study, several pedagogical and research-oriented recommendations can be drawn. From a pedagogical perspective, instructors are encouraged to provide learners with frequent opportunities to develop their writing fluency and self-regulation skills within supportive, engaging, and enjoyable learning environments. The use of AI applications, gamified tasks, and virtual reality contexts can foster intrinsic motivation, reduce writing anxiety, and promote active participation, allowing learners to experiment with language in a meaningful and low-stakes setting. Teachers should also integrate reflective practices, encouraging learners to monitor, evaluate, and adjust their performance to enhance self-regulatory capacities. Moreover, educators are advised to explore innovative AI tools and chatbots that align with their pedagogical goals, ensuring that technology complements rather than replaces teacher-student interaction. By doing so, instructors can create a learner-centered environment where students take responsibility for their own learning, develop autonomy, and achieve sustained improvement in language fluency.

In terms of research implications, future studies should investigate the impact of AI-based interventions on language fluency across different stages of learning and in diverse educational contexts. Researchers are encouraged to examine the integration of writing fluency with other language skills, such as speaking and listening, to explore the holistic benefits of AI in EFL instruction. Additionally, studies could focus on the use of AI applications to support learners with specific challenges, including dyslexia or other learning difficulties, to determine how technology can facilitate equitable access to language learning. The effectiveness of different AI tools, including chatbots like ChatGPT, should also be explored to provide personalized and adaptive learning experiences. Finally, longitudinal research could investigate the sustainability of gains in writing fluency and

self-regulation over time, offering further insights into the long-term pedagogical potential of AI-supported instruction.

By addressing both practical teaching strategies and areas for further research, these recommendations offer a comprehensive roadmap for leveraging AI to enhance EFL learning outcomes, supporting the development of both linguistic proficiency and autonomous, self-regulated learners.

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