

## The Effect of Artificial Intelligence and Dynamic Assessment Synergy on Writing Development of Iranian Nursing Students

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### ABSTRACT

The integration of Artificial Intelligence (AI) into language education has opened new avenues for enhancing academic writing instruction, particularly when combined with human-mediated pedagogical frameworks. This study investigates the impact of AI-assisted feedback via ChatGPT paired with teacher-mediated Dynamic Assessment (TMDA), referred to as AI-DA synergy—on the academic writing development of Iranian nursing students who enrolled in a university-level English as Foreign Language (EFL) course. Grounded in Vygotsky’s Sociocultural Theory (SCT), the study aims to evaluate both the effectiveness of AI-DA synergy and learners’ perceptions of its implementation. Employing a mixed-methods design, the research involved 60 B1-level nursing students randomly assigned to three groups: AI-DA, DA-only, and a control group, each comprising 20 learners. Participants completed two CEFR B1-aligned timed descriptive writing tasks in pretest and posttest phases, yielding quantitative measures of their writing proficiency. Qualitative data were obtained via semi-structured interviews to explore students’ writing development and their critical reflections on AI-DA feedback. ANOVA analyses revealed that the AI-DA group significantly outperformed both comparison groups in writing proficiency. Thematic analysis of student perceptions highlighted five key themes: the necessity of teacher mediation, emotional engagement, skill development, limitations of AI assistance, and trust negotiation. Students expressed appreciation for the dual support system, noting that teacher feedback provided contextual clarity and emotional reassurance, while AI offered immediate, personalized suggestions. Findings underscore the transformative potential of AI-DA synergy in enhancing learners’ academic writing through personalized, scaffolded feedback, urging educators to use AI with human mediation to foster deeper engagement, contextual clarity, and emotionally responsive instruction.

### 1. Introduction

Writing in a second language (L2) is widely recognized as a cognitively demanding, recursive, and strategic endeavor that requires sustained engagement and goal-directed effort from learners (Han & Hiver, 2018). Beyond its academic significance, proficiency in L2 writing plays a pivotal role in

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professional communication, enabling learners to express ideas effectively and participate meaningfully in scholarly discourse (Cancino & Panes, 2021; Poehner & Yu, 2022; Sasaki et al., 2018). For English language learners, writing competence is a core element of communicative ability, encompassing coherence, cohesion, grammatical accuracy, and lexical precision (Ebadi & Rahimi, 2019; Shi et al., 2020). Furthermore, improvements in writing skills often lead to broader linguistic development, including enhanced grammar, enriched vocabulary, and increased fluency (Ferris, 2018; Stoeckel et al., 2021).

Despite its importance, mastering academic writing remains a formidable challenge for many EFL students. These difficulties stem from a multifaceted interplay of linguistic limitations, cognitive barriers, inadequate instructional practices, motivational issues, time constraints, and learners' disengagement (Barrot, 2023; Fathi & Rahimi, 2022; Rahimi & Fathi, 2022). In response to these challenges, recent research has explored the potential of AI-powered writing tool (ChatGPT) to support EFL learners' academic writing development. These technologies offer automated error correction, personalized feedback, and adaptive guidance, thereby enhancing textual coherence, cohesion, and lexical accuracy.

While AI offers valuable support in writing instruction, its integration poses challenges. These include risks of learner overreliance (Barrot, 2023; Zhai, 2024), lack of pedagogical scaffolding (Tarchi et al., 2024), curricular constraints (Chapelle et al., 2024), and the need for ongoing contextual adaptation (Liu et al., 2023; Lund et al., 2023). Although AI's instructional benefits are well-documented (Sun et al., 2021), its assessment potential remains underexplored (Alonzo et al., 2024).

Given the emerging nature of AI research in education (Tarchi et al., 2024), a balanced approach is essential—one that harmonizes AI-driven efficiency with human-mediated instruction to optimize EFL writing development (e.g., Chen et al., 2025; Hyland, 2023; Nguyen et al., 2024; Zhai, 2024). As Yan (2023) emphasizes, teachers play a crucial role in adapting AI-generated feedback to meet learners' specific writing needs. To address this pedagogical gap, the present study examines the integration of AI-assisted feedback with TMDA—a dialogic approach where educators scaffold learners' evolving abilities within the DA framework. This novel combined model, referred to as AI-DA synergy, offers a personalized and responsive pathway to enhance EFL academic writing. Despite its potential, the combination of AI feedback and teacher mediation within DA remains largely unexamined (Poehner, 2024).

TMDA, grounded in an interventionist model of DA, involves assessing learners' needs and delivering tailored mediation—ranging from implicit prompts to explicit instruction—based on individual responsiveness (Poehner, 2005). Rooted in Vygotsky's SCT, DA merges instruction and assessment into a unified process that fosters L2 writing proficiency through dynamic, responsive mediation (Poehner & Yu, 2022; Shrestha, 2020; Yu & Poehner, 2023). This approach entails evaluating learners' ability to identify and resolve performance issues, determining the level of mediation required, and tracking progress toward autonomous control over L2 communicative resources (Poehner, 2008). By facilitating scaffolded learning and collaborative engagement within the learner's Zone of Proximal Development (ZPD), DA promotes meaningful cognitive growth (Vygotsky, 1978). Incorporating Vygotsky's (1978) social constructivist principles into writing mediation research offers valuable insights into how dialogic and interactive writing tasks foster academic writing competence.

Grounded in SCT, this study introduces a novel synergy—AI-DA—that combines TMDA with AI to address persistent challenges in AI-enhanced writing instruction. Recognizing the pivotal role of collaborative engagement and instructional scaffolding in promoting learners' progression from current competence to higher developmental potential, AI-DA leverages AI as a mediational tool within the learner's ZPD (Vygotsky, 1978; Lantolf, 2000). In this framework, AI facilitates scaffolded interactions that support cognitive growth while complementing TMDA through dynamic, emotionally responsive mediation that fosters self-regulation and sustained learner engagement (Jeon, 2023; Poehner, 2008).

## 2. Review of Literature

### 2.1. Artificial Intelligence (AI) and Writing Development

AI-driven feedback systems, powered by advances in natural language processing, have significantly reshaped writing instruction, particularly in EFL contexts. Tools such as ChatGPT offer

real-time, personalized feedback that enhances grammar, syntax, coherence, and overall textual organization (Fathi & Rahimi, 2024). These systems provide consistent and immediate responses, which not only improve writing performance but also foster learner autonomy. A growing body of research supported the positive impact of adaptive writing tools on writing development, with experimental studies reporting gains in fluency, vocabulary acquisition, and argumentative structure (Hwang et al., 2023; Wang & Xue, 2024; Xu et al., 2023). Among these tools, ChatGPT has gained widespread adoption in academic writing among EFL learners, offering structured guidance and scaffolding that supports the development of independent writing strategies (Fathi & Rahimi, 2024; Fitria, 2023; Su et al., 2023; Yan, 2023).

A growing body of empirical research has underscored ChatGPT's pedagogical value in EFL writing instruction. Fathi and Rahimi (2024) found that AI-assisted writing promoted self-regulated learning, enabling students to revise their drafts with minimal teacher intervention. Their participants reported notable gains in coherence, motivation, and technical proficiency. However, while the study acknowledged the importance of teacher mediation for emotional scaffolding and interpretive clarity, it did not embed AI within a teacher mediation in structured assessment framework like DA. Similarly, Su et al. (2023) reported improvements in argumentative writing—especially in organization and clarity—while Fitria (2023) documented enhanced accuracy and vocabulary development. Yan (2023) added that AI support contributed to greater fluency and coherence, reinforcing its role in scaffolding textual development. These benefits are particularly relevant in large or remote learning environments, where AI feedback offers scalable alternatives to individualized instruction (Xu et al., 2023). Hwang et al. (2023) further demonstrated that learners using AI-assisted methods outperformed those relying solely on traditional approaches. Yet, despite these promising outcomes, most studies lacked a coherent framework for human mediation and failed to integrate AI within DA models grounded in SCT. As Alonzo (2018) emphasized, technology-enhanced assessment must preserve dialogic mediation to remain pedagogically valid. Without such integration, AI risks functioning as a decontextualized tool rather than a culturally responsive mediator of learning.

Despite these promising outcomes, several limitations have been identified. Learners have reported inaccuracies in AI-generated feedback, particularly in relation to context-specific language use and cultural nuances (Fathi & Rahimi, 2024). Additionally, concerns about overdependence on AI tools persist, with some studies suggesting that excessive reliance may inhibit creativity and originality. For instance, Niloy et al. (2024) found a negative correlation between ChatGPT use and key elements of creative writing, such as elaboration and content depth. Tarchi et al. (2024) examined ChatGPT's role in source-based writing tasks and noted limited student engagement, citing ethical concerns and lack of domain expertise. These findings suggest that while ChatGPT can facilitate interactive text generation, it may not substantially enhance learners' ability to synthesize conflicting information or integrate source content effectively. Importantly, it cannot assess the students' understanding. Crucially, ChatGPT cannot assess learners' underlying cognitive processes or conceptual understanding, which may lead to ambiguous instructional outcomes and superficial revisions (Hartwell & Aull, 2023; Lu et al., 2024). Moreover, the use of AI in assessment, especially within English language education, lacks robust theoretical grounding and remains methodologically underexplored (Alonzo et al., 2024). However, Abdulhussein Dakhil et al. (2025) used the ELSA Speech Analyzer to assess and enhance speaking performance among intermediate Iraqi EFL learners.

Further critiques have focused on AI's limitations in fostering higher-order thinking and reflective writing. Jeon (2024) and Marzuki et al. (2023) observed that over-reliance on automated feedback may weaken students' analytical skills and self-editing capabilities. Bender (2024) and Pervaiz et al. (2025) raised concerns about biases embedded in AI training data, which can lead to generic or misleading feedback—particularly problematic in linguistically diverse EFL settings. Moreover, the absence of emotional intelligence and adaptability to individual learning styles in AI systems may hinder long-term engagement and personalized learning outcomes (An et al., 2023; Wang et al., 2024; Jeon, 2024). To mitigate these risks, Asadi et al. (2025) advocated for a hybrid approach that combines instructor feedback with AI guidance, fostering both creativity and learner autonomy.

In response to these challenges, scholars increasingly recommend a balanced instructional model that integrates AI tools with human mediation, peer collaboration, and scaffolded support. Asadi et al. (2025) demonstrated that combining ChatGPT with teacher feedback significantly enhances

argumentative essay writing, although ethical concerns such as plagiarism and overreliance remain. Bodaubekov et al. (2025) echoed this view, suggesting that AI-generated feedback should complement rather than replace human input to preserve creativity and student engagement. Mohammadi et al. (2023) asserted the efficacy of integration of technology-driven feedback (Automated Writing Evaluation) when combined with human input, for the enhancement of writing skills. Similarly, Chen et al. (2025), Chan (2023), and Hyland (2022) emphasized the importance of structured integration to ensure ethical, effective, and learner-centered writing environments.

## 2.2. Dynamic Assessment (DA) and AI

DA, rooted in Vygotsky's SCT, emphasizes the central role of mediation in learning (Poehner, 2005). Rather than passively evaluating learners, DA integrates intervention directly into the assessment process, transforming it into a developmental experience. Mediation in DA ranges from subtle, implicit cues to explicit instructional support, with the latter aligning closely with Vygotsky's concept of the ZPD (Poehner, 2005; 2008). This shift from implicit to explicit mediation enhances learners' developmental progression by fostering structured, individualized support.

A key objective of DA is to guide learners from other-regulation—relying on external assistance—toward self-regulation, where they independently manage their learning. This transition reflects the internalization of mediated experiences and is central to DA's pedagogical value. Early studies by Poehner (2005) and Anton (2009) demonstrated DA's effectiveness in higher education writing and placement contexts, highlighting the importance of whole-text construction and revision cycles. Kozulin and Garb (2002) further emphasized personalized mediation aligned with learners' ZPD to improve writing proficiency.

Recent research has expanded DA's application in L2 writing instruction. Yu and Poehner (2023) showed that DA enhances learners' responsiveness to feedback, while Poehner and Yu (2022) introduced rubrics as structured mediation tools to support engagement. Tang and Ma (2023) and Zhang and Xi (2023) provided empirical evidence of DA's impact on college-level writing and metacognitive competence, respectively. Shrestha (2020) synthesized DA's role in academic writing assessment, and Vameghshahi and Ghonsooly (2023) explored innovative instructional formats, including video game-based writing. Amirian et al. (2016) demonstrated that Online Dynamic Assessment (ODA) effectively boosted university students' micro-level writing skills, showing marked improvement in five of eight assessed components. Students also responded positively to the approach, emphasizing its role in enhancing both their writing proficiency and overall engagement.

Technological integration has further diversified DA practices. Andujar (2020) demonstrated the effectiveness of mobile-mediated DA via WhatsApp in improving grammar, vocabulary, and learner autonomy. Vakili and Ebadi (2022) compared face-to-face and computer-mediated DA, finding that the latter promotes deeper engagement and self-regulation.

Despite its promise, DA faces practical challenges. Time constraints, large class sizes, and technological limitations hinder its implementation (Fathi & Rahimi, 2024; Poehner, 2024). Moreover, Faryabi et al. (2024) identified issues in mediation selection, feedback delivery, and teacher training. To address these barriers, AI is increasingly viewed as a scalable and adaptive solution, capable of enhancing mediation strategies and optimizing DA practices in writing instruction.

The integration of AI into language education has prompted a rethinking of assessment practices, particularly in writing instruction. One novel framework is AI-DA synergy, which combines AI-mediated feedback with TMDA to support nursing learners' academic writing development. This dual-scaffolded approach merges AI's adaptive, immediate responses with the interpretive and developmental insights of TMDA, offering a pedagogically responsive model for AI-assisted assessment.

The theoretical foundation of AI-DA synergy is rooted in Vygotsky's SCT and the principles of DA. Within this framework, AI operates as a mediating artifact, shaping cognitive development through scaffolded interactions in the learner's ZPD (Lantolf, 2000; Vygotsky, 1978). AI tools such as ChatGPT provide personalized, real-time feedback that supports linguistic accuracy and fluency, while TMDA fosters deeper cognitive growth by promoting critical thinking, metacognitive awareness, and self-regulation (Poehner, 2008). Together, these components enable learners to co-construct language

knowledge through interaction with more capable agents—teachers and AI—within collaborative writing tasks.

This integration addresses key limitations of traditional DA, particularly its time-intensive nature and limited scalability. AI's efficiency allows for sustained individualized engagement across digital platforms, while DA ensures that feedback remains developmentally meaningful and context-sensitive (Poehner, 2024; Yu & Poehner, 2023). AI-mediated feedback exemplifies artifact-mediated learning, offering graduated assistance that guides learners from other-regulation to self-regulation (Lantolf, 2000; Poehner, 2008). However, it is the diagnostic function of DA that adds critical depth to this model: educators can actively interpret learners' conceptual understanding in real time, making instructional decisions that are both responsive and personalized.

Building on the theoretical and empirical foundations discussed, this pioneering study introduces a novel synergy—AI-assisted feedback combined with TMDA (as referred AI-DA)—to support nursing learners' academic writing development. It also underscores the importance of understanding AI-DA students' perceptions of this integrated approach, as such insights are vital for evaluating its practical effectiveness and informing future instructional strategies (Utami & Winarni, 2023; Zhao, 2023). Guided by these aims, the study addresses the following research questions:

RQ1: To what extent does the writing performance (coherence, sentence structure, and lexical accuracy) of nursing students differ across the AI-DA, DA, and control groups?

RQ2: What are students' perspectives on the integration of AI-DA in their writing development?

### 3. Method

#### 3.1. Participants and Setting

The current study utilized an explanatory mixed-methods design to explore the writing development of 60 Iranian nursing students at a University of Medical Sciences in Northeast Iran (aged 19–26;  $M = 22.5$ ,  $SD = 2.29$ ). Though participants were 60 nursing students, they were identified for this study because they were concurrently enrolled in a university-level EFL course. The sample was drawn from an initial pool of 182 nursing students at the same university using convenient sampling. From the initial pool, 60 students who met the B1 proficiency level on the Oxford Placement Test were randomly allocated to two experimental groups and one control group. Pretest data analysis revealed that there were no significant differences between groups in writing proficiency, confirming a comparable baseline (see Table 2). All students had previous exposure to language learning technologies, including basic ChatGPT 3.5 platforms in their coursework. A B1 level was deemed educationally appropriate for students to demonstrate a sufficient academic writing ability but still warrant explicit instructional facilitation. Although the writing tasks were focused within nursing contexts, they were written from the CEFR B1 descriptors and vetted by EFL writing experts in order to reflect appropriate scope of clarity, relevance, and transferability of writing to EFL contexts wider than nursing class and contextual learning. Therefore, although pedagogically situated, this study's intervention and associated criteria were focused on writing as a function of language rather than a specific area of discipline. Ethical protocols, including informed consent, were followed. Table 1 provides a summary of demographic information.

**Table 1**

*Demographic Details of the Participants.*

Variable		Frequency (N)	Percentage (%)
Gender	Male	29	49%
	Female	31	51%
Academic degree	BA	60	100%
Age	19-26	60	100%

### 3.2. Instrumentation

**3.2.1. Pretest and Posttest Writing Tasks.** In order to evaluate the development of students' writing, pretest and posttest tasks were adapted from *Career Paths: Nursing Student's Book* (Evans & Salcido, 2018) on topics related to health. Five EFL writing experts, each with ten years' experience of teaching English to returning adult learners in health-science majors, evaluated the writing task independently. The tasks were first piloted with six nursing learners in B1 level to ensure clarity and feasibility. The experts assessed it for clarity, applicability to nursing contexts, alignment with CEFR B1 writing descriptors, and appropriateness for intermediate learners. Each expert rated the writing task on a 5-point Likert scale and provided descriptive and/or qualitative comments. Using Pearson product-moment correlation coefficient ( $r = .91$ ) confirmed significant inter-rater reliability, and minor revisions were made to it to improve clarity and fit into appropriate contexts for nursing students. The final writing task was to write a descriptive essay of a minimum of 200 words in 30 minutes. The pretest prompting stated, "*The importance of personal hygiene in preventing illness.*" while the posttest prompt stated, "*The importance of daily hygiene habits in healthy lifestyle.*" The validated pretest-posttest tasks provided a sound basis for evaluating the effects of AI-DA synergy on nursing learner's academic writing progress.

**3.2.2. Semi-structured interview.** A semi-structured interview protocol was designed following established qualitative research standards and was initially piloted with a small group of university students to assess the clarity and relevance of the questions. Subsequently, semi-structured interviews were conducted with the AI-DA group to explore their perspectives on the integration of AI-assisted feedback and TMDA in the writing developmental process. To explore learners' attitudes and perceptions, the researcher asked questions such as: "*Which aspects of AI-DA feedback do you find most beneficial or challenging in improving your writing skills?*" and "*Has using AI tools with teacher's mediation increased your motivation in language learning? If so, how?*".

### 3.3. Procedures

The study employed a structured pretest–treatment–posttest design to investigate the impact of AI-assisted and TMDA on Iranian nursing learners' academic writing development. In the pretest phase, all participants—conveniently selected from the available pool of nursing students and subsequently randomly assigned to AI-DA, DA, or control groups—were initially asked to compose a descriptive essay on the topic "*The Importance of Personal Hygiene in Preventing Illness*" (minimum 200 words) within a predetermined time frame. Trained EFL teachers evaluated the essays using CEFR B1 descriptors, focusing on grammatical accuracy, lexical complexity, organizational structure, and overall clarity of expression. These scores served as baseline data for subsequent comparisons.

In the AI-DA group, learners received integrated writing mediation that combined TMDA with AI-generated feedback via ChatGPT. Over 16 sessions, each lasting 75 minutes, students completed writing tasks while receiving real-time, personalized support from both the teacher and ChatGPT. The mediation process was aligned with Poehner's (2005) ZPD-based framework, beginning with implicit prompts to assess learners' writing challenges and gradually shifting to explicit support as needed. ChatGPT provided academic sample sentences and sentence-level feedback on coherence, cohesion, lexical accuracy, and grammatical range. For example, when a learner wrote ungrammatical sentence like "*personal hygiene have an important effects of on our health,*" ChatGPT suggested "Consider checking the subject-verb agreement in this sentence," prompting the learner to self-correct. If learners failed to respond effectively to implicit cues, the teacher assessed and diagnosed their difficulties and mediated their writing process collaboratively alongside ChatGPT. When necessary, the level of mediation was gradually intensified to provide more explicit support. This adaptive approach aimed to scaffold learners from other-regulation to self-regulation (Poehner, 2008). At the conclusion of each session, learners submitted their written texts directly to the instructor. Figure 1 illustrates five distinct levels of interaction among AI, TMDA, and learners. Following the intervention, participants in the AI-DA group also participated in post-treatment interviews conducted in Persian to explore their perceptions of AI-assisted feedback and TMDA, and its influence on writing development.

**Figure 1.**  
*Five Levels of Interactions among AI, TMDA, and Learners*

Level 5 Autonomy	•Learners independently identify and resolve writing issues without ChatGPT support, demonstrating self-regulation.
Level 4 Semi-Autonomous	•Revision Learners revise with the help of implicit ChatGPT mediation.
Level 3 Dependent Correction	•Learners can detect and correct issues only when prompted by ChatGPT feedback and TMDA.
Level 2 Passive Recognition	•Learners can recognize issues when pointed out, but still require TMDA.
Level 1 No Responsiveness	•Learners are unable to recognize or resolve writing issues, even with explicit support from teacher and ChatGPT

Students in the DA group received TMDA based solely on Poehner's (2005) ZPD framework. Each 75-minute session involved predetermined prompts that progressed from implicit to explicit teacher support depending on individual learner needs. Initially, the teacher provided subtle cues to provoke independent problem-solving and critical thinking. If learners struggled to apply implicit feedback effectively, the mediation became increasingly explicit, offering direct instruction on grammatical accuracy, lexical choices, and organizational structure. Unlike the AI-DA group, no AI tools were used in this condition; all mediation was delivered by the teacher.

In contrast, the control group followed a conventional textbook-based EFL writing approach without any form of mediation. Participants engaged in 75-minute sessions focused on standard writing exercises, grammar instruction, and the teacher's feedback based on pre-designed materials. This group served as the baseline for comparison, representing traditional pedagogical practice in EFL writing instruction. All groups, received 16 sessions of 75 minutes each to ensure equal instructional time.

Following the intervention period, all participants completed a posttest essay titled "*The Importance of Daily Hygiene Habits in a Healthy Lifestyle*," under the same conditions as the pretest. The essays were evaluated using the same CEFR B1 descriptors to ensure consistency. To maintain objectivity, instructors involved in mediation did not participate in test administration or scoring. The combination of quantitative writing scores and qualitative interview data enabled a comprehensive assessment of the AI-DA model's impact on learners' writing proficiency and perceptions. It is worth noting that the instructor participating in this study had extensive experience in implementing DA and demonstrated a high level of proficiency in integrating ChatGPT into the academic writing process.

## 4. Results

The research utilized a mixed-method design to explore the effects of AI-DA synergy on nursing learners' writing. Quantitative data were examined in pretest-posttest comparisons using ANOVA, which was confirmed using the Shapiro-Wilk test for normality. AI-DA students' perceptions of the integrated use of ChatGPT feedback and TMDA were thematically analyzed using NVivo 15.

### 4.1. Writing Skill Development

As demonstrated in Table 2, the pretest scores for writing skills showed no significant differences among the three groups, indicating comparable baseline writing abilities (AI-DA,  $M = 13.75$ ,  $SD = 1.44$ ; DA,  $M = 13.57$ ,  $SD = 1.52$ ; Control,  $M = 13.62$ ,  $SD = 1.97$ ). However, posttest results revealed significant improvements in the AI-DA group ( $M = 17.35$ ,  $SD = 1.23$ ) compared to the DA group ( $M = 14.71$ ,  $SD = 1.52$ ) and the control group ( $M = 13.10$ ,  $SD = 1.97$ ).

**Table 2***Descriptive Statistics of the Experimental and Control Groups for Writing Pre and Post Test Results.*

Group	N	Mean	Std. Deviation	Skewness Ratio	Kurtosis Ratio
Writing AI-DA group (pre)	20	13.7500	1.37171	-.450	-.772
Writing DA group (pre)	20	13.5714	1.63007	-.141	-1.415
Writing control group (pre)	20	13.6190	1.62715	-.543	-.339
Writing AI-DA group (post)	20	17.3500	1.22582	-.285	-1.047
Writing DA group (post)	20	14.7143	1.52128	-.217	-.667
Writing control group (post)	20	13.0952	1.97243	.373	-.911

Note. Pre = Pretest; Post=Posttest

The gain scores, calculated as the difference between posttest and pretest scores, further highlight these differences. The AI-DA group achieved the highest gain ( $M = 3.60$ ,  $SD = 1.12$ ), followed by the DA group ( $M = 1.14$ ,  $SD = 0.88$ ), while the control group showed a slight decline ( $M = -0.52$ ,  $SD = 0.88$ ). As shown in Table 3, one-way ANOVA confirmed that these differences were statistically significant,  $F(2, 59) = 98.61$ ,  $p < .001$ .

**Table 3***The Results of ANOVA Test of the Students' Writing Posttest Scores*

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	175.858	2	87.929	98.610	.000
Within Groups	52.610	59	.892		
Total	228.468	61			

As illustrated in Table 4, Post hoc comparisons indicated significant differences between all pairs of groups ( $p < .05$ ), confirming that the AI-DA intervention was more effective than both the DA and no intervention.

**Table 4***Post-hoc Analysis of Mean Differences on Writing Posttest*

Writing Gain						
(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	95% Confidence Interval Upper Bound
AI-DA	DA	2.45714*	.29503	.000	1.7162	3.1980
	Control	4.12381*	.29503	.000	3.3829	4.8647
DA	AI-DA	-2.45714*	.29503	.000	-3.1980	-1.7162
	Control	1.66667*	.29141	.000	.9349	2.3985
Control	AI-DA	-4.12381*	.29503	.000	-4.8647	-3.3829
	DA	-1.66667*	.29141	.000	-2.3985	-.9349

Note. The mean difference is significant at the 0.05 level.

The findings underscore the pedagogical value of integrating ChatGPT with TMDA\_ as AI-DA synergy\_ in academic writing instruction. Learners in the AI-DA group demonstrated the most significant writing improvements, outperforming peers in both the DA-only and control groups.

#### 4.2. Students' Perception

Transcripts were analyzed using thematic analysis in NVivo version 15. Thematic analysis of interview transcripts identified key themes in all AI-DA students' perceptions of the integration of ChatGPT feedback and TMDA, highlighting views on writing improvement. Excerpts were selected

based on their representativeness, clarity, and depth of insight, ensuring that each quote illustrated a distinct thematic point while preserving the diversity of learner experiences. A brief thematic analysis of students' perceptions regarding the AI-DA model is presented in Table 5.

**4.2.1. The Necessity of Teacher's Mediation along with ChatGPT.** Thematic analysis revealed that students valued the combination of ChatGPT and TMDA as a complementary support system for writing development. While ChatGPT offered instant suggestion, teacher input provided deeper clarification, reducing anxiety and enhancing confidence. This dual mediation fostered a balanced learning environment where students felt both empowered and reassured (Excerpt 1).

*Excerpt 1. Initially, I accepted ChatGPT's suggestions without much thought. However, I soon noticed that some of its recommendations were occasionally unusual. As a result, I started paying attention to my teacher's feedback simultaneously, carefully evaluating whether ChatGPT's suggestions truly aligned with my writing before incorporating them. It was motivating and helpful. I appreciated receiving feedback from a human instructor on my writing.*

**Table 5**  
**The Brief Thematic Analysis of AI-DA Students' Perceptions**

Theme	Summarized Interpretive Insight	Representative Excerpt
Teacher Mediation with ChatGPT	Students valued the combination of AI and teacher feedback, which provided clarity, reduced anxiety, and built confidence.	<i>"I started paying attention to my teacher's feedback... I appreciated receiving feedback from a human instructor."</i>
Emotional Engagement & Motivation	Dual mediation fostered emotional safety, increased motivation, and deeper engagement with writing tasks.	<i>"This motivated me to write in my classes. I was interested in my writing class."</i>
Writing Skill Development	Learners improved in sentence structure, paraphrasing, and cohesion, while teacher support reinforced confidence.	<i>"ChatGPT was beneficial... The presence of my teacher gave me confidence."</i>
Limitations of AI Assistance	Students became more critical of AI feedback, learning to balance its suggestions with contextual judgment.	<i>"Sometimes it did not understand what I had in mind... My teacher implicitly helped me refine my draft."</i>
Skepticism & Trust Negotiation	Initial distrust of AI shifted toward balanced use, guided by teacher mediation; technical barriers also impacted access.	<i>"I didn't trust ChatGPT's responses... ChatGPT was blocked... A high-speed internet connection was essential."</i>

**4.2.2. Emotional Engagement and Motivational Growth.** The second set of themes emphasized students' emotional involvement and increased motivation, which supported their writing development. Teacher mediation alongside ChatGPT boosted creativity and enjoyment, helping students feel less afraid of making mistakes. This led to greater confidence, deeper idea exploration, and stronger engagement in writing tasks. The positive reinforcement enhanced both their skills and enthusiasm for learning (Excerpt 2).

*Excerpt 2: ChatGPT, along with my teacher's feedback, assisted me in overcoming confusion and difficulties in using appropriate linking phrases to create a smoother connection between my writing ideas. This motivated me to write in my classes. I was interested in my writing class.*

**4.2.3. Development of Writing Skills.** The students' development of writing skills, a third group of themes, was closely tied to improvements in sentence structure. As students refined their use of linking phrases and transitions, their writing became more coherent and fluid. Additionally, their enhanced sentence construction and paraphrasing abilities contributed to greater clarity and precision, fostering both technical proficiency and self-assurance in their academic writing (Excerpt 3).

*Excerpt 3: I found ChatGPT beneficial for enhancing my paraphrasing and sentence structure. However, it made me lazy and overly dependent on it. I felt good when I was in my language class. The presence of my teacher gave me confidence in whether I was right or wrong.*

**4.2.4. The Limitations of AI Assistance.** The limitations of AI assistance, as a fourth group of themes, led students to adopt a more critical approach to ChatGPT's recommendations. While AI-generated suggestions occasionally lacked contextual relevance, this challenge encouraged learners to evaluate outputs more carefully, refining their judgment and decision-making in academic writing. As a result, they developed a more discerning perspective, balancing AI-generated insights with their own analytical skills (Excerpt 4).

*Excerpt 4: Through ChatGPT's writing mediation, I was able to improve my use of transitions, ensuring a more seamless and cohesive flow in my writing. However, sometimes it did not understand what I had in mind. Perhaps my prompts were not correct. My teacher implicitly helped me refine my draft. In this way, I liked having my writing graded.*

**4.2.5. Skepticism and Trust Negotiation with ChatGPT.** The final theme centered on students' initial skepticism and hesitation toward ChatGPT's content. Doubts about its credibility made them cautious in trusting its suggestions. With teachers serving as mediators, offering assistance and guidance, students gradually adopted a more critical and balanced approach—learning to assess AI-generated input thoughtfully while relying on structured human support (Excerpt 5).

*Excerpt 5: I was confused because I didn't trust ChatGPT's responses. I often asked my teacher. Eventually, I was able to use it. I wanted more opportunities to practice writing in my coursework.*

Moreover, students faced technical barriers due to limited access and VPN requirements, which hindered seamless interaction with ChatGPT and affected their learning experience. For example one of the AI-DA participants argued that *ChatGPT was blocked... A high-speed internet connection was essential.*

## 5. Discussion

This mixed-method study set out to examine the impact of integrating AI-generated feedback with TMDA—a pedagogical synergy referred to as AI-DA—on the academic writing development of Iranian nursing students. It also underscored the importance of understanding the AI-DA students' perceptions of this integrated approach, recognizing that learner agency and emotional engagement are central to sustainable writing improvement.

To address these aims, the first research question explored writing performance across AI-DA, DA-only, and control groups. The findings revealed that students in the AI-DA group significantly outperformed those in both the DA and control groups, demonstrating the effectiveness of combining AI feedback with responsive human mediation in students' academic writing improvement. These results align with recent studies highlighting the benefits of AI-enhanced writing instruction (Fathi & Rahimi, 2024; Su et al., 2023; Hwang et al., 2023), yet they extend the literature by embedding AI feedback within a theoretically grounded DA framework informed by SCT (Vygotsky, 1978) and Poehner's DA principles (2005, 2008).

By situating AI within TMDA, this study responds to critiques that AI lacks diagnostic depth and pedagogical grounding. Specifically, it addresses Alonzo et al.'s (2024) concern that AI's role in English language assessment remains theoretically underdeveloped and methodologically fragmented. The AI-DA model offers a pedagogically informed framework for intelligent mediation in writing development, contrasting sharply with studies that employed AI as a stand-alone tool (Fitria, 2023; Xu et al., 2023). TMDA contextualizes AI feedback, supports ZPD-based mediation (Vygotsky, 1978), and fosters learner self-regulation (Poehner, 2008). Moreover, it responds to practical limitations in DA implementation—such as time constraints and scalability (Faryabi et al., 2024)—by automating lower-level feedback and reserving teacher input for conceptual mediation. Within the Iranian EFL context, characterized by large class sizes, limited individualized feedback, and exam-driven instruction, the AI-DA model offers a scalable and pedagogically sound alternative. It encourages educators to shift from evaluators to facilitators of AI-supported writing development.

Complementing these quantitative findings, the second research question explored students' perceptions of AI-DA integration in their writing development. Thematic analysis of semi-structured

interviews illuminated learners' positive views of the AI-DA model, emphasizing emotional engagement, skill development, and the indispensable role of teacher mediation. These insights underscore the transformative potential of assessment when AI is pedagogically embedded within a dynamic, human-mediated framework. Learners reported increased motivation and reduced anxiety when teacher support complemented AI input—an affective dimension often missing in AI-only models (An et al., 2023; Jeon, 2024). In terms of skill development, students noted improvements in sentence construction, paraphrasing, and cohesion. These perceptions mirror the quantitative gains and align with research on AI's role in enhancing technical proficiency (Asadi et al., 2025; Su et al., 2023). At the same time, some learners expressed concern about overreliance on AI, echoing warnings from Niloy et al. (2024) and Bender (2024) that excessive dependence may inhibit creativity and critical thinking. Importantly, students described a shift from passive acceptance of AI feedback to active evaluation and revision—a metacognitive evolution supported by teacher mediation. This reflects the reciprocity typology in AI-assisted learning (Fathi & Rahimi, 2024) and underscores the developmental nature of assessment when AI is pedagogically framed.

Taken together, the integration of quantitative and qualitative findings reinforces the pedagogical efficacy of AI-DA synergy. Statistically significant improvements in writing performance were mirrored by learners' self-reported gains in cohesion, sentence structure, and lexical accuracy. Emotional engagement and motivational growth—captured through interviews—offer explanatory depth to the cognitive outcomes observed. This convergence exemplifies the dual function of TMDA as both an assessment and instructional tool (Poehner & Yu, 2022; Shrestha, 2020), while addressing scalability concerns by demonstrating how AI can support—but not replace—human mediation (Bodaubekov et al., 2025). The AI-DA model thus offers a balanced framework that preserves the depth of DA while enhancing its reach and efficiency (Chen et al., 2025; Chappelle et al., 2024).

Furthermore, this study contributes to the literature by addressing several limitations of AI in EFL academic writing assessment. First, AI lacks the ability to assess learners' conceptual understanding (Lu et al., 2024), whereas TMDA compensates through responsive, ZPD-based mediation (Poehner, 2008; Vygotsky, 1978). Second, AI cannot provide affective support, while teacher mediation fosters emotional safety and motivation (Jeon, 2024; Wang et al., 2024). Third, AI may inhibit originality and critical thinking; the current model encourages metacognitive growth and critical engagement (Niloy et al., 2024; Perwaiz et al., 2025). Finally, although traditional DA is resource-intensive, AI-DA offers a scalable, efficient alternative without sacrificing pedagogical depth (Faryabi et al., 2024). By integrating AI within a theoretically grounded assessment framework, this study offers a replicable model that enhances both the cognitive and affective dimensions of EFL writing development—particularly within the Iranian educational landscape.

In sum, these findings contribute to the evolving discourse on AI in education, suggesting that its optimal use lies not in replacing teacher mediation but in amplifying it. As Asadi et al. (2025) and Bodaubekov et al. (2025) argue, AI should complement teacher input to preserve creativity, engagement, and ethical integrity. The AI-DA model exemplifies this complementation, offering a blueprint for future instructional design that integrates technological innovation with sociocultural pedagogy.

## 6. Conclusion

The present study set out to examine the impact of integrating AI-generated feedback with TMDA—a pedagogical synergy referred to as AI-DA—on the academic writing development of Iranian nursing students. The findings revealed that students in the AI-DA group significantly outperformed those in both the DA and control groups, demonstrating the effectiveness of combining automated feedback with responsive human mediation. The qualitative data further illuminated students' evolving perceptions, highlighting their appreciation for the complementary roles of AI and teacher guidance, while also acknowledging the limitations and challenges associated with AI use in educational contexts.

Crucially, the study affirms the dual function of TMDA as both an assessment mechanism and an instructional strategy. Within the AI-DA model, TMDA served to diagnose learners' developmental needs and provide scaffolded support through graduated mediation, while ChatGPT offered immediate feedback that reinforced linguistic accuracy and encouraged revision. This convergence of assessment and instruction within a sociocultural framework aligns with Vygotsky's (1978) notion of the ZPD and

Poehner's (2005, 2008) DA principles, wherein mediation is tailored to learners' responsiveness and fosters progression from other-regulation to self-regulation. The AI-DA model thus exemplifies a dialogic and developmental approach to writing instruction, where technology amplifies human mediation rather than replacing it.

The implications of these findings are multifaceted and relevant to both instructional practice and curriculum design. First, the study underscores the pedagogical value of integrating AI tools like ChatGPT into writing instruction, not as substitutes for teachers, but as scalable supports that enhance feedback quality and learner autonomy. When paired with TMDA, AI feedback becomes more meaningful, as teachers can assess students' needs and contextualize automated suggestions to align with learners' cognitive and emotional needs. This synergy promotes deeper engagement with writing tasks and encourages learners to critically evaluate feedback, thereby fostering metacognitive awareness and independent learning. Furthermore, the AI-DA model offers a promising framework for AI-assisted assessment, allowing educators to monitor learners' responsiveness and progress in real time while adapting mediation accordingly.

Despite its contributions, there are some limitations in this study due to technical barriers such as VPN requirements and inconsistent internet access, which posed challenges to seamless interaction with AI tools, potentially affecting the consistency of the intervention. The duration of the study was also relatively short, and while immediate gains were observed, the long-term effects of AI-DA on writing development remain unexplored. Moreover, given the rapid evolution of AI technologies, the capabilities of tools like ChatGPT are likely to change, necessitating ongoing evaluation and pedagogical adaptation. Additionally, the participants were nursing students enrolled in a university EFL course, which may limit the generalizability of the findings to other disciplines or learner populations. To build on the current findings, future research should explore long-term impacts, cross-context applicability, emotional and cognitive effects, teacher training, and ethical considerations to ensure inclusive and effective AI integration in education. In particular, further investigation is needed into how AI can be systematically embedded within formative and summative assessment frameworks, ensuring that its use aligns with pedagogical goals, supports learner agency, and maintains validity and fairness across diverse educational contexts. Finally, future research should consider including a more diverse sample of learners across academic fields to better understand the broader applicability of AI-assisted writing interventions.

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The authors have no conflict of interest.

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### **Declaration of Applying AI**

AI tools were used exclusively for proofreading to improve readability and language quality. All enhancements were made under strict human supervision to avoid errors, omissions, or bias.

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