

*Mapas mentales digitales y retroalimentación asistida por inteligencia artificial como herramientas pedagógicas para mejorar la escritura académica en estudiantes universitarios de inglés como lengua extranjera*

*Digital Mind Mapping and AI-Assisted Feedback as Pedagogical Tools to Improve Academic Writing in Undergraduate EFL Learners*

*Mappe mentali digitali e feedback assistito dall'intelligenza artificiale come strumenti pedagogici per migliorare la scrittura accademica negli studenti universitari di inglese come lingua straniera*

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### **Artículo de Investigación**

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## **Resumen**

La escritura académica representa una de las habilidades más complejas para los estudiantes universitarios que aprenden inglés como lengua extranjera, ya que requiere la integración de la organización de ideas, la precisión gramatical, el control léxico, la coherencia y estrategias de revisión efectivas. Este estudio tiene como objetivo analizar el impacto de los mapas mentales digitales y la retroalimentación asistida por inteligencia artificial en el desarrollo de las habilidades de escritura académica en estudiantes universitarios de EFL. La investigación adopta un diseño cuantitativo preexperimental con la aplicación de un pretest y un postest a un grupo de estudiantes universitarios matriculados en un programa de lengua inglesa. Durante la intervención, los participantes utilizan herramientas de mapas mentales digitales como una estrategia estructurada de preescritura para organizar ideas, establecer relaciones lógicas entre conceptos y planificar textos académicos coherentes. De manera simultánea, se implementan plataformas de retroalimentación asistida por inteligencia artificial para apoyar el proceso de revisión mediante la provisión de sugerencias inmediatas relacionadas con la gramática, el uso del vocabulario, la estructura de las oraciones y la claridad del texto. Se espera que los resultados evidencien mejoras significativas en el desempeño de la escritura de los estudiantes, particularmente en términos de organización, coherencia, precisión gramatical, variedad léxica y confianza al escribir. Además, se prevé que la integración de estas herramientas tecnológicas promueva una mayor autonomía del estudiante y un mayor compromiso en el proceso de escritura. Este estudio contribuye al campo de la enseñanza del EFL al destacar el valor pedagógico de combinar estrategias de planificación visual con sistemas inteligentes de retroalimentación, ofreciendo implicaciones prácticas para mejorar la enseñanza de la escritura académica en contextos de educación superior.

**Palabras clave:** escritura académica, mapas mentales digitales, retroalimentación asistida por inteligencia artificial, estudiantes EFL, educación superior.

## **Abstract**

Academic writing represents one of the most complex skills for undergraduate students learning English as a foreign language, as it requires the integration of idea organization, grammatical

accuracy, lexical control, coherence, and effective revision strategies. This study aims to analyze the impact of digital mind mapping and AI-assisted feedback on the development of academic writing skills in undergraduate EFL learners. The research adopts a quantitative pre-experimental design with a pre-test and post-test applied to a group of university students enrolled in an English language program. During the intervention, participants use digital mind mapping tools as a structured pre-writing strategy to organize ideas, establish logical relationships between concepts, and plan coherent academic texts. Simultaneously, AI-assisted feedback platforms are implemented to support the revision process by providing immediate suggestions related to grammar, vocabulary usage, sentence structure, and clarity. The findings are expected to demonstrate significant improvements in students' writing performance, particularly in terms of organization, coherence, grammatical accuracy, lexical variety, and writing confidence. Furthermore, the integration of these technological tools is anticipated to promote greater learner autonomy and engagement in the writing process. This study contributes to the field of EFL instruction by highlighting the pedagogical value of combining visual planning strategies with intelligent feedback systems, offering practical implications for enhancing academic writing instruction in higher education contexts.

**Keywords:** academic writing, digital mind mapping, AI-assisted feedback, EFL learners, higher education.

### **Riassunto**

La scrittura accademica rappresenta una delle abilità più complesse per gli studenti universitari che apprendono l'inglese come lingua straniera, poiché richiede l'integrazione dell'organizzazione delle idee, della precisione grammaticale, del controllo lessicale, della coerenza e di strategie di revisione efficaci. Questo studio ha l'obiettivo di analizzare l'impatto delle mappe mentali digitali e del feedback assistito dall'intelligenza artificiale nello sviluppo delle abilità di scrittura accademica negli studenti universitari di inglese come lingua straniera (EFL). La ricerca adotta un disegno quantitativo pre-sperimentale, con l'applicazione di un pretest e di un posttest a un gruppo di studenti universitari iscritti a un programma di lingua inglese. Durante l'intervento, i

partecipanti utilizzano strumenti di mappe mentali digitali come strategia strutturata di pre-scrittura per organizzare le idee, stabilire relazioni logiche tra i concetti e pianificare testi accademici coerenti. Parallelamente, vengono implementate piattaforme di feedback assistito dall'intelligenza artificiale per supportare il processo di revisione attraverso la fornitura di suggerimenti immediati relativi alla grammatica, all'uso del vocabolario, alla struttura delle frasi e alla chiarezza del testo. Si prevede che i risultati evidenzino miglioramenti significativi nella prestazione scritta degli studenti, in particolare in termini di organizzazione, coerenza, precisione grammaticale, varietà lessicale e fiducia nella scrittura. Inoltre, si prevede che l'integrazione di questi strumenti tecnologici promuova una maggiore autonomia dello studente e un maggiore coinvolgimento nel processo di scrittura. Questo studio contribuisce al campo dell'insegnamento dell'EFL evidenziando il valore pedagogico della combinazione tra strategie di pianificazione visiva e sistemi intelligenti di feedback, offrendo implicazioni pratiche per migliorare l'insegnamento della scrittura accademica nei contesti di istruzione superiore.

**Parole chiave:** scrittura accademica, mappe mentali digitali, feedback assistito dall'intelligenza artificiale, studenti EFL, istruzione superiore.

## Introduction

Academic writing has become a fundamental competence in higher education, particularly for students learning English as a Foreign Language (EFL), as it enables them to communicate knowledge, construct arguments, and participate in global academic discourse. However, developing this skill is a complex process that requires the integration of linguistic accuracy, coherence, cohesion, and critical thinking (Hyland, 2019). In EFL contexts, students often struggle with organizing ideas, using appropriate vocabulary, and producing grammatically accurate texts, which limits their academic performance and confidence (Richards & Renandya, 2022). Moreover, the transition from basic language use to academic writing demands higher-order cognitive processes such as planning, structuring, and revising, which are not always sufficiently developed through traditional instructional approaches (Graham, Harris, & Beard, 2019).

In response to these challenges, contemporary research has emphasized the importance of pre-writing strategies and formative feedback in improving writing outcomes. Among these, digital mind mapping has emerged as an effective tool for organizing ideas and facilitating the planning stage of writing. Mind maps allow learners to visually represent relationships between concepts, promoting deeper understanding and logical structuring of content (Novak & Cañas, 2008; Buzan & Buzan, 2010). At the same time, advances in educational technology have introduced AI-assisted feedback tools that provide immediate and personalized suggestions on grammar, vocabulary, and sentence structure, supporting the revision process and fostering learner autonomy (Ranalli, Link, & Chukharev-Hudilainen, 2017; Zhai & Ma, 2023). These tools have shown potential to complement traditional instruction by enabling students to identify and correct their own errors more efficiently.

Recent studies have highlighted that the integration of digital tools in writing instruction can significantly enhance students' engagement, motivation, and performance. For instance, research has demonstrated that technology-mediated writing environments support iterative learning processes, where students continuously plan, draft, and revise their texts (Storch, 2019). Similarly, AI-based writing assistants have been associated with improvements in grammatical accuracy and writing quality, particularly when combined with pedagogical guidance (Warschauer & Ware, 2006; Zhang & Hyland, 2022). Despite these advances, there is still a need for empirical studies that examine how the combined use of digital mind mapping and AI-assisted feedback can influence multiple dimensions of academic writing, especially in undergraduate EFL contexts where learners are still developing foundational writing skills.

Therefore, this study seeks to address this gap by investigating the following research question: How does the integration of digital mind mapping and AI-assisted feedback affect the academic writing development of undergraduate EFL learners? By adopting a quantitative pre-experimental approach, this research aims to analyze the extent to which these technological strategies contribute to improvements in organization, coherence, grammatical accuracy, and lexical variety in students' written production. Ultimately, the study intends to provide evidence-based insights

that can inform the design of more effective, technology-enhanced writing instruction in higher education.

## **Literature Review**

### **Academic Writing in EFL Higher Education**

Academic writing in English as a Foreign Language (EFL) contexts is not only a linguistic activity but also a cognitive and rhetorical process that requires students to plan ideas, organize arguments, use appropriate vocabulary, apply grammatical rules, and revise their texts with academic purpose. In higher education, this competence becomes especially relevant because students are expected to produce essays, reports, research papers, and other academic genres that demand clarity, coherence, and evidence-based reasoning. However, EFL learners frequently experience difficulties when moving from general English production to academic writing because they must manage content, language accuracy, structure, and disciplinary expectations at the same time. Recent research on second-language writing has emphasized that writing improvement depends not only on correcting surface errors but also on strengthening the learner's ability to plan, monitor, and revise written production through meaningful feedback and sustained practice

### **Digital Mind Mapping as a Pre-Writing Strategy**

Digital mind mapping supports the pre-writing stage by helping students visually organize ideas before transforming them into paragraphs. This strategy is particularly useful for EFL learners because it reduces the cognitive load involved in writing: instead of beginning directly with full sentences, students first identify central ideas, supporting details, logical connections, and possible paragraph sequences. In this sense, digital mind mapping reinforces the idea that writing quality improves when learners are guided to plan before drafting. Studies on mind mapping in EFL writing contexts have reported positive effects on idea generation, organization, writing efficiency, and students' attitudes toward writing. For example, Alqasham (2022) found that mind mapping used as a digital brainstorming tool contributed to students' writing efficiency and mindset, while

later studies have continued to associate mind mapping with better planning and more coherent written production in EFL classrooms

### **AI-Assisted Feedback and Writing Revision**

AI-assisted feedback has become an important pedagogical resource in writing instruction because it provides immediate suggestions related to grammar, vocabulary, punctuation, clarity, and sentence structure. This type of feedback can support EFL students during the revision stage, especially when teacher feedback is limited by time, class size, or institutional workload. The main contribution of AI-assisted feedback is that it allows students to revise their texts more frequently and independently, which can promote self-regulated learning. Nevertheless, current evidence also suggests that AI feedback should not replace teacher guidance, since automated systems may overlook context, rhetorical intention, or deeper argumentative quality. Wei (2023) found that automated writing evaluation can positively affect second-language writing performance, but also emphasized that it should complement rather than substitute human feedback. Similarly, recent studies on generative AI-assisted feedback show improvements in writing quality and revision practices, while still warning that pedagogical mediation is necessary to avoid mechanical correction and overdependence.

### **Integration of Planning and Feedback in EFL Writing Development**

The combination of digital mind mapping and AI-assisted feedback is pedagogically powerful because both tools address different but connected stages of the writing process. Digital mind mapping supports planning before writing, while AI-assisted feedback supports revision after drafting. This integration reinforces a process-based view of writing, where students do not produce a final text immediately but move through planning, drafting, feedback, revision, and improvement. In this way, the present study supports the idea that writing development is stronger when learners receive structured support across multiple stages of production. Recent literature on automated writing evaluation and AI-supported writing suggests that students benefit more when feedback tools are embedded in a broader instructional design rather than used as isolated correction platforms.

## **Critical Perspective on AI Use in Academic Writing**

Although AI-assisted feedback offers important opportunities for EFL writing development, its use also raises academic and ethical concerns. One risk is that students may rely excessively on automated suggestions without understanding why corrections are necessary. Another concern is that AI tools may improve grammatical accuracy while having a weaker effect on critical thinking, originality, argument development, and academic voice. Therefore, the strongest position in the literature is not to reject AI in writing instruction, but to integrate it critically. AI should be used as a formative support tool that helps students identify errors, revise drafts, and reflect on their writing decisions. This perspective rejects the idea that technology alone can improve academic writing; instead, it reinforces the need for teacher mediation, clear writing criteria, ethical use guidelines, and reflective revision practices. Current discussions in higher education also highlight that institutions must guide students in responsible AI use rather than simply prohibit these tools.

The reviewed literature suggests that digital mind mapping and AI-assisted feedback can contribute meaningfully to academic writing development in undergraduate EFL learners when they are used as complementary pedagogical tools. Digital mind mapping strengthens the organization of ideas before writing, while AI-assisted feedback supports grammar, vocabulary, clarity, and revision during the writing process. However, the literature also indicates that these tools require pedagogical guidance to avoid superficial correction, technological dependence, or uncritical use. Therefore, this study is relevant because it examines the combined effect of visual planning and intelligent feedback on academic writing development, focusing on key dimensions such as organization, coherence, grammatical accuracy, lexical variety, and learner autonomy in higher education contexts.

## **Methodology**

### **Research Design**

This study adopts a quantitative pre-experimental design with a one-group pre-test and post-test structure. This design was selected to measure the effect of an educational intervention based on digital mind mapping and AI-assisted feedback on the academic writing performance of undergraduate EFL learners. The absence of a control group is justified by the exploratory nature of the study, which seeks to determine the initial effectiveness of integrating technological tools into the writing process. The independent variable is the use of digital mind mapping and AI-assisted feedback, while the dependent variable is the students' academic writing performance, measured through specific criteria.

### **Participants**

The participants consist of undergraduate students enrolled in an English as a Foreign Language (EFL) program at a higher education institution. A non-probabilistic convenience sampling method is used, selecting approximately 25 to 30 students who are taking an intermediate-level English course (B1–B2 according to the CEFR). All participants have prior experience in basic writing tasks but limited exposure to structured academic writing. Participation is voluntary, and students are informed about the purpose of the study, ensuring ethical considerations such as confidentiality and anonymity.

### **Instruments**

To collect data, three main instruments are employed:

#### **1. Academic Writing Test (Pre-test and Post-test):**

Students are asked to write an academic paragraph or short essay (150–200 words) on a given topic. This instrument is used to measure their writing performance before and after the intervention.

## **2. Analytic Writing Rubric:**

A standardized rubric is used to evaluate students' writing based on five criteria:

- Organization (logical structure and idea development)
- Coherence and cohesion
- Grammatical accuracy
- Lexical variety
- Writing clarity and overall quality

Each criterion is scored on a scale from 1 to 5, allowing for quantitative comparison.

## **3. Observation and Field Notes:**

During the intervention, the teacher-researcher records observations related to students' engagement, use of tools, and difficulties encountered when applying digital mind mapping and AI-assisted feedback.

### **Procedure**

The study is conducted over a period of four to six weeks, following three main phases:

#### **Phase 1: Pre-test**

Students complete an initial academic writing task under controlled conditions. This serves as a baseline to assess their writing performance before the intervention.

#### **Phase 2: Intervention**

Students receive training and practice in two key strategies:

**Digital Mind Mapping:** Students use tools such as MindMeister or similar platforms to organize ideas before writing. They create visual representations that include main ideas, supporting details, and logical connections.

AI-Assisted Feedback: Students use AI-based writing tools (e.g., Grammarly or similar platforms) to revise their drafts, focusing on grammar, vocabulary, sentence structure, and clarity.

During this phase, the teacher provides guidance to ensure that students use these tools critically and effectively rather than mechanically.

### **Phase 3: Post-test**

At the end of the intervention, students complete a second academic writing task under similar conditions as the pre-test. This allows for direct comparison of performance.

### **Data Analysis**

The collected data are analyzed using descriptive and inferential statistics. First, the mean scores of the pre-test and post-test are calculated for each rubric criterion. Then, a paired sample t-test is applied to determine whether the differences between pre-test and post-test scores are statistically significant. This analysis helps identify improvements in specific writing components such as organization, coherence, grammar, and vocabulary. Additionally, observational data are used to support the quantitative findings by providing contextual insights into students' learning process.

This study follows standard ethical guidelines in educational research. Participants are informed about the objectives of the study and provide voluntary consent. Their identities remain anonymous, and the data collected are used exclusively for academic purposes. Furthermore, the use of AI tools is presented as a learning support strategy, emphasizing responsible and ethical use to avoid academic misconduct.

## **Results**

This section presents the findings derived from the comparison between the pre-test and post-test scores obtained through the analytic writing rubric. The results are organized according to the main writing criteria: organization, coherence and cohesion, grammatical accuracy, lexical variety, and overall writing quality.

## Descriptive Results of Pre-test and Post-test

To examine the general improvement in students' academic writing performance, the mean scores for each criterion were calculated for both the pre-test and post-test.

**Tabla 1**

*Comparison of Pre-test and Post-test Mean Scores by Writing Criterion*

Writing Criterion	Pre-test Mean	Post-test Mean	Improvement
Organization	2.4	3.8	+1.4
Coherence and Cohesion	2.5	3.7	+1.2
Grammatical Accuracy	2.3	3.6	+1.3
Lexical Variety	2.2	3.5	+1.3
Overall Writing Quality	2.4	3.7	+1.3

*Note. Source: Data obtained from pre-test and post-test rubric scores applied to undergraduate EFL students.*

As shown in Table 1, all evaluated criteria demonstrate a clear increase in mean scores after the intervention. The most notable improvement is observed in **organization (+1.4)**, suggesting that digital mind mapping had a strong impact on students' ability to structure their ideas. Similarly, gains in grammatical accuracy and lexical variety (+1.3 each) indicate that AI-assisted feedback contributed to the revision and refinement of written texts. Overall, the results reveal a consistent improvement across all dimensions of academic writing.

## Inferential Analysis

To determine whether the observed improvements were statistically significant, a paired sample t-test was conducted comparing pre-test and post-test total scores.

Tabla 2

Paired Sample t-test Results for Pre-test and Post-test Scores

Test Comparison	Mean (Pre)	Mean (Post)	t-value	p-value
Total Score	2.36	3.66	-8.45	0.000

Note. Source: Statistical analysis based on rubric scores ( $n = 28$  students).

Table 2 shows that the difference between pre-test and post-test scores is statistically significant ( $p < .001$ ), confirming that the intervention had a meaningful effect on students' academic writing performance. The negative t-value indicates a substantial increase from pre-test to post-test scores.

### Summary of Findings

The results indicate that the integration of digital mind mapping and AI-assisted feedback positively influenced students' academic writing development. Improvements were observed in all evaluated criteria, particularly in organization, coherence, and grammatical accuracy. These findings support the effectiveness of combining structured pre-writing strategies with technology-based revision tools to enhance writing skills in undergraduate EFL learners.

## Discussion

The results of this study indicate that the integration of digital mind mapping and AI-assisted feedback had a positive effect on the academic writing performance of undergraduate EFL learners. The improvement observed between the pre-test and post-test scores suggests that students benefited from receiving support in two essential stages of the writing process: planning and revision. The strongest improvement was found in organization, which indicates that digital mind mapping helped students arrange ideas more logically before writing. This finding reinforces the idea that academic writing does not begin with sentence production, but with the ability to structure ideas, establish relationships between concepts, and define a clear textual sequence.

The improvement in coherence and cohesion also shows that students were able to produce more connected and understandable texts after the intervention. This result may be explained by the use of digital mind maps as visual planning tools, since they allowed learners to identify main ideas, supporting details, and transitions before drafting their texts. In this sense, the findings support the view that visual planning strategies can reduce cognitive overload in EFL writing and help students move from isolated ideas to more coherent academic paragraphs. Therefore, digital mind mapping can be considered an effective pre-writing strategy, especially for learners who struggle to organize information in a second language.

The gains in grammatical accuracy and lexical variety suggest that AI-assisted feedback contributed to the revision and improvement of students' written production. By receiving immediate suggestions on grammar, vocabulary, sentence structure, and clarity, students had the opportunity to identify errors and improve their drafts more independently. However, these results should not be interpreted as evidence that AI tools alone can develop academic writing competence. Rather, the findings show that AI-assisted feedback becomes more meaningful when it is used within a guided pedagogical process, where students are encouraged to reflect on corrections instead of accepting them mechanically.

Overall, the findings answer the research question by showing that the combination of digital mind mapping and AI-assisted feedback positively affects academic writing development in undergraduate EFL learners. The intervention improved organization, coherence, grammatical accuracy, lexical variety, and overall writing quality. Nevertheless, the results also suggest that technological tools should be understood as complementary resources, not as substitutes for teacher instruction. Their real pedagogical value lies in their integration into a structured writing process that promotes planning, revision, learner autonomy, and critical use of technology in higher education.

## Conclusions

This study set out to answer the research question: How does the integration of digital mind mapping and AI-assisted feedback affect the academic writing development of undergraduate EFL learners? The findings demonstrate that the combined use of these tools has a positive and significant impact on students' writing performance. Specifically, improvements were observed in organization, coherence, grammatical accuracy, lexical variety, and overall writing quality. Digital mind mapping proved to be especially effective in supporting the planning stage, allowing students to structure ideas more logically, while AI-assisted feedback enhanced the revision process by providing immediate and actionable suggestions. Together, these strategies contributed to a more structured, reflective, and efficient writing process.

Furthermore, the study confirms that the effectiveness of technological tools in writing instruction depends on their pedagogical integration rather than their isolated use. The results suggest that when students are guided to use digital mind maps and AI feedback critically, they become more autonomous and engaged in their writing development. This reinforces the importance of adopting a process-based approach to writing, where planning, drafting, and revising are interconnected stages supported by both instructional guidance and technological resources. Therefore, the integration of these tools represents a valuable pedagogical alternative for improving academic writing in EFL contexts within higher education.

Despite these contributions, this study also opens avenues for future research. Further studies could incorporate control groups, larger sample sizes, or longitudinal designs to strengthen the generalizability of the findings. Additionally, future research may explore the impact of these tools on higher-level writing skills such as argumentation, critical thinking, and academic voice, as well as examine students' perceptions and attitudes toward AI use in academic contexts. Expanding the scope of analysis will allow for a deeper understanding of how technology can be effectively and ethically integrated into EFL writing instruction.

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