

Effectiveness Of Generative Ai-Supported Digital Rhetoric Instruction On Students' Persuasive Writing Performance in Higher Education

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Abstract

The main problem in learning persuasive writing in higher education is students' low ability to build logical arguments, maintain coherence, and combine digital rhetorical strategies effectively. This research aims at the effectiveness of generative AI-based digital rhetoric learning in improving the quality of students' persuasive writing. The method used was a quasi-experiment with two classes (N=60): an experimental class that utilized AI and a control class that studied conventionally. The results showed a significant improvement in the experimental group, from a total score of 2.68 to 3.86, while the control group increased from 2.68 to 3.02. Paired T-test produces $t(29)=11.42$; $p<.001$ with an effect size of $d=2.08$, much larger than the control group ($t(29)=3.21$; $p=.003$; $d=0.58$). ANCOVA analysis also showed significant differences, $F(1,57)=28.74$; $p<.001$, with $\eta^2=.34$. These findings imply that AI functions as a cognitive scaffold that strengthens strategic argumentation, organizational coherence, and the rhetoric of awareness in digital writing learning.

Keywords: *Generative Artificial Intelligence; Digital Rhetoric Instruction; Persuasive Writing Performance; Argumentation Skills; Higher Education*

INTRODUCTION

Research on the dynamic relationship between digital rhetoric, generative AI technology, and persuasive writing skills is beginning to occupy a strategic position in higher education discourse. The rapid development of large-scale language models capable of generating text, such as ChatGPT, has led to significant changes in how students interact with academic and non-academic writing processes. The emergence of this technology creates a new space in literacy practices that demands comprehensive adjustments to pedagogical approaches. The ability of AI to mimic rhetorical styles, generate alternative arguments, and provide specific frameworks for thinking demonstrates the potential for transforming persuasive writing instruction toward a more adaptive and responsive format to the needs of today's learners. The emphasis on the transformational potential of generative AI in education has been highlighted by several recent studies demonstrating increased engagement and expanded rhetorical strategies when AI is used in a targeted manner (Kim et al., 2024; Abdelmagid et al., 2025).

The integration of digital rhetoric with generative AI technology creates a learning ecosystem that enables students to achieve a more authentic writing experience. The principles of digital rhetoric, which fundamentally emphasize the use of digital media as a space for the production of meaning, are now transforming with the emergence of AI, which is capable of constructing coherent and convincing texts. This development places educators in a position that demands mastery of new strategies to optimally utilize AI's potential. Several research reports indicate that the use of AI in learning contexts has the potential to enhance student creativity, expand the choice of rhetorical strategies, and facilitate the process of exploring ideas before entering the stage of independent text development (Verma et al., 2025). These principles open up opportunities for designing more scaffolded learning, enabling students to manage the writing process with less cognitive pressure.

The introduction of AI into writing practice has also begun to drive improvements in the quality of feedback students receive. The quality of feedback significantly impacts the development of writing skills because students can revise based on new insights into the strengths and weaknesses of their texts. Empirical evidence highlighting the integration of formative feedback and the use of AI indicates significant improvements in the quality of persuasive writing and student motivation to learn (Weber et al., 2024; Nguyen et al., 2024). This improvement occurs because students can obtain alternative examples of arguments, text organizational structures, and variations in message delivery styles. This situation demonstrates that AI can act as a mediator, helping clarify the rhetorical decisions students need to make, particularly in developing focused and convincing arguments.

An AI-based approach to persuasive writing is also considered capable of strengthening the development of students' reflective skills. Reflective skills are crucial because the persuasive writing process is not only about expressing an opinion but also includes the ability to understand the audience, weigh the strength of an argument, and adapt rhetorical style to the context. Findings from research applying AI in the context of reflective writing indicate an increase in students' metacognitive awareness, particularly in reassessing the appropriateness of text structure, the accuracy of diction, and the alignment between communication goals and rhetorical strategies used (Neshaei et al., 2025; Hong et al., 2025). These findings indicate that AI technology functions not only as a technical aid but also as a means of shaping higher-order thinking processes.

Recent literature reviews show that AI's ability to support the writing process is beginning to be understood as a tool to overcome obstacles frequently encountered by students. These obstacles can include difficulty generating initial ideas, a lack of understanding of rhetorical structures, or limitations in generating argument variety. Instruction utilizing generative AI is believed to provide a framework that helps students focus on the essential aspects of persuasive writing. Several studies have shown that AI can reduce irrelevant cognitive load, allowing students to focus on the process of constructing arguments and selecting effective rhetorical strategies (Gada & Chudasama, 2024). The role of AI as a cognitive load simplifier aligns with the principles emphasized in cognitive load theory, which states that good instructional design should focus on reducing load that is detrimental to learning and increasing load that facilitates the construction of conceptual schemas (Merriënboer & Sweller, 2005).

Reflecting on the relationship between AI technology and cognitive load leads the discussion to the realm of planning, organization, and revision, as core writing processes. The persuasive writing process is a complex activity that demands the ability to generate ideas, organize structures, and critically reassess texts. AI support has the potential to facilitate students' management of this process because AI-based instruction can provide a model of reasoning that can be replicated and modified. This approach also aligns with Kalyuga's (2011) description of the potential of digital technology to reduce unnecessary cognitive load, allowing learners more space to work on developing text quality. This understanding suggests a significant opportunity for educators to design instruction that integrates AI not only as a technical tool but also as a supporting framework for students' thinking processes.

A key issue identified in the literature is the limited empirical research quantitatively assessing the effectiveness of AI-based instruction. The majority of published studies to date are exploratory or descriptive in nature and lack a strong empirical basis for the impact of AI on the quality of students' persuasive writing. A systematic analysis of findings from a global literature review reveals that few studies have utilized experimental or quasi-experimental designs to measure improvements in writing quality after AI-based interventions are implemented (Yan et al., 2023). This gap highlights the need for a more comprehensive and measurable research approach so that learning practices involving AI are based not only on theoretical assumptions but also on retestable empirical evidence.

Another emerging issue is the growing concern about students' dependence on AI technology. Excessive reliance has the potential to reduce students' ability to generate ideas and develop arguments independently. This concern is growing with the increasing ease of access to AI services capable of producing high-quality text in a short time. Several academic discussions have suggested that uncontrolled use of AI can weaken critical thinking skills and reduce students' creativity (Zhang, 2025). This warning emphasizes the importance of learning that positions AI as a support for the learning process, not a substitute for writing skills.

Efforts to address these issues require research designs that can more deeply test the effectiveness of AI-based digital rhetoric instruction. The relevance of such research is particularly high given the demands of higher education that are moving toward technology-based adaptive learning. Some suggested future research agendas emphasize measuring changes in the quality of persuasive writing, students' thinking strategies, levels of engagement in the learning process, and the

dynamics of cognitive processes when AI is used as part of instruction (Aldhafeeri et al., 2025). This research direction can contribute to the formulation of more evidence-based writing instruction policies. The importance of structured empirical research oriented toward measuring learning outcomes impacts not only the theoretical realm but also pedagogical applications. An evidence-based approach can provide guidance to educators in determining relevant learning strategies, particularly in the context of the increasingly widespread integration of AI in higher education. The ability to combine digital rhetoric, cognitive load theory, and AI support within a coherent pedagogical framework can offer innovative solutions to address students' weaknesses in composing coherent, logical, and strategic persuasive texts.

This overall description demonstrates that the integration of generative AI in persuasive writing instruction is a highly promising area for development as an empirical research agenda. The theoretical foundations of digital rhetoric, AI technology, cognitive load, and reflective skills provide a solid foundation for designing more measurable research. Strengthening empirical approaches is imperative so that pedagogical decisions regarding the use of AI are based not only on assumptions but also on valid scientific evidence.

METHOD

Research Design

This study employed a quasi-experimental design with a pretest–posttest non-equivalent control group. This design was chosen because it is considered appropriate when the classroom context does not permit full randomization. This principle aligns with the view of Shadish, Cook, and Campbell, who explain that quasi-experimental designs provide an opportunity to analyze causal relationships in real-life educational situations when randomization is not feasible. This design allows researchers to evaluate the effectiveness of interventions comparatively without disrupting the established classroom structure.

The pretest–posttest framework is also recommended in writing ability research because it facilitates the measurement of change with a high degree of reliability. Hyland (2016) explains that writing ability develops through a gradual process, so a design that measures change longitudinally provides a more accurate picture of the impact of instruction. The use of this design is relevant for assessing the extent to which generative AI-based digital rhetoric instruction affects the quality of students' persuasive writing.

Participants

The research participants consisted of two classes of students in the D4 Digital Business program at the Lombok Business Academy. Approximately 60 students were selected using a purposive sampling technique. This technique aligns with Creswell's (2014) view that participant selection can be tailored to research objectives when the population possesses certain relevant characteristics.

Inclusion criteria were formulated based on higher education research standards: active students, experience in writing courses, and willingness to participate in all stages of the research. Patton (2015) emphasized that selecting participants based on relevant characteristics will improve the quality and suitability of the research data.

The experimental and control classes were distinguished based on a regular class structure without randomization. Borg and Gall (2003) noted that educational research is often conducted with pre-formed groups, and the use of naturalistic classes remains valid as long as the treatment and external variables are properly controlled. This approach ensures that the evaluation of treatment effects is conducted under authentic learning conditions.

Instructional Intervention

An intervention based on digital rhetoric and generative AI support was designed to improve students' abilities to plan, organize, and revise arguments. The concept of digital rhetoric draws on Eyman's (2015) perspective, which defines it as a rhetorical practice mediated by digital technology,

where the use of digital media influences the construction and delivery of messages. This framework was used as the basis for designing AI-assisted learning activities.

Generic AI capabilities, such as ChatGPT, are utilized as scaffolding for students in generating ideas, developing arguments, and evaluating writing structure. This scaffolding principle is understood through the perspective of Vygotsky (1978), who explained that external support can accelerate the development of cognitive abilities through the zone of proximal development (ZPD). In this study, AI was positioned as external support, helping students navigate complex thinking processes during writing.

The intervention lasted 4–6 learning sessions, each lasting 100 minutes. The experimental group utilized AI for brainstorming, generating argument variations, and developing rhetorical structures. The use of AI refers to the perspective of Luckin et al. (2016), who asserted that artificial intelligence can function as a cognitive partner if pedagogically designed.

The control group underwent conventional rhetoric instruction without AI assistance to ensure a valid comparison. Material deepening was conducted through discussion, peer assessment, and independent practice, following the traditional rhetorical pedagogical approach described by Aristotle in Rhetoric and supported by contemporary analysis by Crowley & Hawhee (2004).

Instruments and Measures

The main research instruments were a persuasive writing test, assessment rubric, cognitive process questionnaire, and AI usage log in the experimental group.

a. Persuasive Writing Test

A persuasive writing task was used in the pretest and posttest to assess changes in writing ability. The principle of using authentic tasks in task-based assessment is more capable of measuring writing ability holistically.

b. Assessment Rubric

The assessment rubric was developed based on the principles of rhetorical assessment: logos, ethos, pathos, organizational coherence, and style and diction. The analytical rubric follows writing assessment guidelines that require rubrics with measurable indicators to increase reliability.

Inter-rater reliability was evaluated using the Intraclass Correlation Coefficient (ICC) for performance assessment because it provides a more stable reliability estimate than other methods.

c. Cognitive Process Questionnaire

The questionnaire was developed based on cognitive load theory. This theory emphasizes the importance of separating cognitive load into intrinsic, extraneous, and germane. This instrument aims to measure the impact of the intervention on the process of planning, argument development, and writing revision.

d. AI Interaction Logs

AI interaction logs were analyzed to map student activity when using AI. The principle of log analysis is that digital artifacts can provide insights into learning patterns and cognitive strategies.

Procedure

The research procedure was implemented through five sequential stages to ensure systematic and replicable data collection. The orientation stage began with participants being informed about the research objectives and the ethical use of AI as a means of implementing the principle of transparency in educational research. The next stage was a pretest, in which participants were asked to complete a writing task to obtain an initial overview of their abilities before the treatment was administered. The treatment stage was implemented by providing AI-based digital rhetoric instructions to the experimental group, while the control group received learning without AI assistance in accordance with effective instructional design principles. After the intervention was completed, participants underwent a posttest to measure changes in their persuasive writing skills. All written work was then

assessed during the scoring and coding stages by two independent, blind assessors, ensuring optimal objectivity and reliability of the assessment.

Data Analysis

Data analysis in this study used a combined quantitative and qualitative approach to obtain a comprehensive picture of the intervention's effectiveness. Quantitative analysis was conducted using a paired sample t-test to measure changes in persuasive writing scores in each group, and an independent t-test or ANCOVA to compare posttest scores with control pretest scores, while the strength of the intervention's influence was calculated using Cohen's d effect size. The reliability of the writing assessments was tested using the Intraclass Correlation Coefficient (ICC) to ensure inter-rater consistency. Qualitative analysis was conducted through a review of AI usage logs and students' open-ended responses using thematic coding techniques, which enabled researchers to identify patterns of meaning, cognitive strategies, and rhetorical tendencies that emerged during the writing process in a technology-based learning context.

RESULTS

Descriptive Statistics

Descriptive analysis was conducted to describe changes in persuasive writing skills before and after the intervention in both groups. Assessment scores focused on five components of rhetoric: logos, ethos, pathos, coherence-organization, and style-diction. Table 1 displays the means (M) and standard deviations (SD) for both groups.

Component	Experiment Pretest M(SD)	Experiment Posttest M(SD)	Control Pretest M(SD)	Control Posttest M(SD)
Logos	2.68 (0.54)	3.87 (0.48)	2.71 (0.52)	3.04 (0.50)
Ethos	2.74 (0.56)	3.91 (0.45)	2.70 (0.55)	3.02 (0.48)
Pathos	2.60 (0.50)	3.75 (0.51)	2.63 (0.49)	2.95 (0.52)
Coherence & Organization	2.72 (0.57)	3.95 (0.46)	2.69 (0.53)	3.10 (0.48)
Style & Diction	2.65 (0.59)	3.80 (0.49)	2.68 (0.57)	2.98 (0.50)
Total Score	2.68 (0.55)	3.86 (0.48)	2.68 (0.53)	3.02 (0.49)

Table 1. Mean Pretest and Posttest Persuasive Writing Skills

The results in Table 1 show that both the experimental and control groups experienced improved scores. However, the improvement in the experimental group appeared to be greater and more consistent across all rhetorical components than in the control group.

Inferential Statistics

The inferential analysis provides a strong indication of the effectiveness of AI-based digital rhetoric instruction in improving students' persuasive writing skills. A paired samples t-test showed that the experimental group experienced highly significant improvement between the pretest and posttest, with a $t(29) = 11.42$ and $p < .001$. Cohen's $d = 2.08$, which falls within the very large effect category, confirms that the intervention had a substantive impact and was not simply a small increase or a statistical fluke. This indicates that AI-based learning successfully helped students formulate stronger arguments, structure their writing more coherently, and improve their overall rhetorical style. The control group also showed improvement, albeit much lower, with a $t(29) = 3.21$, $p = .003$, and $d = 0.58$, which is considered a moderate effect. This improvement is thought to be due to the regular learning process, but it is not comparable to the impact of the AI intervention in the experimental group.

The comparison between the two groups was further analyzed using ANCOVA, with pretest scores controlled as a covariate. The analysis revealed a highly significant difference between the two groups in posttest scores, as indicated by $F(1, 57) = 28.74$, $p < .001$. The eta squared (η^2) value of .34 indicates that approximately 34% of the variance in writing improvement was influenced by the AI-

based intervention—a significant value in educational research. The adjusted mean difference in posttest scores further corroborated this finding, with the experimental group achieving a score of 3.89, while the control group only achieved 3.04. This striking difference indicates that the use of AI not only helped students speed up their text-writing process but also enriched their rhetorical quality, increased logical strength and coherence, and encouraged more appropriate use of language style in persuasive contexts. Overall, these results confirm that AI-based instruction makes a significant pedagogical contribution to enhancing the effectiveness of persuasive writing instruction.

Component-Level Improvement

The most significant improvement in the experimental group was seen in the coherence and organization of arguments, indicating that students were increasingly able to organize their ideas systematically and logically after receiving generative AI support. This ability developed because the AI provided an initial structure in the form of an outline, suggested alternative paragraphing patterns, and offered transition suggestions that helped students maintain a coherent flow of argumentation. Students who previously struggled to connect main ideas with supporting ideas were now able to produce more coherent and focused writing. This pattern of improvement indicates that the AI acted as a conceptual guide, helping students identify the logical sequence in a persuasive text, allowing them to focus not only on the content of the argument but also on how to structure and convey it effectively. Improved coherence also demonstrated that students increasingly understood the importance of alignment between claims, reasons, and evidence in constructing a convincing message.

Significant improvements were also found in the logos aspect, which relates to the strength of logic and argumentation. Generative AI has been shown to help students broaden the scope of their arguments by providing a diverse selection of ideas, supporting examples, and counterarguments that can sharpen the quality of their persuasiveness. Students who previously struggled to develop fact-based arguments now have access to richer reasoning models, which they then adapt to the context of their writing. AI also plays a role in helping students identify logical gaps in initial drafts and propose relevant argumentative refinements. This process strengthens students' ability to construct more structured claims, include more contextual supporting evidence, and balance main arguments with rebuttals that strengthen their positions. These findings suggest that AI not only provides inspiration for ideas but also helps students internalize the reasoning patterns necessary for writing strong and comprehensive persuasive texts.

The third aspect that showed significant improvement was ethos, specifically related to the credibility of their delivery style. The AI's support for generating a variety of formal styles provided students with the opportunity to evaluate and adjust the tone of their writing to suit both academic and professional persuasive contexts. Students began to understand that credibility is built not only through the content of an argument but also through conveying a message with appropriate, polite language that reflects the writer's competence. AI helped students develop a more consistent rhetorical style, avoid unnecessary repetition, and choose diction that supports a professional and trustworthy impression. Improvements in ethos demonstrate that students are increasingly aware of the relationship between their self-image as writers and the effectiveness of their messages. This awareness aligns with the principles of classical rhetoric, which emphasize that audience trust grows from a writer's ability to demonstrate clarity, honesty, and accuracy in communication.

Overall, developments in these three aspects demonstrate that generative AI not only provides technical assistance but also influences the cognitive and rhetorical dimensions underlying the persuasive writing process. These results confirm that AI-based digital rhetorical instruction can expand students' thinking capacity, improve the organization of ideas, strengthen the logic of arguments, and build more mature rhetorical credibility.

Cognitive Process Findings (Qualitative Results)

Thematic analysis of cognitive process questionnaires and AI interaction logs showed that the generative AI-based intervention not only influenced the quality of their writing but also profoundly

impacted how students process, develop, and revise their ideas. The three main themes identified reflect changes in students' mindsets and writing strategies after engaging in AI-based digital rhetoric learning.

The first theme, changes in planning strategies, illustrates how students in the experimental group became more structured and systematic in planning their texts. Before the intervention, some students reported difficulty starting writing due to a lack of ability to identify the main idea or determine the direction of their argument. The presence of AI helped them form an initial framework by mapping ideas, identifying key claims, organizing relationships between ideas, and considering the intended audience. Students used AI as a tool to stimulate their initial thinking processes, so that planning activities were no longer spontaneous or intuitive, but became more directed and strategy-based. This finding is reflected in student statements such as, "AI helps me see the relationships between ideas before I start writing," indicating that AI acts as a cognitive partner in the conceptualization stage.

The second theme, deeper revision, reflects a significant shift in how students evaluate and edit their writing. Before using AI, revisions were generally limited to grammatical corrections or sentence adjustments. Interacting with AI encouraged students to make substantial revisions that directly increased the strength of their arguments. They began examining the logic of their argument, strengthening evidence through additional data or justification, restructuring paragraph structures to ensure coherence, and adjusting their rhetorical style to more effectively persuade their audience. AI functioned as an "active reader," providing feedback on weaknesses in their arguments and offering alternative developments. This led students to be more critical of the quality of their first drafts and better prepared to undertake a thorough reconstruction of their writing structure.

The third theme, increased metacognitive awareness, indicates that students have become not only more skilled writers but also more reflective about their own thought processes. This awareness is evident in how they began to independently evaluate the consistency of their arguments, consider the effectiveness of rhetorical strategies, and compare the quality of their initial and revised drafts. Students no longer viewed AI as a provider of answers, but rather as a tool to assess whether their revisions were appropriate and aligned with their persuasive goals. They began to develop reflective questions such as "Is my argument strong enough?", "Is my style appropriate for my audience?", or "How does this change enhance persuasive power?". This pattern suggests that AI encourages students to develop self-monitoring in their writing, an important indicator of the development of higher-order writing skills.

These three themes collectively demonstrate that the use of AI has a multidimensional impact on students' writing learning process. The impacts extend beyond technical or structural aspects to critical thinking, the ability to evaluate writing quality, and an awareness of the rhetorical strategies necessary to produce effective persuasive texts. These findings strengthen AI's position as a pedagogical tool capable of facilitating higher-order learning when used purposefully and supported by an appropriate instructional approach.

AI Interaction Logs

Analysis of AI interaction logs provides a detailed overview of how students utilize generative AI support during the persuasive writing process. The data shows that students do not use AI randomly, but rather in patterns that reflect cognitive and rhetorical needs at each stage of writing. These patterns demonstrate that AI serves to bridge knowledge gaps, enrich writing strategies, and simplify complex tasks that previously posed obstacles in the text production process.

The highest use was seen in brainstorming and outlining activities, with 62% of students utilizing AI at this stage. This indicates that students require initial support in formulating ideas and establishing the direction of their writing. AI helps them generate key ideas, identify relevant topics, and organize these ideas into a more coherent framework. These interactions indicate that many students are still at a stage in their writing development where they require structural guidance to

begin their assignments. AI acts as a planning facilitator, not a substitute for thinking, but rather as a tool that provides an initial structure that students then develop independently.

As many as 48% of students used AI to generate counterarguments, a crucial component of persuasive writing that strengthens the credibility and complexity of an argument. This use indicates that students are beginning to understand the importance of presenting opposing viewpoints as a rhetorical strategy that strengthens the position of the main argument. AI helps provide alternative perspectives that students may not have previously considered, broadening the logical spectrum they use in issue analysis. This pattern indicates that AI encourages students to focus not only on strengthening the main claim but also on considering more balanced and in-depth argumentative dynamics.

The most dominant activity was the use of AI for paragraph evaluation and logical revision, with a figure reaching 71%. This pattern indicates that AI intervention was most frequently utilized in the phase of strengthening the internal structure of the writing. Students asked AI to identify inconsistencies, provide suggestions for strengthening logic, and offer alternative paragraph restructurings to make the message clearer and more convincing. The high use of AI in the revision aspect indicates that students rely not only on AI to generate content but also to improve their critical thinking when assessing the effectiveness of their arguments. The presence of AI facilitates academic self-monitoring, which is an indicator of metacognitive development in writing.

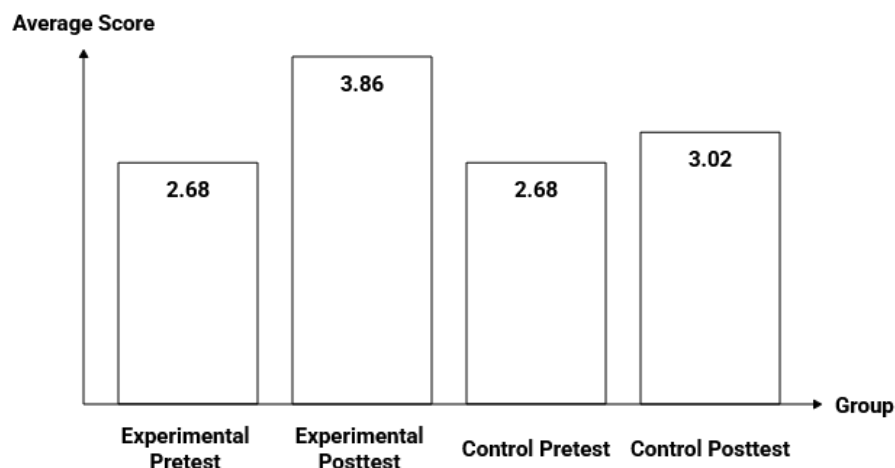
A significant portion of students, 33%, requested AI assistance for stylistic variation, particularly when they wanted to adapt their persuasive tone to suit their audience or when they felt their writing style was too monotonous. This pattern suggests that students are beginning to understand the relationship between rhetorical strategies and linguistic choices. AI helped them find more appropriate diction, enrich sentence variety, and adjust the formality of their text. This use indicates that students focused not only on the content of their argument, but also on how to present it convincingly and professionally.

The highest frequency of AI use occurred during the first draft and final revision sessions, the two most cognitively demanding stages. During the first draft stage, AI helped students navigate their writing to avoid writer's block. During the final revision stage, AI was used to ensure that their argument, style, and overall structure aligned with their persuasive goals.

Overall, this pattern of AI use demonstrates that students are utilizing technology not as a writing machine, but as a cognitive partner supporting them in planning, organizing, and refining their text. These findings suggest that generative AI serves as scaffolding, strengthening students' critical thinking, rhetorical reflection, and revision skills throughout the persuasive writing process.

Visualization of Results

Comparison of changes in average persuasive writing scores between the experimental and control groups based on pretest and posttest results. This visualization is used to demonstrate the extent to which the AI-powered digital rhetoric-based intervention resulted in improved writing skills in both groups.



The visualization shows that the experimental group experienced significantly greater improvement than the control group, thus indicating that AI-based digital rhetoric instruction had a strong impact on the development of students' persuasive writing skills.

DISCUSSION

Interpretation of Findings

The research findings indicate that digital rhetoric instruction based on generative AI resulted in significant improvements in the quality of students' persuasive writing. Consistent improvements in logos, ethos, pathos, organizational coherence, and style indicate that AI integration can strengthen the overall reasoning and rhetorical construction process. The significant effect size in the experimental group indicates that generative AI technology functions not merely as a technical aid, but as cognitive scaffolding that enriches students' writing strategies.

The pattern of improvement in writing quality indicates that students not only produce more logical arguments but are also able to organize their ideas coherently and adapt their persuasive style to suit the audience's needs. Thematic findings from the AI usage log and cognitive process questionnaire indicate a positive response to AI use during the planning and revision stages. Students reported being better able to identify relationships between ideas, check the consistency of arguments, and develop stronger justifications. These data indicate that the effectiveness of the intervention is reflected not only in the final writing scores but also in the changes in the thinking that underpin the writing process itself.

Comparison with Previous Studies

The results of this study reinforce the findings of several previous studies highlighting the potential of generative AI to support writing learning. The improvements in argumentation quality and coherence align with reports by Kim et al. (2024) and Verma et al. (2025), which show that AI can simulate complex rhetorical structures and provide strategic examples for learners to emulate. The increased student engagement through rapid, automated feedback also aligns with the findings of Weber et al. (2024) and Nguyen et al. (2024), which emphasize that AI can fill the feedback gap that instructors often cannot provide intensively.

This research also adds to the literature on digital rhetoric. As Eyman (2015) argued, digital rhetoric is rhetorical practice shaped by digital media. The findings of this study provide empirical evidence that AI, as part of a digital medium, can serve to enrich learners' rhetorical strategies. The involvement of AI in students' cognitive processes during writing also aligns with the views of Luckin et al. (2016) on AI as a cognitive partner that helps learners navigate complex tasks.

This study also confirms the relevance of cognitive load theory as outlined by Sweller et al. (2019). The reduction in extraneous cognitive load in the experimental group was evident in the students' increased ability to focus on arguments and coherence. Process data showed that students

no longer struggled to start writing or find transitions between paragraphs, as the AI provided a basic framework that they could develop independently.

Mechanisms: Cognitive and Instructional Processes

Quantitative and qualitative data provide a clear picture of the mechanisms by which AI supports the learning process. The first mechanism is evident in the idea generation stage, where AI provides alternative ideas, example arguments, and structures that students can use to plan their writing more systematically. This is consistent with Vygotsky's (1978) ZPD theory, which states that external support can strengthen the process of internalizing knowledge.

The second mechanism is evident in the revision stage, where AI provides input in the form of logical critiques, suggestions for paragraph restructuring, and identification of weak points in arguments. Students become more active in making substantial revisions rather than simply improving linguistic aspects. This mechanism supports Flower and Hayes's argument regarding the importance of recursive processes in writing, where writers continually move between planning, drafting, and revising.

The third mechanism relates to increased rhetorical awareness. The use of AI appears to encourage students to consider their audience and communication purpose more explicitly. This tendency is evident in students' statements about beginning to examine the appropriateness of their writing style and the appropriateness of their persuasive tone. This situation reinforces Hyland's (2016) view of writing as a social activity that demands awareness of the reader.

Theoretical and Pedagogical Implications

The research findings have several theoretical implications. First, they reinforce the idea that digital rhetoric needs to incorporate AI integration as part of the contemporary digital literacy ecology. Rhetoric is no longer understood exclusively as a human practice, but rather as a collaborative process between humans and intelligent systems capable of modeling specific rhetorical patterns.

The second implication relates to writing pedagogy. Traditional writing instruction needs to adapt to the changing technological landscape. The integration of generative AI has been shown to help overcome classic barriers to writing learning, such as difficulty getting started, lack of ideas, or inability to organize text. AI can function as an instructional partner, enriching the quality of guidance, especially in learning contexts with high faculty-student ratios.

The third implication relates to cognitive load theory. The support of AI in providing rhetorical models and argumentative structures suggests that this intervention can shift some of the extraneous cognitive load, allowing students to focus on the generative load that supports knowledge construction. These findings can extend the cognitive load theory model to the context of digital writing.

Limitations

This study has several limitations. The sample size was relatively small and confined to a single vocational institution, so generalization of the results should be done with caution. The intervention duration of only a few weeks was insufficient to capture long-term changes in students' writing habits.

Another limitation lies in the variation in students' technological capabilities. Access to and skills in using AI may influence intervention outcomes. Potential bias is also possible because students perceive AI as an assistive tool, so there is the possibility of changes in learning behavior solely due to expectations about the technology.

Ethical aspects, including reliance on AI to complete academic assignments, need to be considered. The intervention has provided guidelines for the ethical use of AI, but further research is needed to ensure that students continue to develop independent writing skills.

Recommendations for Future Research

Further research is recommended to use a longitudinal design to examine the impact of AI interventions on the long-term development of writing skills. This investigation can be expanded to

various disciplines and study programs to test the stability of the intervention's effectiveness across different contexts.

Further research could also focus on a variety of writing tasks, such as critical analysis, literature reviews, or multimodal argumentative texts. A deeper exploration of cognitive processes during interactions with AI could be conducted through think-aloud protocols or screen recordings.

Future research could also explore ethical aspects and the development of digital literacy, including how students understand the limits of AI use and how AI influences the identity of academic writers.

CONCLUSION

The research findings indicate that generative AI-based digital rhetoric instruction has a strong impact on improving the quality of students' persuasive writing. This improvement was significant across all components of rhetoric, from argumentative strength, evidence organization, organizational coherence, to the appropriateness of persuasive style and tone. The difference in score improvement between the experimental and control groups indicates that students who received AI support were able to produce more coherent, critical, and strategic writing in a persuasive context. Cognitive process data confirms that the intervention also impacted how students manage their thinking processes during writing, including the planning, revision, and rhetorical reflection stages.

This research's contribution lies in the empirical evidence that strengthens the role of AI as a cognitive scaffold in learning persuasive writing. These findings enrich the theoretical framework of digital rhetoric by confirming that rhetorical practice in the era of artificial intelligence is influenced not only by the digital medium but also by the collaboration between writers and intelligent systems that function as cognitive partners. The instructional model tested in this study provides insight into how AI can be pedagogically leveraged to reduce unnecessary cognitive load, strengthen focus on argument development, and enhance students' rhetorical awareness. These findings offer an extension of cognitive load theory and process-based writing theory, positioning AI as a strategic component in instructional design.

The practical implications of this research focus on developing writing pedagogy in higher education. AI integration has been shown to complement lecturers' role in providing individual guidance, particularly in classrooms with large numbers of students. Educators can utilize AI as a supporting tool to facilitate brainstorming, idea mapping, argumentative revision, and the production of alternative rhetorical structures. This research also indicates that educational institutions need to develop policies governing the ethical use of AI, ensuring that technology is used as a learning tool, not as a substitute for independent writing skills.

Further recommendations point to the need for more in-depth and extensive research. Longitudinal research is crucial to assess the sustainability of intervention effects on student writing habits. Research in other disciplinary contexts is also crucial, given that argumentation patterns and forms of persuasion differ across disciplines. Future studies could delve more deeply into the dynamics of students' cognitive processes when interacting with AI, for example through think-aloud protocols, screen recording analysis, or digital footprint mapping. Research on the ethical dimensions and development of AI-based digital literacy also needs to be strengthened, particularly regarding students' ability to assess the quality of AI suggestions, manage dependency, and maintain their academic writing identities.

The overall findings in this study indicate that AI-based digital rhetoric interventions have significant potential to improve the quality of students' persuasive writing, while also providing new directions for the development of writing learning theory and practice. The integration of generative AI technology into writing curricula needs to be continuously evaluated through an evidence-based approach to ensure its use remains aligned with pedagogical goals and the development of academic literacy competencies in the digital age.

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