

Cultivation of Critical Thinking Skills: Exploring the Impact of Generative Artificial Intelligence-Enabled Instruction in English Essay Writing

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Abstract: This study explores the impact of generative artificial intelligence (AI)-enabled instruction on critical thinking in English essay writing among 1,050 first-year English majors across four colleges. Pedagogical strategies, including facilitating critical responses and emphasizing real-world application, are identified to enhance generative AI's impact. Both qualitative and quantitative analyses reveal significant post-intervention improvements in critical thinking skills. This research contributes to understanding how generative AI can effectively foster critical thinking in educational settings.

Keywords: Generative artificial intelligence; Critical thinking; Pedagogy; Quasi-experiment

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1. Study background

This research project addresses the challenges of traditional language education methods amid technological advancements. Conventional approaches prioritize grammatical accuracy over critical thinking skills, hindering students' ability to navigate modern communication complexities. Generative artificial intelligence (AI) presents an opportunity to bridge this gap by providing personalized support in English essay writing instruction. Integrating generative AI into education aims to foster critical thinking skills essential for success in the 21st century. Thus, this study explores the theoretical, practical, and empirical aspects of integrating generative AI into language education to inform educational practice and policy, contributing to pedagogical innovation.

2. Research objectives

- (1) Pedagogical exploration: To explore pedagogical strategies for effectively implementing generative AI in English writing instruction to optimize its impact on critical thinking development.
- (2) Assessing impact: To assess the impact of generative AI-enabled instruction on students' critical thinking

skills in their essays.

3. Conceptual framework and hypothesis

3.1. Cognitive offloading theory

Central to the conceptual framework is the cognitive offloading theory^[1], which posits that external aids, such as generative AI, can alleviate cognitive load and enhance cognitive processes^[2]. According to this theory, generative AI serves as a cognitive tool that supports students' writing process by automating certain cognitive tasks, such as generating ideas, organizing content, and providing feedback. By offloading these cognitive tasks onto the AI system, students can alleviate cognitive load, allowing them to allocate more cognitive resources to higher-order thinking skills, such as analysis, evaluation, and synthesis^[3]. Research by Shum contributed practical examples pointing to the potential for generative AI to promote critical analysis as a cognitive offloading tool^[4]. The research by Bearman *et al.* underscored the importance of prioritizing critical thinking over mechanical writing skills and incorporating cognitive offloading into assessment design to promote academic integrity and learning^[5].

3.2. Zone of Proximal Development (ZPD)

Drawing upon Vygotsky's sociocultural theory, the conceptual framework also considers the notion of the Zone of Proximal Development (ZPD). According to Vygotsky, the ZPD represents the range of tasks that a student can perform with the assistance of a more knowledgeable other, such as a teacher or peer. The integration of generative AI into education aligns with Vygotsky's Zone of Proximal Development (ZPD) framework, where AI serves as a scaffold for critical thinking development^[6]. As emphasized in ZPD theory, learning is most effective in the "zone" between independent and assisted tasks, where educators, or in this case AI, provide guidance and resources to facilitate learning^[7]. Kasimova further underscored the role of AI as a teaching tool, promoting critical thinking, teamwork, and proficient communication in foreign language instruction^[8]. Moreover, Muthmainnah *et al.* suggested that by presenting tasks within students' ZPD, AI can scaffold learning experiences to enhance critical thinking^[9].

3.3. Sociocultural learning theory

The third component of the conceptual framework is informed by the sociocultural learning theory, which emphasizes the importance of social interaction and collaboration in knowledge construction^[10]. Drawing on the principles of sociocultural learning theory, Zhang advocated for the integration of generative AI tools in college English writing instruction to foster critical thinking, collaboration, and creativity among students^[11]. Alier *et al.* further highlighted the potential of generative AI to augment traditional teaching methods by creating original content through algorithms and data, thus enhancing the interactive and personalized learning experience^[12].

4. Research methodology

4.1. Population and sample

The total population for this experiment was 1,050 first-year English major students across four colleges. Since the experiment aimed to investigate the effectiveness of generative AI-enabled instruction, purposive sampling was used to intentionally select samples who were more representative of the population to control for the potential influence of language proficiency on the outcome of the research and to enhance the internal validity of the research. As a result, eight classes with 240 samples (two classes from each college) were selected to participate in the teaching experiment, divided into an intervention group (IG) and a control group (CG) in each college.

4.2. Research procedure

The research procedure commenced with an extensive literature review to identify existing pedagogical strategies for integrating generative AI into English writing instruction. Following this, the identified strategies were applied in the IGs, while traditional writing instruction was conducted in the CGs. Data collection involved both qualitative and quantitative methods, including interviews and pre-test and post-test critical thinking scores of student essays. Subsequently, empirical findings and pedagogical insights were synthesized to devise practical recommendations for English essay writing courses.

4.3. Data collection

Data collection encompassed both qualitative and quantitative methods. Qualitative data was gathered through interviews with students in the IGs after the intervention. Quantitative data included pre-test and post-test critical thinking scores of student essays. To gauge students' critical thinking skills, the Analytical Critical Thinking Scoring Rubric (ACTSR) adapted from the Holistic Critical Thinking Scoring Rubric ^[13] was employed, which has been widely used for grading critical thinking skills in written works, with a set of instructions on how to use it.

4.4. Data analysis

Qualitative data from interviews with students provided insights into their perceptions regarding the integration of generative AI in English essay-writing courses. Thematic analysis was conducted to identify recurring patterns and themes within the qualitative data. Statistical Package for Social Studies (SPSS) version 26 software was used to analyze the quantitative data derived from the experiment. The type of statistics used in this study was descriptive and inferential statistics.

5. Results

5.1. Pedagogical exploration

5.1.1. Facilitating critical responses to generative AI's answers

To foster critical thinking, structured prompts or guiding questions can be utilized to prompt students to critically analyze generative AI's responses. For instance, students can be provided with examples of inaccurate or biased information generated by generative AI and asked to evaluate its credibility, reliability, and relevance. Additionally, active learning techniques such as case studies and role-playing scenarios can promote deeper engagement and critical thinking by immersing students in real-life contexts. For example, students can engage in collaborative problem-solving activities where they tackle challenging problems or tasks related to essay writing, thus enhancing their critical thinking skills.

5.1.2. Instructing students to utilize generative AI to realize cognitive offload

Teaching students how to ask generative AI more specific questions can enhance their critical thinking by encouraging them to articulate their information needs effectively. For instance, students can learn to utilize Socratic inquiry during conversations with generative AI, promoting self-directed critical thinking. Moreover, generative AI can provide language support by suggesting vocabulary and grammar, allowing students to focus on developing critical thinking rather than language-related challenges.

5.1.3. Promoting academic integrity and originality in essay writing with generative AI

Explicit instruction on academic integrity and plagiarism can foster critical thinking by helping students understand the importance of originality in their writing assignments. For example, teachers can incorporate guided practice

activities that require students to generate original content, encouraging them to think critically and creatively. Additionally, fostering a culture of academic honesty and ethical writing practice through ongoing discussions and collaborative learning experiences can further enhance students' critical thinking skills.

5.1.4. Real-world application emphasis

Practices were chosen to emphasize the real-world application of critical thinking skills. By incorporating scenarios and examples relevant to practical situations, students are encouraged to connect theoretical knowledge gained through generative AI with practical challenges encountered in essay writing. For example, current event discussions can help students relate critical thinking skills to contemporary issues, while collaborative problem-solving projects encourage them to integrate critical thinking into real-world problem-solving.

5.2. Assessing impact

5.2.1. Qualitative analysis

After the interview, feedback data from 120 student samples in the Intervention Groups were collected. Here's an interpretation of what these frequent words may imply, as shown in **Table 1**.

Table 1. Interpretation of the top 12 words

Words	Interpretation
Generative AI	Participants consistently associated the approach with this platform or tool, indicating its central role in the instructional process.
Ability, writing, skills	Emphasis on the development of students' abilities, writing skills, and overall competence, suggesting that these are perceived as key outcomes.
Feedback, evidence, arguments	Recognition of the importance of feedback, evidence-based reasoning, and constructing well-supported arguments, indicating a focus on critical thinking and effective communication.
Essays	Continual mention of essays suggests a sustained emphasis on this mode of expression, reinforcing its role in the learning process.
Thinking	The recurring term "Thinking" emphasizes the importance of cultivating critical thinking skills, aligning with the broader goals of the instructional approach.
Peers	The mention of peers suggests a social or collaborative dimension, highlighting the role of interaction among students.
Numbers	The inclusion of "Numbers" in the Word Cloud suggests a recognition of the importance of integrating quantitative elements into the learning experience or the development of critical thinking skills.
Perspectives	The inclusion of "Perspectives" suggests an acknowledgment of diverse viewpoints or approaches, indicating an awareness of multiple ways of thinking.

In summary, students expressed enthusiasm and appreciation for the generative AI-enabled instruction. They highlighted the benefits of interacting with generative AI, such as its ability to provide diverse perspectives, offer valuable feedback, and stimulate thought-provoking discussions.

5.2.2. Quantitative analysis

(1) Pre-test statistical results

Table 2 shows that there were no statistically significant differences ($P > 0.05$) between the IGs and CGs in terms of critical thinking skills before the intervention of generative AI-enabled instruction. Both IGs and CGs displayed moderate levels of comprehension with analytical insight, interpretation with critical judgment,

integration with practical application, inference with problem-solving, and reflective insight with argumentation. This suggests that students in both groups had comparable baseline levels of critical thinking abilities prior to the implementation of generative AI integration.

Table 2. Pretest average score and *t*-test result for critical thinking scores categorized by colleges and five subsections

College	Groups	Comprehension with analytical insight		Interpretation with critical judgment		Integration with practical application		Inference with problem-solving		Reflective insight with argumentation	
		Mean	<i>P</i>	Mean	<i>P</i>	Mean	<i>P</i>	Mean	<i>P</i>	Mean	<i>P</i>
College A	IG	2.90	0.16	2.90	0.07	2.77	0.39	3.30	0.10	2.93	0.50
	CG	2.67		2.57		2.63		3.00		3.07	
College B	IG	2.96	0.07	2.88	0.84	2.92	0.45	2.80	0.60	3.04	0.48
	CG	2.60		2.84		2.76		2.92		2.88	
College C	IG	3.03	0.42	2.63	0.28	3.14	0.05	2.83	0.18	2.80	0.87
	CG	2.91		2.80		2.80		2.60		2.77	
College D	IG	2.90	0.28	3.17	0.42	3.07	0.56	3.07	0.60	2.77	0.51
	CG	2.73		3.03		2.97		2.97		2.63	

Note: * $P \leq 0.05$, ** $P \leq 0.01$

(2) Post-test statistical results

As shown in **Table 3**, students in IG demonstrated significant improvements in critical thinking skills compared to CG across all colleges. IG students showed higher scores in comprehension, interpretation, integration, inference, and reflective insight. For instance, in College A, IG achieved 3.70 compared to CG's 3.10 ($P < 0.001$) in comprehension. Similar trends were observed in interpretation, integration, inference, and reflective insight. These findings confirm the effectiveness of generative AI-enabled instruction in enhancing critical thinking skills, supporting the hypothesis that students exposed to such instruction exhibit significant improvement in critical thinking compared to those receiving traditional instruction.

Table 3. Post-test average score and *t*-test result for critical thinking scores in writing English essays categorized by colleges and five subsections

College	Groups	Comprehension with analytical insight		Interpretation with critical judgment		Integration with practical application		Inference with problem-solving		Reflective insight with argumentation	
		Mean	<i>P</i>	Mean	<i>P</i>	Mean	<i>P</i>	Mean	<i>P</i>	Mean	<i>P</i>
College A	IG	3.70	0.000**	3.53	0.004**	3.70	0.000**	3.67	0.001**	3.70	0.000**
	CG	3.10		3.10		2.83		3.20		3.17	
College B	IG	3.76	0.000**	3.80	0.000**	3.76	0.01*	3.72	0.005**	3.80	0.000**
	CG	2.80		2.92		3.36		3.24		3.08	
College C	IG	3.77	0.000**	3.57	0.000**	3.49	0.004**	3.57	0.000**	3.63	0.000**
	CG	3.11		3.03		3.09		2.80		2.91	
College D	IG	3.73	0.000**	3.77	0.001**	3.53	0.006**	3.73	0.000**	3.63	0.000**
	CG	3.03		3.33		3.10		3.07		3.00	

Note: * $P \leq 0.05$, ** $P \leq 0.01$

6. Discussion and conclusion

In terms of pedagogical exploration, various instructional strategies were identified to optimize generative AI's impact on critical thinking development, including facilitating critical responses, instructing cognitive offload, promoting academic integrity, and emphasizing real-world application.

For assessing impact, both qualitative and quantitative analyses revealed significant improvements in students' critical thinking skills post-intervention, demonstrating the positive impact of generative AI-enabled instruction.

Generative AI shows promising effects in enhancing critical thinking skills in English essay writing. It offers diverse perspectives, feedback, and discussion stimulation. Ethical concerns regarding academic integrity and plagiarism must be addressed with guidelines and educator training. Future research should focus on tailored professional development for educators, student engagement with AI, and ethical and policy considerations. These studies aim to inform practice and ensure responsible AI integration in education, enhancing learning outcomes and experiences.

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