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# A Correlational Study of Critical Thinking and Its Relationship with AI Tool Use for Writing

Andrew Schenck[a] *, Caiyun Zhang[b], Sharon Graham[c]

[a] American University of Sharjah, United Arab Emirates; https://orcid.org/0000-0002-3864-6267
[b] Zhengzhou Sias University, China; https://orcid.org/0009-0005-1869-1465
[c] Fort Hays State University, United States; https://orcid.org/0009-0000-8058-7208

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**Abstract**

Little is known about how Critical Thinking (CT) is related to AI tool use for writing. More research is needed to help educators understand how cognitive training should be used in conjunction with AI-assisted learning practices to complement the writing process. Due to the need for further research, empirical data was collected from 650 Chinese university students via two surveys. The first survey elicited information about knowledge and support for CT, while the second gathered information about AI tool use for different writing tasks (brainstorming, resource collection, outlining, drafting, revising and editing). Results from each survey were analyzed separately and then compared using the Spearman rho formula. Learners who thought that CT was unnecessary or perceived weaknesses in their own ability to use CT tended to use AI for drafting papers. In contrast, learners who thought that CT was important tended to use AI only for outlining and revision. Findings appear to suggest that learners with different levels of CT knowledge or ability need specialized training. Cultivation of effective CT skills and AI-assisted learning practices may require a targeted approach at each stage of the writing process, which is based upon individual learner needs.

**Keywords:** critical thinking, AI, writing, L2, EFL.

## 1. Introduction

Recently, I asked ChatGPT to create a Toulmin argument about using AI for writing. The LLM replied with a claim that "AI writing tools should be used as supportive aids in the writing process, not as replacements for human authorship" (OpenAI, 2025). The LLM went on to support this claim with evidence, expounding upon the efficacy of AI tools for brainstorming, outlining, and revision. Finally, the claim and evidence were connected with a warrant, which stated that writing is enhanced when AI tools are used in a way that does not replace critical thinking. The response was cogent and sound, not to mention extremely fast. It is this effortless and nearly instantaneous production of effective feedback which highlights the potential pedagogical application of LLMs. They may be used as personal tutors at every stage of the writing process, providing ideas, outlines, and examples. It is no wonder that researchers have cited the ability of AI to transform how learners acquire writing skills. It is not just a new tool. It is a

* Corresponding author. English Department, American University of Sharjah, United Arab Emirates.
e-mail address: aschenck@aus.edu

paradigm shift in how we conceptualize education, "revolutionizing traditional pedagogical approaches and opening up new possibilities for students and educators" (Yusuf et al., 2024, p. 2).

AI has become particularly important in L2 writing, serving as a personal tutor that can provide immediate feedback (Gao et al., 2025). For English learners with lower levels of proficiency, it may be used as a scaffold, providing language resources or outlining information to help structure arguments. It may also serve to check and improve grammar and vocabulary choice. Finally, it may be used for ideation, providing new insights that a learner can use to expand and support argumentative writing. Research does indeed confirm the positive impact of AI on writing development (Andreou & Christani, 2025; Gayed et al., 2022; Khalifa & Albadawy, 2024; Marzuki et al., 2023; Song & Song, 2023; Wale & Kassahun, 2024). In a recent experiment involving 295 EFL learners, using AI resulted in better skills for the refinement of grammatical features, vocabulary, and sentence structure (Zhao, 2025). In another study of 259 Chinese undergraduate students, AI-assisted tools had a particularly strong, positive impact on the quality of writing content (Zhang, 2025). This impact on subject matter has been shown to span multiple writing genres. Human-AI collaboration was found to increase the creativity and quality of narrative essay content (Fang et al., 2023). It was also shown to improve argumentative essay quality, while simultaneously fostering valuable critical thinking skills (Zhang et al., 2025).

Although research supporting AI tool use for writing is extensive, precisely how these tools should be used in the classroom has not been clearly established. Rapid development of LLMs like ChatGPT, DeepSeek, and Baidu Ernie have led to confusion, as educators race to develop policies that ensure academic integrity, as well as student development (Roe et al., 2023). Currently, there are concerns that access to AI tools may lead to overreliance; students may use digital tools in lieu of critical thinking skills needed for brainstorming, organizing, and revising written content (Ningrum, 2023; Talgatov et al., 2024; Zhai et al., 2024). To ensure that AI tools cultivate valuable thinking skills needed to improve writing, more research is needed. Further inquiry may provide new insights, which help educators make better choices about using AI tools to develop students' critical thinking and writing.

## 2. Literature Review

As pointed out by Wilson (2025), writing is more than a simple means of recording information; it is a tool for thought whereby "individuals clarify ideas, evaluate evidence, and refine arguments, engaging in an iterative process that strengthens problem solving and decision making" (para. 3). As a means of expanding thought processes, writing is closely linked to critical thinking. In argumentative essays, for example, learners must brainstorm ideas, make an argument, collect evidence, and link this evidence to the argument. They must also use a combination of evidence and analysis to make key inferences about the argument posed. Finally, they must consider different points of view and examine personal biases when designing a cogent argument for their reader. Writing processes directly align with known models for critical thinking (Suh et al., 2025). Paul and Elder (2019), for example, established a model conceptualizing CT as a series of processing tasks, which examine information for purpose, inferences, implications, assumptions, and points of view. Clear parallels between persuasive writing and critical thinking reveal an inextricable link, which must be considered when implementing new AI-assisted pedagogical techniques.

Educators worry that AI tools may adversely impact the close relationship between argumentative writing and critical thinking. One major concern is that excessive dependence on AI may negatively impact deep learning and critical thinking skills when writing (Deep & Chen, 2025). Recent research appears to suggest that this concern is not unfounded. In a recent study of writing conducted at MIT, LLM technology was found to have a negative impact on cognitive functions related to critical thinking. A total of fifty-four participants were separated into three groups: an LLM group, a Search Engine group, and a Brain only group to complete essay tasks. Results revealed a distinct neural pattern of activity based upon group. The amount of neural activity increased as technological support was reduced. Brain only participants had the highest neural activity, followed by the Search Engine group, and ending with the LLM group (Kosmyna

et al., 2025). Research also revealed that perceived ownership of essays which were written with LLMs was low. Overall, the research suggests that AI technologies may adversely impact the relationship between writing and critical thinking.

Potential problems with the adoption of new AI technologies may be caused by the most positive characteristic of an LLM, its power and versatility. Generative AI tools like ChatGPT, DeepSeek, and Baidu Ernie can find resources, construct outlines, and write entire papers. Unlike former writing tools like automated writing evaluation, which provided feedback based on mechanics, coherence, and organization, modern LLMs can complete tasks at any stage of the writing process (Wilson, 2025). This allows learners the ability to bypass almost any aspect of the writing process. When a learner lacks the ability or proficiency to complete a task, LLMs may serve as a scaffold, but they may also serve as a means to escape from the challenges posed by self-regulated composition.

As pointed out by Octaberlina et al. (2024), AI can reduce thinking and creativity in academic writing, replacing cognitive tasks that learners should perform independently. With the potential to use effective AI tools in maladaptive ways, it is no wonder that AI treatments within writing studies often produce inconsistent results. Many studies report AI to be both an asset and a hindrance (Alharbi, 2023; Nuguyen, 2024). One qualitative study, for example, reported greater student cooperation, lowered anxiety, and enhanced brainstorming; at the same time, the study reported overreliance on the AI technology (Rizkiani et al., 2024). Another study identified the positive effects of AI technology on writing quality and critical thinking skills, while simultaneously recognizing that excessive usage could adversely impact independent learning (Zakaria et al., 2025). A final study reported that AI tools promoted self-directed learning when implemented effectively into pedagogical designs yet were detrimental to the development of writing skills when over relied upon (Deep & Chen, 2025).

Although research has correctly identified the role of AI as both an asset and hindrance to the writing process, the precise impact of technological tools on cognitive development in writing remains poorly understood. Current studies often examine LLM tool use and thinking skills by using integrated experimental designs that do not properly delineate each causal variable. This perspective is illustrated by a recent study of 60 high school students in East Java, Indonesia, which examined the effects of EssayAiLab on writing; the study found "a significant effect of artificial intelligence and creative thinking, partially and altogether, on students' writing skills in descriptive text" (Supeno et al., 2024, p. 510). While the results are intriguing, the findings are limited by a failure to discreetly define each variable and its role in shaping the writing process. Both AI and cognitive processes need to be clearly defined. Comprehensive understanding of each individual variable may help educators design more effective instruction. If educators comprehend factors that influence the writing process, they may use their knowledge to predict learning outcomes when new pedagogical strategies are implemented.

Some studies have recognized the need to more clearly define variables related to AI and CT. In a recent study by Deckler et al. (2024), for example, AI tool use was clearly defined by examining three of its principal components: knowledge, skills, and attitude. Similarly, a study of 366 elementary school teachers from Indonesia recognized the same three constructs when examining CT (Suratmi & Sopandi, 2022). As exemplified by the studies, both AI and CT require knowledge, a repertoire of skills, and a positive disposition which transforms thought into action. Although component parts of each variable have been identified, these parts are often studied in isolation. Concerning attitudes about CT, for example, research focused on dispositions directly related to the successful application of higher order thinking skills, such as inquisitiveness, confidence, and a desire to be well informed (Dwyer et al., 2017; Facione, 1990). While useful, this research largely neglected examination of external technological influences such as AI. Rather than being independent factors, AI and CT may be interdependent determinants of effective writing. As an example, learners who are motivated to use CT may depend less upon AI when generating ideas or analysing content, thereby cultivating valuable skills for writing. Conversely, learners who overuse AI may

be less inclined to independently complete writing tasks, negatively affecting the acquisition of higher order thinking skills. Further research is needed to examine the integrated impact of AI and CT on a learner's writing development.

Albeit underexplored in prior research, CT dispositions may be closely linked to AI-assisted tool use for writing, meaning that variance of one variable may have a significant impact on the other. This potential impact is exemplified by research of learner emotions and their influence on AI tool use. A recent study, for example, found that learners with strong affective traits such as high motivation and confidence used AI technology more effectively (Kim, 2025). Such study illustrates a need to carefully examine learner characteristics to understand how AI is used for writing. Although emotional differences have been investigated, differences in attitudes about CT have not been adequately examined in accordance with AI tool use for writing. Learners with certain skills or support for CT may use AI tools differently than peers who disregard or lack such skills. In addition to CT, differences between writing tasks may impact how AI is utilized. Writing is a multistage process, which involves brainstorming, collection of resources, outlining, drafting, and revising. Currently, writing studies tend to examine the writing process holistically, neglecting careful examination of each individual task. More study is needed to understand how CT impacts writing at each stage of the process.

Review of existing literature reveals that further study of both CT dispositions and AI-assisted writing practices is needed. Educators need to understand how variability in attitude about CT relates to AI tool use for writing. At present, studies of AI tool use for writing often emphasize learners' attitudes about the technology itself (Darwin et al., 2024), rather than attitudes about CT. Furthermore, little empirical investigation of variability in AI tool use at different stages of the writing process has been conducted, revealing a need for further research. Additional study of CT and AI tool use with writing is clearly needed. Further inquiry may clarify key relationships between causal variables, which allow educators to predict how pedagogical reforms will impact the learner.

## 3. Research Questions

The purpose of the study was to comprehensively examine relationships between critical thinking and AI tool use for writing. In order to fulfill this aim, the following questions were posed:

1. What are learners' attitudes toward the application and importance of CT in classroom instruction?

2. How do EFL learners use AI tools across different stages of the writing process?

3. What is the relationship between learners' CT attitudes and their AI tool use in writing?

The study was designed to provide more information about the relationship between CT attitudes and AI tool use, which may be useful for the improvement of AI-integrated writing instruction.

## 4. Methodology

This study used a quantitative approach to examine relationships between critical thinking and AI tool use for writing. Empirical data was collected using two surveys. This data was then evaluated using a combination of descriptive and inferential statistics. The method was designed to yield new insights about the variables and their relationship to each other.

### *4.1. Participants/Sampling*

Participants for the study were recruited from intact classes at a university in mainland China. These classes ranged in size from 30 to 60 students each. In total, 650 Chinese participants started to fill out both surveys, 404 female and 246 male. Ages ranged from 18 to 21. Learners' majors included nursing, business administration, finance, English, and information management. Only 514 learners completed each question from each survey.

### *4.2. Instruments/Materials*

To examine perceptions of CT, a seven-question survey was used (See Appendix A). Each survey question employed a five-item Likert scale with the following potential answers: 1 (Not at all true), 2 (Not true), 3 (Somewhat true), 4 (True), 5 (Very true). This survey, which was adapted from Zhang (2022), was specifically designed for English learners in Chinese EFL language contexts, making it a valid measure. It also examined learners' positive and negative attitudes about CT. Questions 1, 2, 3, 6, and 7 elicited information about the perceived importance and utility of CT, whereas questions 4 and 5 elicited information about perceived unimportance of CT. Principal Components Analysis with Varimax rotation provided support for the validity of these two factors (See Appendix B). Analysis of Cronbach's reliability of these two variables was .78 and .74 respectively, suggesting an acceptable degree of reliability.

To examine the use of AI in writing, a survey was designed which elicited information about how often AI tools were used at each stage of the writing process (See Appendix C). The survey included seven questions about brainstorming, research, outlining, writing, and revision (See Appendix C). Students responded to these questions by providing a Likert scale score which ranged from 1 (Not at all true), 2 (Not true), 3 (Somewhat true), 4 (True), 5 (Very true). Principal Components Analysis with Varimax rotation provided support for the validity AI in writing as a single factor (See Appendix D). To examine reliability of the instrument, internal consistency was evaluated using Cronbach's alpha. Calculation yielded an acceptable value $\alpha = .80$, suggesting that the instrument has an acceptable measure of reliability.

Both surveys were translated into Chinese by an instructor of English with the Chinese L1. The surveys were then checked by an expert in English-Chinese translation to ensure that the instruments were valid and accurate versions of the originals.

### *4.3. Procedure*

IRB approval for the investigation was obtained from Fort Hays State University on May 6, 2025 (Reference number: 25-0130). Before administration of surveys, instructors explained that they were not compulsory, and no adverse impact would result from choosing not to take them. Instructors further explained that learners could opt out of the survey at any time without fear of penalty. Next, three English instructors administered the digital surveys via Microsoft forms to intact classes, which ranged in size from 30 to 60 students each. Informed consent had to be provided before participants filled out the surveys. Learners were given a QR code to scan and each survey was completed by phone. After filling out the surveys, data was collected and downloaded for statistical evaluation. Likert scale responses were changed to empirical values for statistical comparison.

For research question one, attitudes about CT were evaluated by averaging Likert scale values for each question of the Critical Thinking Survey. For research question two, AI practices for writing were evaluated by averaging Likert values for each question of the AI Usage for Writing Survey. Finally, relationships between CT with AI usage for writing were evaluated by comparing empirical values from each question of each survey using the Spearman rho formula. This non-parametric statistic was used because Likert scale values were ordinal. Pairwise deletion of missing data was used when calculating correlations.

## 5. Results and Discussion

### *5.1. Research Question One: The Importance of CT*

Research question one sought to examine knowledge and perceived importance of CT (See Figure 1). CT questions expressing knowledge and support for CT (1, 2, 3, 6, and 7) had higher overall average scores than questions which regarded CT to be unnecessary (4 and 5). The findings suggest that students in this context support CT.

Respondents felt most strongly about a personal need for more CT instruction. Question 7, ("I need more instruction from teachers") had the highest Likert score average (4.11). A high score for this question suggests that learners do have some awareness of the need for critical thinking skills. Although students reported that teachers did provide this instruction (4.05), they perceive a need for more.

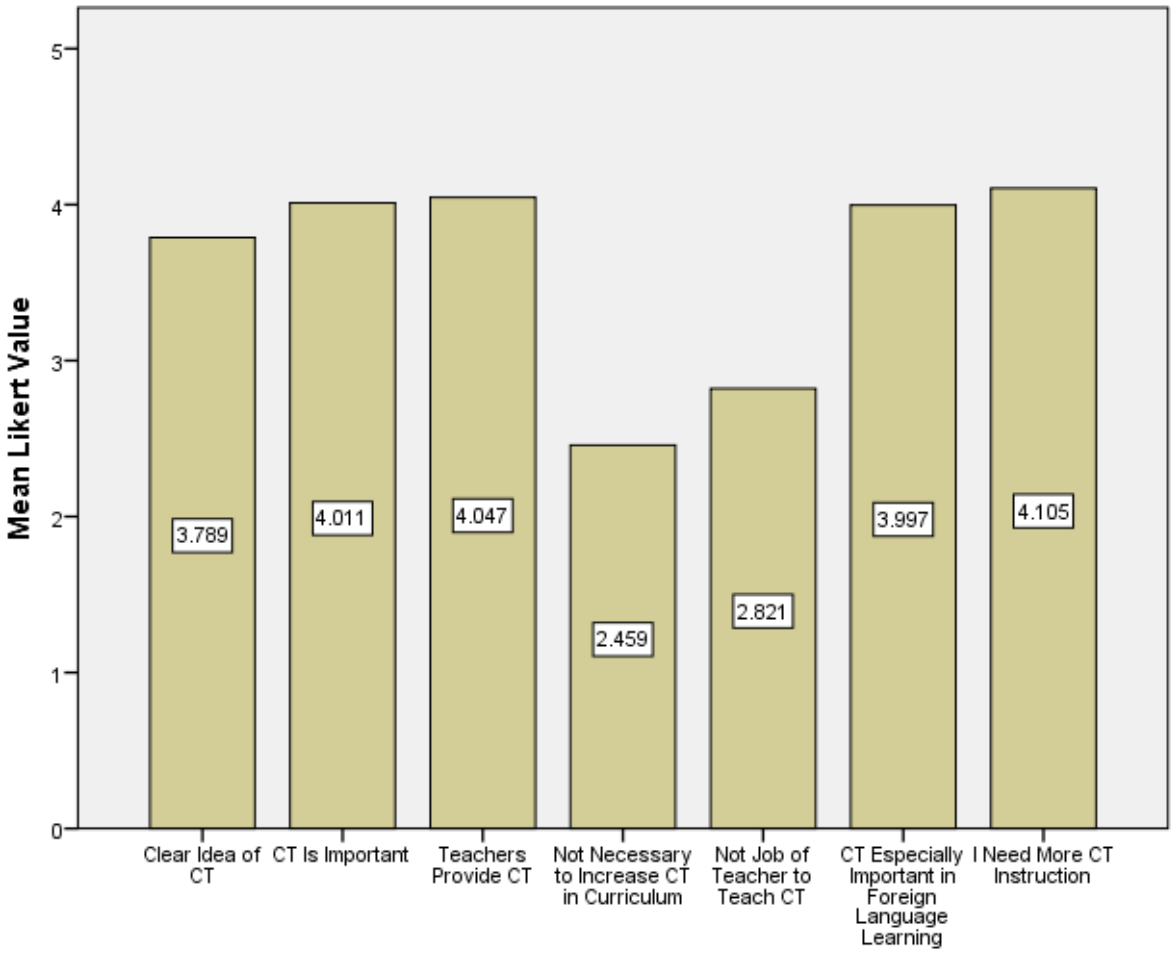


**Fig. 1.** Likert score averages for the Critical Thinking Survey.
*Note*. Questions appear in order from one to seven.

Learners also tended to feel that CT was important in the classroom. Concerning general classes, perceived importance yielded a Likert score value of 4.01. Concerning foreign language classes specifically, perceived importance nearly reached a value of 4 (3.997). Although students tended to perceive CT to be important, they may not be able to clearly define what CT is. The first survey question, which asked if learners could define what CT is, had a lower Likert score of 3.79. Overall, results suggest that learners

identify the importance of CT but also need increased instruction to clearly define the skills needed for critical inquiry and analysis.

Concerning negative attitudes about CT in questions four and five, the Likert averages are much lower, ranging from 2.4 to 2.8. Lower values suggest that learners predominantly recognize the importance of CT. Some learners, however, may feel that the expansion of CT curricula and instruction is largely unnecessary.

### *5.2. Research Question Two: AI Usage for Writing Tasks*

Results of the AI usage survey for different writing tasks revealed very similar overall Likert averages, suggesting moderate use of AI to assist with each language task (See Table 1). All of the averages were in the Somewhat True range. Using AI to write an assignment or paper had the lowest value. Although not largely different, tasks like brainstorming, checking content, and checking grammar had the highest overall averages, each of which was slightly higher than 3.40. This finding suggests that learners use AI more often for brainstorming, checking content, and checking grammar.

**Table 1**
*Likert Score Averages for the AI Usage Survey*

| | AI Usage Survey | | | | | | |
|---|---|---|---|---|---|---|---|
| | Brainstorm or get ideas for my paper | Find articles to use for my writing | Write an outline | Revise or edit my writing | Check and improve the content of my writing | Check and improve the grammar of my writing | Write a homework assignment or paper |
| Mean | 3.45 | 3.34 | 3.28 | 3.39 | 3.44 | 3.43 | 3.10 |
| N | 546 | 544 | 544 | 544 | 546 | 544 | 546 |
| Std. Deviation | .791 | .838 | .903 | .866 | .786 | .804 | 1.067 |

### *5.3. Research Question Three: Relationships between Attitudes about CT and AI Usage*

Spearman rho correlations revealed several significant relationships between critical thinking and the use of AI for different writing tasks (See Table 2). First, students with a clear idea of CT (CT survey question 1) reported using AI for brainstorming and checking content or grammar, yet avoided using AI to find articles, write an outline, or write an essay draft. This finding may suggest that clear conceptualization of cognition promotes positive use of technology for writing. Although learners with knowledge of CT used AI to gain initial ideas or check work, they did not use it to structure or develop their arguments for the paper. Heightened awareness of cognition may promote independent connection of ideas (e.g., outlining) and expansion of analysis (e.g., drafting) without technological assistance.

Learners who thought that CT was unnecessary revealed a tendency to use AI for drafting a paper. For example, learners who felt that additional CT was not needed for class tended to use AI for writing homework assignments or composing essays ($r_s$ = .17; $p$ = .000). Notably, this correlation was the highest in Table 2. This finding may highlight the importance of providing CT instruction to reduce overreliance on AI for writing. Learners who thought providing CT was not the teacher's job also tended to use AI for writing homework assignments or papers, even though the correlation was not significant at a < .05 ($r_s$ = .08; $p$ = .07). Findings may reflect the impact of AI on critical thinking and brain activity, which was reported by Kosmyna et al. (2025). Learners with AI dependency may have less brain activity and decreased critical thinking, leading to the belief that CT is not important. Through relying on AI to write drafts, learners may also place less focus on different stages of the writing process, explaining why correlations

are not generally significant for tasks other than drafting. Learners who regard CT to be unnecessary may need special training; they may need instruction which promotes an appreciation for critical thinking skills at each stage of the writing process.

In addition to learners who did not think that CT was necessary, learners who identified a personal need for more CT instruction used AI to draft homework assignments and papers ($r_s$ = .10; $p$ = .02). However, these learners also reported using AI during different phases the writing process: finding articles, writing an outline, revising/editing, checking content, and checking grammar. Through reporting a need to have more CT instruction, these learners reflect self-awareness of cognitive weaknesses, as well as a genuine desire to learn. Perceived weaknesses may be counterbalanced through a reliance on AI. At the same time, a desire to learn may drive extensive use of AI at each stage of the writing process. Technological assistance may serve as a compensatory strategy for learners who genuinely want to write effectively. Correlations for these learners were the highest and most significant at each stage of the writing process, perhaps reflecting an overreliance on AI due to insufficient CT skills.

**Table 2**
*Correlations between CT Values and AI Use for Writing Tasks*

| Correlations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Brainstorm or get ideas for my paper | Find articles to use for my writing | Write an outline | Revise or edit my writing | Check and improve the content of my writing | Check and improve the grammar of my writing | Write a homework assignment or paper |
| Clear Idea of CT | $r_s$ | .089* | .060 | .050 | .061 | .097* | .110* | -.025 |
| | *P* | .043 | .173 | .260 | .167 | .027 | .013 | .573 |
| | *N* | 517 | 516 | 515 | 515 | 517 | 515 | 517 |
| CT Is Important | $r_s$ | .040 | .118** | .109* | .110* | .156** | .159** | -.002 |
| | *P* | .369 | .007 | .013 | .013 | .000 | .000 | .960 |
| | *N* | 516 | 515 | 514 | 514 | 516 | 514 | 516 |
| Teachers Provide CT | $r_s$ | .090* | .073 | .098* | .113* | .135** | .121** | .010 |
| | *P* | .040 | .098 | .026 | .011 | .002 | .006 | .823 |
| | *N* | 517 | 516 | 515 | 515 | 517 | 515 | 517 |
| Not Necessary to Increase CT in Curriculum | $r_s$ | .005 | .065 | .050 | .090* | -.001 | .039 | .173** |
| | *P* | .917 | .143 | .255 | .042 | .978 | .372 | .000 |
| | *N* | 516 | 515 | 514 | 514 | 516 | 514 | 516 |
| Not Job of Teacher to Teach CT | $r_s$ | -.025 | .022 | -.026 | .035 | .034 | -.020 | .080 |
| | *P* | .572 | .614 | .560 | .429 | .435 | .645 | .071 |
| | *N* | 517 | 516 | 515 | 515 | 517 | 515 | 517 |
| CT Especially Important in Foreign Language Learning | $r_s$ | .063 | .044 | .132** | .090* | .121** | .138** | .030 |
| | *P* | .152 | .313 | .003 | .042 | .006 | .002 | .500 |
| | *N* | 517 | 516 | 515 | 515 | 517 | 515 | 517 |
| I need more instruction from a teacher in how to develop CT | $r_s$ | .053 | .119** | .144** | .133** | .180** | .149** | .099* |
| | *P* | .226 | .007 | .001 | .003 | .000 | .001 | .024 |
| | *N* | 517 | 516 | 515 | 515 | 517 | 515 | 517 |

Learners who believed that CT was important tended to avoid using AI to draft papers or complete homework assignments. However, they did use AI for outlining, editing, and revision. Learners who place importance on CT may realize the importance of brainstorming and developing their own ideas through drafting. Results suggest that helping learners to identify the importance of CT could promote cognitive skills for creativity and analysis while decreasing dependence on AI when writing.

Overall, results suggest that learners who lack an appreciation of CT tend to use AI more often when writing a paper or doing homework assignments, which may reveal less cognitive engagement. In contrast, learners who appreciate CT tend to use AI tools primarily for outlining, revision, and editing. These findings may have distinct implications for pedagogy and training. Cultivating awareness of critical thinking skills may be an important element of AI-assisted writing classrooms, helping to reduce cognitive dependence on AI. For learners who lack an awareness of CT, more regimented oversight of AI tool use may also be required. Concerning learners with an appreciation of CT, metacognitive reflection may be needed for precise tasks associated with increased AI tool use, which include outlining, revision, or editing. Educators may also prompt metacognitive reflection on technological tool use more consistently at each stage of the writing process, ensuring that learners carefully consider their reliance, or possibly overreliance, on technological tools. It is important to note that cultural values and educational traditions may impact what CT training is needed. Learners and educators from Chinese EFL contexts, for example, often hold collective cultural beliefs that promote uniformity and adherence to authority. CT training designs will need to cultivate an appreciation for local cultural values while encouraging problem-solving skills, cognitive engagement, and effective writing.

While the current study provides new insights, further research to assess how writers use AI technology will be needed. Additionally, weak correlations in the present study ($r_s$ < 03) require further research to ascertain their true impact on the learning process. More comprehensive investigation of CT dispositions is needed in conjunction with other variables that affect the writing process. Such inquiry can give us a clear and comprehensive understanding of how variables interact to influence the writing process.

## 6. Conclusion

The present study reveals a clear relationship between different levels of knowledge or support for CT and AI-assisted writing habits. Learners who thought that CT was important tended to use AI in a more limited capacity, for outlining or revision. These learners report more individual cognitive effort when conceptualizing and drafting papers. In contrast, learners who thought that CT was unnecessary or perceived weaknesses in their own ability used AI more often to draft papers. Relying on AI to write papers reveals a key weakness in cognitive effort, which may require specialized training. Learners without knowledge or support for CT may need instruction emphasizing critical inquiry and creativity. They may also need training that promotes positive AI tool use while simultaneously decreasing technological dependence. For learners with awareness and appreciation of CT, careful monitoring of AI tool use may be needed for specific activities such as outlining, revision, and editing. Finally, all learners may benefit from careful reflection of AI tool use and cognitive activity at each stage of the learning process. Such assistance can help ensure that AI assistance complements cognitive efforts to brainstorm, conceptualize, construct, and draft essays.

Results of the present study appear to have distinct implications for pedagogy and curriculum design. Overall, the significant links suggest that training in CT may help to promote responsible use of AI, just as training in responsible use of AI may promote CT skills. Integrating reflective tasks at each stage of the writing process may make AI-assisted instructional tasks more effective, ensuring maximal student engagement. While the present study provides important insights about the relationship between CT and AI-assisted writing, it is important to note that correlation does not ensure causation. More experimental study will be needed to help educators understand the causal links between variables. With a more precise understanding, educators can more accurately predict how CT training and AI-assisted language learning will affect the learner, leading to better pedagogical choices that enhance writing instruction.

## 7. Limitations and Suggestions for Further Research

More experimental study will be needed to help educators understand the causal links between variables, which can allow for curricular reform that will maximize student effort and effective use of AI in the writing process. While the present study provided some useful data for interpretation, its design could not be used to establish causal relationships between CT dispositions and AI tool use. The study's design was also limited in its evaluation of diverse learner characteristics. For example, different perspectives related to university major were not examined, despite having a potential impact on writing or AI tool use. The population examined in the study was also limited to college students from one regional university in mainland China, which precludes generalizability of results to other populations. In order to provide a more complete perspective of how learners conceptualize CT and use AI for writing, further experimental study of diverse learner populations is needed.

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## Appendix A

### Critical Thinking Survey*

1. **Not at all true**
2. **Not true**
3. **Somewhat true**
4. **True**
5. **Very true**

1. I have a clear idea of what the term critical thinking‘ means.
2. Learning critical thinking is an important part of my study as a student.
3. Teachers give us the training of critical thinking in many courses.
4. It is not necessary to increase the role of critical thinking into the curriculum.
5. It is not the job of the teacher to teach critical thinking in the classroom.
6. Critical thinking is especially important in foreign language learning.
7. I need more instruction from teachers about how to train critical thinking skills.

*Adapted from Zhang (2022)

## Appendix B

### Principle Component Analysis for the Critical Thinking Survey

**Total Variance Explained**

| | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|---|---|---|
| Component | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 2.805 | 40.070 | 40.070 | 2.805 | 40.070 | 40.070 | 2.805 | 40.069 | 40.069 |
| 2 | 1.597 | 22.820 | 62.890 | 1.597 | 22.820 | 62.890 | 1.597 | 22.821 | 62.890 |
| 3 | .752 | 10.750 | 73.640 | | | | | | |
| 4 | .513 | 7.333 | 80.973 | | | | | | |
| 5 | .501 | 7.164 | 88.137 | | | | | | |
| 6 | .439 | 6.272 | 94.409 | | | | | | |
| 7 | .391 | 5.591 | 100.000 | | | | | | |

Extraction Method: Principal Component Analysis.

**Rotated Component Matrix[a]**

| | Component | |
|---|---|---|
| | 1 | 2 |
| Clear Idea of CT | .697 | |
| CT Is Important | .787 | |
| Teachers Provide CT | .791 | |
| Not Necessary to Increase CT in Curriculum | | .891 |
| Not Job of Teacher to Teach CT | | .886 |
| CT Especially Important in Foreign Language Learning | .786 | |
| I need more instruction from teacher in how to develop CT | .671 | |

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

## Appendix C

## Survey of AI Usage for Writing

1. **Not at all true**
2. **Not true**
3. **Somewhat true**
4. **True**
5. **Very true**

I often use AI (DeepSeek, ChatGPT, etc.) to do the following:

1. Brainstorm or get ideas for my paper.
2. Find articles to use for my writing.
3. Write an outline.
4. Revise or edit my writing.
5. Check and improve the content of my writing.
6. Check and improve the grammar of my writing.
7. Write a homework assignment or paper.

# Appendix D

## Principle Component Analysis for the Survey of AI Usage for Writing

**Total Variance Explained**

| | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| Component | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 3.285 | 46.922 | 46.922 | 3.285 | 46.922 | 46.922 |
| 2 | .929 | 13.268 | 60.190 | | | |
| 3 | .749 | 10.702 | 70.892 | | | |
| 4 | .655 | 9.357 | 80.249 | | | |
| 5 | .522 | 7.460 | 87.709 | | | |
| 6 | .488 | 6.964 | 94.673 | | | |
| 7 | .373 | 5.327 | 100.000 | | | |

Extraction Method: Principal Component Analysis.

**Component Matrix[a]**

| | Component |
|---|---|
| | 1 |
| 1. Brainstorm or get ideas for my paper. | .610 |
| 2. Find articles to use for my writing. | .636 |
| 3. Write an outline. | .734 |
| 4. Revise or edit my writing. | .739 |
| 5. Check and improve the content of my writing. | .721 |
| 6. Check and improve the grammar of my writing. | .741 |
| 7. Write a homework assignment or paper. | .597 |

Extraction Method: Principal Component Analysis.

a. 1 components extracted.