AI-Assisted Writing: How Gemini Reduces Cognitive Load among ESL Learners

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ABSTRACT

Writing in a second language imposes a heavy dual-task burden, causing extraneous cognitive overload that hinders higher-order composition goals. This study investigated the efficacy of Gemini in reducing intrinsic, extraneous, and germane cognitive load among English as a Second Language (ESL) learners. Data were collected through a quantitative survey design using a 10-section questionnaire administered to 135 respondents across different genders and academic disciplines (science and technology, and social sciences). The results show that Gemini significantly reduces the unnecessary cognitive load, especially in terms of translation (M = 4.16) and linguistic support. Moreover, the tool improves relevant loads by increasing student engagement (M = 4.01) and stimulating critical thinking through the evaluation of different perspectives. Similar cognitive benefits were observed for all demographic characteristics. Ultimately, Gemini works as a "cognitive partner" that takes learners from localised error monitoring to the overall rhetorical techniques. This study promotes the incorporation of AI-assisted scaffolding into ESL curriculum to shift writing teaching from basic mechanical accuracy to critical assessment and creative synthesis.

Keywords: Gemini AI, ESL Writing, Cognitive Load Theory, Generative AI, Metacognitive Strategies, Linguistic Scaffolding.

INTRODUCTION

1.1 Background of the Study

The production of text in a second language is a complicated activity which involves the simultaneous coordination of macro-level planning and micro-level execution. Cognitive overload is common with English as a Second Language (ESL) learners who are struggling with foreign grammar structures, vocabulary limitations, and cultural mechanics, while trying to formulate creative ideas. According to Sweller's (2024) Cognitive Load Theory, this psychological bottleneck arises because the working memory capacity of an ESL learner is finite and is fully consumed by the intrinsic load of language mechanics, leaving little mental energy for higher-order rhetorical expression and critical thought. However, the emergence of advanced Large Language Models (LLMs) like Google's Gemini has shifted this educational landscape. These tools do more than spell check; they serve as "cognitive scaffolds" in Vygotsky's Zone of Proximal Development. They create a collaborative environment that affects how to manage language anxiety and mental exhaustion during the process of writing.

Generative AI has received much recent attention in the educational literature, but this study is quite pertinent in that it moves the scholarly focus from the end written result to the interior cognitive process of the writer. The topics of plagiarism, grading, and essay quality have dominated the discourse around early AI research. In contrast, this work focuses on the psychological mechanics that are happening continuously in the learner's mind during human-AI collaboration. Furthermore, emerging empirical frameworks, such as the Cognitive Load Scale

for AI-assisted L2 Writing, warn that AI can have both positive and negative effects. Gemini can alleviate linguistic fatigue but at the expense of imposing a new cognitive cost, termed AI-management fatigue, which entails a cognitive effort on the part of learners to control prompts and critically evaluate AI outputs.

This research directly addresses this issue, exploring whether the addition of the Gemini protocol leads to a decrease in cognitive load or just a reallocation of traditional language stress to a new digital burden. Ultimately, readers should approach this work with the notion that Gemini is explored not as an automation hack to skip writing but as an external cognitive partner. The research examines the impact of several platform architectures on the writing habits of non-native speakers, assessing the distinctive pedagogical features of Gemini, including its real-time web integration, source verification tools, and adaptive feedback systems that promote active learning. In order to transfer the lower-order technical mechanics to an AI collaborator, ESL learners may free up important working memory capacity. The purpose of this experiment is to find out if scaffolding makes the usually draining L2 writing process a more lucid, highly metacognitive and less demanding learning experience.

1.2 Statement of Problem

Recent research on AI-assisted writing has mostly focused on product-oriented outcomes such as plagiarism detection, grading efficiency, and essay quality (Li & Hafner, 2023; Zou et al., 2024). Although these studies have enhanced comprehension of generative AI in educational settings, they risk reducing writing to a mechanical product, neglecting the cognitive processes that transpire within the learner during production. This limited focus overlooks writing as a metacognitive process of meaning construction. Research on Cognitive Load Theory (Sweller, 2024; Kalyuga, 2023) consistently emphasises the cognitive challenges faced by ESL students in managing language mechanics alongside advanced rhetorical tasks. However, empirically it is not yet known how AI technologies respond to these difficulties. Instead, much of the research positions AI as either a promoter of linguistic precision or a danger to academic integrity. The subject of AI as a cognitive scaffold remains unanswered.

Recent frameworks, as the Cognitive Load Scale for AI-assisted L2 Writing (Chen & Zhang, 2025), indicate that while AI can mitigate language-related difficulties, it also necessitates more effort to effectively manage the AI tools. Students must utilise cognitive resources for formulating enquiries, validating sources, and evaluating AI results. AI may not only reduce workloads but also reallocate them to new domains of activity. The study gap pertains to the insufficient investigation of how advanced LLMs, such as Gemini, influence the internal cognitive processes of ESL learners in writing.

Recent studies (e.g., Liu & Park, 2025) advocate for further research on the psychological foundations of human-AI collaboration and urge scholars to transcend superficial product evaluation in favour of process-oriented inquiry. This study investigates whether Gemini serves as a genuine cognitive companion that reduces overall mental strain or simply substitutes old linguistic challenges with new digital demands.

1.3 Objective of the Study and Research Questions

The objective of this study is to explore Gemini's potential to reduce cognitive load in writing. Specifically, this study is done to answer the following questions:

i. Is there any significant relationship between (a) Cognitive Load and (b) Gemini across gender?

$H_{o1:}$ There is no significant relationship between (a) Cognitive Load and (b) Gemini across gender

ii. Is there any significant relationship between (a) Cognitive Load and (b) Gemini across disciplines?

$H_{o2:}$ There is no significant relationship between (a) Cognitive Load and (b) Gemini across disciplines

iii. How do learners perceive intrinsic cognitive load in writing?

iv. How do learners perceive extraneous cognitive load in writing?

v. How do learners perceive germane cognitive load in writing?

vi. How do learners perceive the use of Gemini in writing?

vii. Is there a relationship between Gemini and writing strategies to reduce cognitive load?

$H_{o3:}$ There is no significant relationship between Gemini and writing strategies to reduce cognitive load.

LITERATURE REVIEW

2.1 Theoretical Framework of the Study

(a) Cognitive Load Theory in the Writing Process

Cognitive Load Theory (CLT) was first proposed by Sweller (1988) and subsequently developed by Plass et al. (2010), which states that the human working memory is limited in capacity and that surpassing this limit is an impediment to processing and retaining information. In the case of ESL writing, learners usually have to deal with an excessive extraneous cognitive load since they have to handle complicated linguistic encoding, including grammar, syntax, and vocabulary, along with the intrinsic burden of developing coherent ideas (Wang, 2024). CLT supports the writing process by offering a systematic approach for identifying intrinsic (task difficulty), extraneous (instructional format), and relevant (knowledge development) burdens to pinpoint where mental resources are being "wasted." This allows for the design of teaching technologies that remove lower-level linguistic demands, freeing up mental space for the relevant load required to master high-level rhetorical methods and deep learning.

(b) Gemini Assistance

Recent empirical literature increasingly frames Large Language Models (LLMs), specifically Google Gemini, as powerful, interactive "cognitive scaffolds" that alter the psychological landscape of second language (L2) writing. Traditional computer-assisted language learning tools primarily focused on passive error correction, whereas Gemini introduces a dynamic human-AI collaborative ecosystem that actively alleviates a learner's working memory capacity. The research demonstrates that Gemini markedly alleviates L2 writing anxiety and bolsters learners' confidence by providing immediate, contextually relevant feedback on vocabulary acquisition, grammar, and sentence construction, thereby effectively mitigating the inherent cognitive load linked to basic linguistic tasks (Azmi & Fithriani, 2025; Derakhshan, 2025). Furthermore, researchers observe that Gemini's distinctive architecture, characterised by its multimodal capabilities, real-time web access, and LearnLM active learning principles, enables learners to ground their writing in a contemporary academic context and semantic accuracy more effectively than text-only models (Gupta, 2024; Miguez Gordillo, 2026). Thus, by offloading these draining micro-level technical duties onto Gemini, ESL authors can reallocate their limited mental resources to higher - order metacognitive processing, global paragraph organisation, and unified rhetorical articulation.

2.2 Past Studies on Gemini and Writing

Recent literature has increasingly focused on the application of Gemini in academic writing, particularly for English as a Foreign Language (EFL) learners. Several key studies have highlighted its unique multimodal and web-integrated capabilities:

Pratiwi et al. (2024) examined the effect of the tool on the accuracy of the language, and found that Gemini considerably enhanced EFL learners' collocation skill and paragraph-level grammatical accuracy in a Paragraph Writing course.

According to Park and Gupta (2024), the multimodal characteristics of Gemini, which enable it to handle text, images and web-based data, make it particularly well-suited for vocabulary development, contextual understanding, and content relevance in academic writing.

Akhoon et al. (2024) conducted a comparative analysis of Gemini and ChatGPT-3.5 in the context of academic writing tasks. It was shown that Gemini attained 100% accuracy in research-based enquiries, but ChatGPT achieved 70%. The advantage was attributed to Gemini's incorporation into the Google ecosystem, which provides real-time data accessibility and accurate bibliographic references.

Barrot (2024) experimentally demonstrated that Gemini excels in organization and source integration, yielding a 20% enhancement in task performance for visually supported jobs. A substantial amount of study has been undertaken regarding the efficacy, cognitive impacts, and interaction dynamics of generative artificial intelligence, including Google Gemini, in academic writing. Kosmyna et al. (2025) investigated the neurophysiological expenses associated with essay writing using LLMs. They found that reliance on AI tools can result in "cognitive debt," where brain connection diminishes and memory recall of the produced material is severely degraded.

Kawinkoonlasate (2025) performed the study to explore (a) the relative usefulness of Google Gemini and ChatGPT for developing academic writing skills and (b) the motivating influence and practical barriers of their implementation in educational settings. The study examines the comparison between conversational and multimodal paradigms of AI feedback to determine their impact on language accuracy, essay form and learner engagement. The respondents are third-year university EFL learners taking a research writing course. There are 80 responses from two universities in Thailand. The instruments employed are pre- and post-writing assessments, a Likert-scale questionnaire influenced by the Technology Acceptance Model, semi-structured interviews, and teacher observation checklists. Findings showed that both AI tools enhanced linguistic accuracy and structure, with Google Gemini excelling in multimodal feedback and source integration, especially for rural learners, although its use raised concerns about overreliance and plagiarism. The authors recommend that teachers employ hybrid AI models adapted to low-resource environments and that these AI models be combined with intensive literacy education and instructor mentorship to ethically optimise advantages.

Subsequently, the study by Yao and Fan (2025) further investigated (a) the distinctive cognitive demands of human-AI collaborative writing and (b) the psychometric assessment of these demands. The present study aims to design and validate a multidimensional tool, the Cognitive Load Scale for AI-assisted L2 Writing (CL-AI-L2W), to systematically assess how cognitive resources are distributed when students co-write with AI. The respondents were mid-to-high L2 learners in Chinese institutions. The sample comprised 546 respondents, divided into an exploratory factor analysis sample (n=241) and a confirmatory factor analysis sample (n=305). The administered instruments were an AI-assisted argumentative writing assignment, the CL-AI-L2W questionnaire, the Second Language Writing Anxiety Inventory, a Writing Self-Efficacy Scale, and a Subjective Mental Effort Scale. The findings reveal a four-factor structure of cognitive load in AI writing: Prompt Management, Critical Evaluation, Integrative Synthesis, and Authorial Core Processing, with Critical Evaluation placing the highest cognitive demand on users. This study implies that it provides a crucial, validated instrument for future writing research and demonstrates the pedagogical necessity of training students in critical AI evaluation, as fact-checking AI output has become more mentally taxing than text generation itself.

Kosmyna et al. (2025) investigated (a) the cognitive cost of interacting with LLMs during an essay writing assignment and (b) the influence of doing so on text ownership, memory encoding, and brain connection. This research is about tracking the physical reality of "cognitive debt" by comparing the brain activity of writers using an LLM, a standard search engine or simply their minds. The respondents include adults and college students in the Boston region. Number of respondents 54 The tools employed are: Enobio 32 electroencephalography (EEG) headsets to evaluate dynamic Direct Transfer Function (dDTF) connection, pre- and post-assessment interviews, and Natural Language Processing (NLP) assessments judged by an AI judge and human teachers. The results suggest that participants who relied on LLMs had the weakest overall neural coupling (a considerable decline in focused attention and executive function), suffered severe deficits in short-term memory recall of their own writing, and felt a fragmented feeling of authorship. The implications of this study are that hasty reliance on LLMs postpones mental effort in the short term but incurs long-term cognitive costs, including reduced critical inquiry and memory consolidation. These findings suggest that educators must require students to engage in active, self-driven cognitive effort before employing generative tools.

Additionally, Fang et al. (2026) also examined (a) dynamic human-LLM co-writing interactions, and (b) the cognitive effort of editing necessary to incorporate AI ideas into the writing process. This work formalises proactive co-writing as a sequential decision process with a "Human-in-the-Loop" and evaluates it not just on output quality, but also on metrics that reflect user acceptance behaviour and cognitive friction. The responders are people with experience in academic writing. The user study includes 30 respondents and a wider simulation with 1,688 continuation queries. The instruments employed are a proprietary interactive co-writing interface, controlled document-continuation enquiries, and post-task questionnaires evaluating Perceived Workload, Usefulness, Customisation and Adaptability. Interactive, stateful proactive cooperation leads to a significant improvement in the accuracy of intent prediction, resulting in higher user acceptance rates and lower cognitive editing effort (as quantified by Knowledge-aware Editing Distance) than passive prompting. This work suggests that future writing assistants and pedagogical frameworks should be stage-aware and adaptive, as users need to shift between early-stage exploration and late-stage refinement, and systems should respect these boundaries to reduce cognitive load without undermining the writer's agency.

The literature presents a complex dichotomy of views on AI in writing, with researchers acknowledging the potential for Google Gemini and similar tools to improve linguistic accuracy, source integration, and efficiency, but also warning of serious ethical and neurocognitive risks, including erosion of working memory, loss of authorial voice, and cognitive debt. They contended that unguided AI aid compromises the deep neuronal processing and critical evaluation necessary for effective learning and text ownership. These findings make it clear that the answer to reducing Gemini's cognitive load difficulties while leveraging its strength is cognitive stewardship. The literature suggests that the tools themselves may contribute to cognitive atrophy, but it is believed that a highly structured pedagogical workflow in which students rely solely on their own cognition for brainstorming and drafting before invoking Gemini for targeted verification and multimodal refinement will preserve the writer's autonomy and working memory capacity while utilising AI's highest capabilities.

2.3 Conceptual Framework of the Study

Figure 1 below shows the conceptual framework of the study. This study integrates Cognitive Load Theory (Sweller, 1988; Raoofi et al., 2017; Youssef et al., 2024) to illustrate their interrelationship. Raoofi et al. (2017) assert that writers employ tactics including metacognitive, effort management, cognitive, social, and affective strategies during the writing process.

Sweller (1988) introduced the Cognitive Load theory, which explains how learning can be facilitated. The first is (i) intrinsic cognitive load, and learning is simplified by breaking down the complex information into steps. In this context, writing is facilitated by the use of metacognitive writing strategies, where writers depend on their planning skills to begin the writing process (Rahmat, 2021). The second Extraneous Cognitive Load is (ii) Extraneous Cognitive Load, and this refers to the difficulty of performing a task due to confusing irrelevant information. In the context of writing, the process of transferring information can confuse writers (Khairuddin et al., 2021), especially when it comes to conflicting information. This can be reduced when writers use strategies like Effort Regulation and Cognitive Writing strategies. The third and final type of Cognitive Load in learning is Germane Cognitive Load. This is actually a "good load" as this type of load helps learners process information and transfer the learned information into their long-term memory. In the context of writing, the mental resources are facilitated through Social and Affective writing strategies. The use of social strategies gives learners a sense of engagement, and this positive feeling increases learners' affective responses.

Today's technological age has introduced the use of Gemini to facilitate learners' work online. According to Youssef et al. (2024), the use of Gemini impacts learners' critical thinking abilities, academic achievement and engagement with writing.

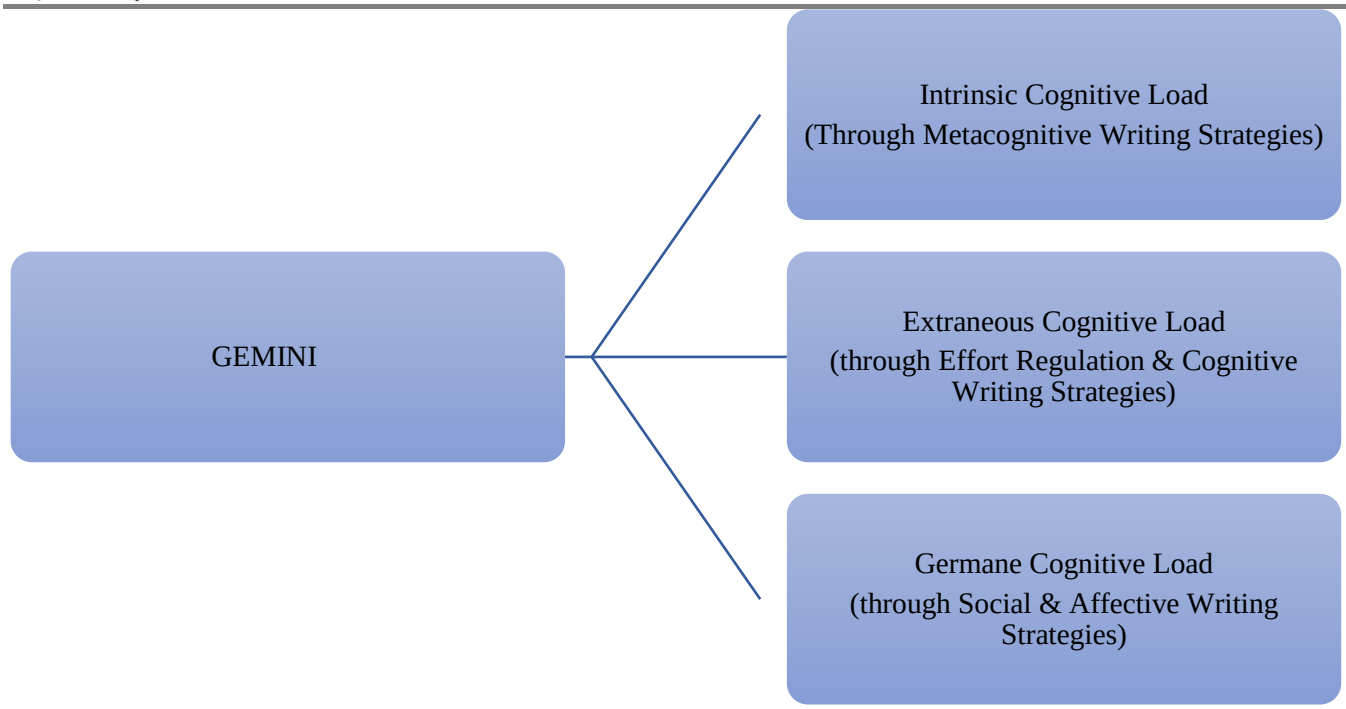

Figure 1- Conceptual Framework of the Study Gemini as a Mode to Reduce Cognitive Load in Writing

METHODOLOGY

In this study, a convenience sampling method was adopted where participants were chosen on the basis of their availability and willingness to participate. A total of 135 participants responded to the survey. This sample size is statistically adequate for quantitative analysis, exceeding the minimum thresholds required for parametric testing and ensuring a robust item-to-response ratio for the 5-point Likert scale instrument adapted from Sweller (1988), Raoofi et al. (2017), and Youssef et al. (2024). Table 1 below shows the categories used for the Likert scale: 1 is for Never, 2 is for Rarely, 3 is for Sometimes, 4 is for Often and 5 is for Always.

Table 1- Likert Scale Use

1	Never
2	Rarely
3	Sometimes
4	Often
5	Always

Table 2- Distribution of Items in the Survey

SECTION	VARIABLE	CONSTRUCT	NO OF ITEMS/ INDICATORS	
B	Intrinsic Cognitive Load	Metacognitive	10	.854
	Extraneous Cognitive Load	Effort Regulation	4	.862
		Cognitive	6	.
	Germane Cognitive Load	Social	4	.770

		Affective	3	
C	GEMINI	Critical thinking abilities	4	16 (.926)
		Academic achievement	4	
		Gemini usage	5	
		Student engagement	3	
				43(.946)

Table 2 outlines the structural distribution of items, constructs, and corresponding reliability coefficients (Cronbach's alpha) within the research instrument. The survey instrument was adapted from two primary validated sources in educational psychology and technology acceptance literature: the cognitive load and writing strategy items in Section B were adapted from Sweller (1988) and Oxford (1990). Strategy Inventory for Language Learning (SILL), while the AI interaction and engagement metrics in Section C were adapted from the Technology Acceptance Model (TAM) framework popularised by Davis (1989) and modified for generative AI systems by Zhai et al. (2021). The entire instrument comprises a total of 43 items and demonstrates excellent internal consistency, yielding an overall Cronbach's alpha of .946.

(i) Section B: Cognitive Load Variables (27 Items Total)

Section B captures the three core dimensions of cognitive load theory mapped against specific language learning strategies. It contains a total of 27 items distributed across five sub-constructs:

- Intrinsic Cognitive Load: Evaluated through *Metacognitive Strategies* with 10 items, demonstrating high reliability (Cronbach alpha = .854). These items assess how students organise, plan, and self-evaluate their writing.

- Extraneous Cognitive Load: Measured using two sub-constructs: *Effort Regulation* (4 items, Cronbach alpha = .862) and *Cognitive Strategies* (6 items). These indicators track the operational friction and mental stamina required to navigate language barriers and writing mechanics.

- Germane Cognitive Load: Measured via *Social Strategies* (4 items, Cronbach alpha = .770) and *Affective Strategies* (3 items). These items focus on how learners process deep learning schemas, handle emotional writing anxiety, and collaborate with peers to resolve conceptual blocks.

(ii) Section C: Gemini Integration Variables (16 Items Total)

Section C evaluates user interaction, cognitive impacts, and systemic perceptions of the AI tool. This section contains a total of 16 items and shows an exceptionally high reliability index (Cronbach alpha = .926). It is divided into four main indicator groups:

- Critical Thinking Abilities: Consists of 4 items that measure how verifying Gemini's outputs stimulates independent research and scepticism.

- Academic Achievement: Comprises 4 items tracking the perceived improvements in overall grade performance and guidance capability.

- Gemini Usage: Features 5 items that analyse the direct functional application of the model, specifically focusing on translation and content composition productivity.

- Student Engagement: Contains 3 items that evaluate the interactivity, ease of use, and human-like engagement level of the interface.

Table 3- Reliability Levels, Cronbach's Alpha Ranges, and Their Interpretations

Reliability Level	Cronbach's Alpha range	Interpretation
Excellent	0.9 and above	Indicates very high internal consistency
Good	0.80-0.89	Reflects strong internal consistency
Acceptable	0.70-0.79	Indicates acceptable internal consistency
Questionable	0.60-0.69	Reflects questionable internal consistency
Poor	Below 0.6	Indicates poor internal consistency

Table 3 presents the reliability levels by Ahmad et al. (2024) to help researchers determine the external reliability of the instruments selected. Table 2 also shows the survey reliability. The analysis shows a Cronbach alpha of .854 for intrinsic load, .862 for extraneous, .770 for germane load, and .926 for Gemini. The overall Cronbach's alpha for all 43 items is .946, thus indicating good reliability of the instrument used. The results are presented using further analysis with SPSS to answer the research questions for this study.

FINDINGS

2.4 Demographic Analysis

According to Zienefuss, et.al (2021), researchers report demographic data in percentages to establish sample representatives, and allow for generalizability to a larger population. The reporting also provides an overview of participants' characteristics. Percentages offer a clear and understandable picture of the sample makeup.

Table 4- Percentage for Demographic Profile

Question	Demographic Profile	Categories	Percentage (%)
1	Gender	Male	29%
		Female	71%
2	Discipline	Science & Technology	49%
		Social Sciences & Humanities	51%

Table 4 shows the demographic profile of the participants with a clear distribution of gender and academic discipline. The respondent pool is clearly dominated by females at 71%, with males making up the remaining 29%. In contrast, the distribution by academic discipline is almost balanced. 51% of the participants are related to the social sciences & humanities and 49% to science & technology. The balance of disciplines ensures that a wide range of needs in academic writing is addressed in the study, although the findings reflect the population of female ESL learners in these fields to a greater extent.

2.5 Inferential Statistics (significant difference)

According to Shah (2023), there are three main functions of a T-test. Firstly, T-tests are done to compare means. This test is also done to determine if the average scores (mean) or values of two groups, or one group against a known value, are different enough to be considered statistically meaningful and are not just due to random chance. Secondly, a T-test is done to test hypotheses. Researchers use t-tests to test hypotheses about means, such as whether a new treatment significantly impacts a variable or if there's a difference in performance between two distinct groups. Lastly, the T-test is used to identify significant differences. The output of a t-test provides

a p-value (significance value). If this p-value is below a predetermined threshold (often 0.05), it indicates a statistically significant difference, allowing researchers to conclude the populations from which their samples were drawn.

However, a one-way ANOVA (Analysis of Variance) is a statistical technique that compares the means of three or more independent (unrelated) groups to see if there is a statistically significant difference among them. It is a parametric test for the effect of a single independent variable (the factor) on a dependent variable.

4.2.1 Findings for Gender

This section presents data to answer research question 1: Is there any significant relationship between (a) Cognitive Load and (b) Gemini across gender?

$H_{o1:}$ There is no significant relationship between (a) Cognitive Load and (b) Gemini across gender

Table 5: T-Test for (a) Cognitive Load and (b) Gemini across gender

Group Statistics

	Q1:GENDER	N	Mean	Std. Deviation	Std. Error Mean
COGNITIVE_LOAD	MALE	39	3.7037	.44102	.07062
	FEMALE	96	3.8657	.47792	.04878
GEMINI	MALE	39	3.5881	.58818	.09418
	FEMALE	96	3.7630	.52353	.05343

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Significance One-Sided p	Two-Sided p	Mean Difference	Std. Error Difference	Lower	Upper
COGNITIVE_LOAD	Equal variances assumed	.074	.786	-1.825	133	.035	.070	-.16204	.08881	-.33769	.01362
	Equal variances not assumed			-1.888	75.989	.031	.063	-.16204	.08583	-.33298	.00890
GEMINI	Equal variances assumed	1.506	.222	-1.697	133	.046	.092	-.17488	.10307	-.37875	.02899
	Equal variances not assumed			-1.615	63.756	.056	.111	-.17488	.10829	-.39122	.04146

A two-sample t-test was performed to investigate the relationship between (a) Cognitive Load and (b) Gemini across gender. There were no significant differences between (a) Cognitive Load (p=.070) and (b) Gemini (p=.092) across genders.

4.2.2 Findings for Discipline

This section presents data to answer the research question 2: Is there any significant relationship between (a) Cognitive Load and (b) Gemini across disciplines?

$H_{o2:}$ There is no significant relationship between (a) Cognitive Load and (b) Gemini across disciplines

Table 6: T-Test for (a) Cognitive Load and (b) Gemini across disciplines

Group Statistics

	Q2:DIS	N	Mean	Std. Deviation	Std. Error Mean
COGNITIVE_LOAD	S&T	66	3.9265	.50685	.06239
	SS,H&B	69	3.7160	.41349	.04978
GEMINI	S&T	66	3.8324	.53046	.06530
	SS,H&B	69	3.5978	.54079	.06510

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means							
										95% Confidence Interval of the Difference	
		F	Sig.	t	df	Significance One-Sided p	Two-Sided p	Mean Difference	Std. Error Difference	Lower	Upper
COGNITIVE_LOAD	Equal variances assumed	3.237	.074	2.649	133	.005	.009	.21044	.07946	.05328	.36760
	Equal variances not assumed			2.637	125.488	.005	.009	.21044	.07981	.05248	.36839
GEMINI	Equal variances assumed	.031	.860	2.543	133	.006	.012	.23456	.09225	.05210	.41702
	Equal variances not assumed			2.544	132.913	.006	.012	.23456	.09221	.05218	.41694

A two-sample t-test was performed to investigate the relationship between (a) Cognitive Load and (b) Gemini across disciplines. The results show a highly significant difference for both baseline Cognitive Load (p = .009) and Gemini evaluation (p = .012). Therefore, H_02 is rejected. Science & Technology students experience significantly higher writing-related cognitive load (M = 3.9265) and report significantly higher utility and engagement with Gemini (M = 3.8324) compared to Social Science students. This suggests that students in technical disciplines experience more additional burden in writing academic content and depend more on Gemini as a required cognitive support to surmount language barriers.

2.6 Descriptive Statistics

Why is there a need to report the mean and standard deviation? According to Vetter (2017), mean (M) represents the average, or centre, of a data set. Standard deviation (SD) indicates the typical distance of individual observations from the mean, which shows the data's variability or spread. A low SD means the data points are clustered close to the mean, whereas a high. SD indicates they are more spread out.

2.6.1 Findings for Intrinsic Cognitive Load in Writing

This section presents data to answer research question 1: How do learners perceive intrinsic cognitive load in writing? In the context of this study, metacognitive writing strategies.

Table 7- Mean(M) and Standard Deviation (SD) for PLANNING STAGE—METACOGNITIVE (MWS)

ITEM	M	SD
MWSQ 1 I organize my ideas prior to writing.	3.70	0.68
MWSQ 2 I revise my writing to make sure that it includes everything I want to discuss in my writing.	4.01	0.76
MWSQ 3 I check my spelling.	4.14	0.83
MWSQ 4 I check my writing to make sure it is grammatically correct.	4.10	0.79
MWSQ 5 I evaluate and re-evaluate the ideas in my essay.	3.79	0.80
MWSQ 6 I monitor and evaluate my progress in writing.	3.71	0.78
MWSQ 7 I revise and edit an essay two or more times before I hand it in to my teacher.	3.90	0.96
MWSQ 8 I go through the planning stages in my writing.	3.79	0.75
MWSQ 9 I go through the drafting stages in my writing.	3.60	0.90
MWSQ 10 I go through the revising and editing stages in my writing.	3.79	0.77

Based on the data in Table 7, the analysis of the Planning Stage for Metacognitive Writing Strategies (MWS) reveals that students heavily prioritise surface-level editing and mechanical correctness over initial conceptual planning and drafting. Students demonstrated the highest engagement with final-polish strategies, specifically checking spelling (MWSQ3) and ensuring grammatical correctness (MWSQ4: M=4.10, SD=0.79), alongside a strong commitment to ensuring all intended content is included (MWSQ2: M=4.01, SD=0.76). Conversely, the lowest levels of agreement were found in the foundational stages of writing, particularly in executing distinct drafting phases (MWSQ9: M=3.60, SD=0.90) and pre-writing organisation (MWSQ1: M=3.70, SD=0.68). Interestingly, while many students claim to revise and edit their essays multiple times (MWSQ7: M=3.90), this item yielded the highest standard deviation (SD=0.96), indicating a notable polarisation where some students frequently iterate on their drafts while others rarely do. Overall, these findings suggest that while the students

possess highly developed metacognitive awareness during the post-writing and evaluative phases, they underutilise systematic structuring and drafting strategies at the beginning of the writing process.

2.6.2 Findings for Extraneous Cognitive Load in Writing

This section presents data to answer research question 2: How do learners perceive extraneous cognitive load in writing? In the context of this study, this is measured by (i) Effort Regulation and (ii) Cognitive Strategies.

Table 8- Mean(M) and Standard Deviation (SD) for EFFORT REGULATION (ERS)

ITEM	M	SD
ERSQ 1I write a lot to develop my writing skills.	3.34	0.84
ERSQ 2I often work hard to do well in my writing, even if I don't like English writing tasks.	3.80	0.93
ERSQ 3: Even if the writing activities are difficult, I don't give up but try to engage in them.	4.10	0.75
ERSQ 4I concentrates as hard as I can when doing a writing task.	4.14	0.67

Table 8 shows that learners generally demonstrate strong effort regulation when facing writing tasks, indicating effective management of extraneous cognitive load. The highest mean scores for items on persistence concentration (ERSQ 3 and ERSQ 4) reveal that most students remain engaged and focused even when writing is challenging, with low variability suggesting consistent agreement. Meanwhile, moderate scores for practicing writing (ERSQ 1) and working hard despite disinterest (ERSQ 2) imply that while learners value improvement, motivation may fluctuate depending on task appeal. Overall, the results suggest that learners possess positive self-regulatory behaviours, maintaining attention and perseverance as strategies to minimise cognitive strain and enhance writing performance.

B. Table 9- Mean(M) and Standard Deviation (SD) for TRANSLATING STAGE-COGNITIVE (CWS)

ITEM	M	SD
CWSQ 1 I use memorised grammatical elements such as singular and plural forms, verb tenses, prefixes and suffixes, etc, in my writing	3.63	0.86
CWSQ 2I put newly memorised vocabulary in my sentences.	3.72	0.81
CWSQ 3In order to generate ideas for my writing, I usually engage myself in brainstorming.	3.76	0.83
CWSQ 4I use different words that have the same meaning.	3.71	0.84
CWSQ 5I use my experiences and knowledge in my writing.	4.16	0.73
CWSQ 6I try to use effective linking words to ensure a clear and logical relationship between sentences or paragraphs	3.85	0.82

The data in Table 9 reveal that learners employ a range of cognitive strategies during the translating stage of writing, with generally high mean scores indicating active engagement in constructing meaning. The strongest agreement appears in CWSQ 5 (M = 4.16), showing that students frequently draw on personal experiences and knowledge to enrich their writing, a sign of deep cognitive involvement. Similarly, CWSQ 6 (M = 3.85) suggests consistent use of linking words to ensure coherence. Moderate means for grammar use, vocabulary application,

brainstorming, and synonym substitution (M ≈ 3.6–3.7) imply that while these strategies are common, they vary among individuals. Overall, the results point to learners' balanced use of both linguistic and conceptual strategies, reflecting effective cognitive processing and self-regulation in transforming ideas into written text.

2.6.3 Findings for Germane Cognitive Load in Writing

This section presents data to answer research question 3: How do learners perceive germane cognitive load in writing? In the context of this study, this is measured by; (i) Social and (ii) Affective writing strategies

(i) Table 10- Mean(M) and Standard Deviation (SD) for SOCIAL (SWS)

ITEM	M	SD
SWSQ1 In order to generate ideas for my writing, I usually discuss the writing topic with a friend or classmate.	3.74	0.84
SWSQ 2After revising and editing my essay thoroughly, I ask a friend or my classmate to read and comment on it.	3.49	0.90
SWSQ 3I try to identify friends or classmates whom I can ask for help in my writing.	3.76	0.93
SWSQ 4 When I have trouble writing my essay, I try to do it with my classmates or friends.	3.80	0.95

Table 10 indicates a strong tendency among students to utilise social writing strategies (SWS), with mean scores ranging from 3.49 to 3.80. Students most frequently collaborate when facing difficulties (M = 3.80, SD = 0.95), followed closely by seeking peer assistance (M = 3.76, SD = 0.93) and discussing topics to generate ideas (M = 3.74, SD = 0.84). Conversely, asking peers for feedback after independent revision (M = 3.49, SD = 0.9) is the least used strategy, though it shows the highest response variability. Overall, these findings demonstrate that students highly value collaborative peer support during their writing process.

(ii) Table 11- Mean(M) and Standard Deviation (SD) for AFFECTIVE (AWS)

ITEM	M	SD
AWSQ1I try to write an essay in class with confidence and ease	3.69	0.85
AWSQ2I try to relax whenever I feel afraid of writing.	3.91	0.75
AWSQ3I encourage myself to write even when I am afraid of making mistakes	3.96	0.80

Table 11 reveals that students actively employ affective writing strategies (AWS) to manage their emotions, with high mean scores across all items. The most prominent strategy is self-encouragement despite the fear of making mistakes (M = 3.96, SD = 0.80), closely followed by conscious efforts to relax when feeling anxious about writing (M = 3.91, SD = 0.75). Attempting to write in class with confidence and ease yielded the lowest mean (M = 3.69, SD = 0.85). Overall, these low standard deviations indicate consistent consensus among students, demonstrating a robust reliance on emotional self-regulation to overcome writing anxiety.

2.6.4 Findings for Gemini

This section presents data to answer the research question 4: How do learners perceive the use of Gemini in writing? In the context of this study, this is measured by (i) critical thinking abilities, (ii) academic achievement, (iii) Gemini usage, and (iv) students' engagement.

(i) Table 12- Mean(M) and Standard Deviation (SD) for CRITICAL THINKING ABILITIES (CT)

ITEM	M	SD
CTQ1 I usually need clarification on the precision and reliability of information provided by Gemini, which enhances my critical thinking skills.	3.41	0.86
CTQ2 Gemini's responses made me doubt their validity, leading me to seek further clarification or evidence.	3.42	0.90
CTQ3 I actively explore alternative viewpoints or sources of information when using Gemini to ensure a comprehensive understanding of the topic.	3.61	0.74
CTQ4I need clarification about the accuracy of Gemini's output, which often encourages me to evaluate the information and conduct additional research independently.	3.55	0.78

Table 12 highlights how Gemini acts as a catalyst for evaluative thought rather than just a passive information source. The data shows that learners are most active in cross-referencing information, with CTQ3 ("I actively explore alternative viewpoints or sources of information when using Gemini to ensure a comprehensive understanding of the topic.") receiving the highest mean of M=3.61 (SD=0.74). This suggests that the AI's output encourages a "trust but verify" mindset among ESL learners. While items CTQ1 and CTQ2 show slightly lower means (M=3.41 and M=3.42, respectively), they indicate that the occasional ambiguity or perceived invalidity of AI responses actually serves a pedagogical purpose by prompting students to seek further evidence and conduct independent research. Overall, the results suggest that Gemini promotes a healthy level of scepticism and independent inquiry.

(ii) Table 13- Mean(M) and Standard Deviation (SD) for ACADEMIC ACHIEVEMENTS (AA)

ITEM	M	SD
AAQ1 I actively explore alternative viewpoints or sources of information when using Gemini to ensure a comprehensive understanding of the topic.	3.45	0.76
AAQ2 Gemini brings innovative ideas that are ready to be shared with students.	3.87	0.79
AAQ3 Students can anticipate robust writing guidance from Gemini.	3.80	0.76
AAQ4 Gemini has improved my academic performance.	3.70	0.76

The data in Table 13 show that students generally have a positive impact on their Academic Achievements (AA) from the use of Gemini, appreciating its utility in the creative and structural dimensions. Notably, respondents appreciate the AI's capacity to produce innovative and classroom-ready ideas (AAQ2: M = 3.87, SD = 0.79) and provide comprehensive guidance throughout the writing process (AAQ3: M = 3.80, SD = 0.76), leading to a shared impression that the tool actively boosts their overall academic performance (AAQ4: M = 3.70, SD = 0.76). However, relatively lower agreement on actively cross-checking alternative sources or viewpoints (AAQ1: M = 3.45, SD = 0.76) indicates a potential vulnerability towards passive acceptance of AI-generated content. The low standard deviations (0.76 to 0.79) across all items indicate a significant group consensus. Ultimately, Gemini is a useful catalyst for academic productivity and writing support, but these findings point to a need for more critical digital literacy, encouraging students to actively triangulate AI insights with independent research.

(iii) Table 14- Mean(M) and Standard Deviation (SD) for GEMINI USAGE (CU)

ITEM	M	SD
CUQ1 Gemini is a state-of-the-art writing model that is favourably used today.	3.67	0.74

CUQ2 Students seek help from Gemini's assistance in composing essays and articles.	3.81	0.77
CUQ3 Gemini helps students in English language translation.	4.16	0.76
CUQ4 Employing Gemini significantly improves human productivity.	3.72	0.88
CUQ5 The advent of Gemini marks a groundbreaking transformation in Natural Language Processing capabilities.	3.80	0.79

Based on the data in Table 14, the analysis and interpretation of Gemini Usage (CU) reveals that students predominantly leverage the model for linguistic support and academic composition, recognising its profound impact on productivity and technological advancement. Respondents demonstrated the highest level of agreement regarding the tool's utility in English language translation (CUQ3: M = 4.16, SD = 0.76), followed closely by its practical application as an assistant for composing essays and articles (CUQ2: M = 3.81, SD = 0.77). Students also recognized the broader technological significance of the AI, acknowledging it as a ground-breaking transformation in Natural Language Processing capabilities (CUQ5: M = 3.80, SD = 0.79) and a significant driver of human productivity (CUQ4: M = 3.72, SD = 0.88), though CUQ4 also exhibited the highest variation in responses, indicating slight differences in how effectively individual users experience these productivity gains. The lowest, yet still favourable, mean was found in the general perception of Gemini as a state-of-the-art writing model widely used today (CUQ1: M = 3.67, SD = 0.74). Overall, these findings suggest that Gemini is not just a passive technological novelty, but an actively integrated and highly valued cognitive tool that heavily optimises language processing, translation and academic writing workflows for students.

(iv) Table 15- Mean(M) and Standard Deviation (SD) for STUDENT ENGAGEMENT (SE)

ITEM	M	SD
SEQ1 Gemini is more interactive, human-like, and engaging for the students.	3.67	0.78
SEQ2 Gemini increases confidence in my ability to conduct research/to search for materials	3.76	0.83
SEQ3 Gemini is easy to use and more engaging for me	4.01	0.77

Based on the data in Table 15, the analysis and interpretation of Student Engagement (SE) indicate that the accessibility and user-friendly nature of Gemini are the primary drivers of student interaction, which subsequently bolsters their academic self-efficacy. Students expressed the strongest agreement regarding the tool's usability and personal appeal, finding Gemini exceptionally easy to use and highly engaging (SEQ3: M = 4.01, SD = 0.77). This high engagement translates into increased psychological empowerment, as evidenced by a strong agreement that the tool successfully enhances student confidence when conducting research and searching for academic materials (SEQ2: M = 3.76, SD = 0.83). While still favourably received, the lowest mean in the set was attributed to the perception of Gemini being uniquely interactive, human-like, and engaging compared to other experiences (SEQ1: M = 3.67, SD = 0.78). Overall, these results indicate that Gemini is a highly user-friendly driver of education. Its simple user experience and relatively low threshold for participation are not only engaging for students, but also encourage a more confident and independent approach to academic inquiry.

2.7 Exploratory Statistics

According to He (2024), correlation is a statistical technique that shows how strongly two variables are related to each other or the degree of association between the two. It is a common tool for describing simple relationships without making a statement about cause and effect. This section presents data to answer the research question on correlation.

4.4.1 Findings for the Relationship between Gemini and writing strategies to reduce cognitive load

This section presents data to answer research question 5: Is there a relationship between Gemini and writing strategies to reduce cognitive load?

In order to determine whether there is a significant association between Gemini and writing strategies to reduce cognitive load, data were analysed using SPSS for correlations. Results are presented separately in Table 16 below.

Table 16- Correlation between Gemini and writing strategies to reduce cognitive load

		Intrinsic Cognitive Load	Extraneous Cognitive Load	Germane Cognitive Load
Gemini	Pearson (Correlation	.589**	.486**	.532**
	Sig (2-tailed)	<.001	<.001	<.001
	N	135	135	135

**Correlation is significant at the 0.01 level (2-tailed)

Table 16 shows that there is an association between Gemini and writing strategies to reduce cognitive load. According to He (2024), the coefficient is significant at the .05 level and a positive correlation is measured on a 0.1 to 1.0 scale. Weak positive correlation would be in the range of 0.1 to 0.3, moderate positive correlation from 0.3 to 0.5, and strong positive correlation from 0.5 to 1.0.

Correlation analysis shows that there is a highly significant association between Gemini and (a) intrinsic cognitive load (r=.589**) and (p=<.001); (b) a moderately significant association between extraneous cognitive load (r=.486**) and (p=<.001); and (c) a highly significant association for germane cognitive load (r=.532**) and (p=<.001). This means that the null hypothesis is rejected for $H_{o3.}$

CONCLUSION

5.1 Summary of Findings and Discussions

This study explored the effectiveness of Gemini in decreasing ESL learners' cognitive load when writing. Several major conclusions emerged in answering the research questions about student views and the relationship between cognitive load and Gemini usage.

Regarding demographic differences (RQ1 and RQ2), the results showed that the association between cognitive load and Gemini usage was not significant across gender, indicating that both male and female students experienced the influence of the tool similarly. However, although there was a significant difference in the experience of cognitive load between academic subjects, the actual use of Gemini did not significantly differ between science and social science students.

The results of the study showed that for internal cognitive load (RQ3), learners mostly used metacognitive methods at the surface-level editing phase. The most perceived strategies were checked for grammar correctness and spelling, and the least participation was in the foundational planning and drafting stages. This result is in agreement with the study conducted by Pratiwi et al. (2024) which demonstrated that the use of Gemini can enhance the grammatical accuracy at the paragraph level and the collocation proficiency of EFL learners.

RQ4: Learners showed strong effort regulation for the external cognitive load. The highest replies suggested that students focus hard and continue even when writing activities are tough and also actively utilise their own knowledge and personal experiences as a cognitive technique. On the other hand, writing for practice gave the

lowest agreement. This result is consistent with the research of Park and Gupta (2024) which indicates that the multimodal capabilities of Gemini are uniquely positioned to support contextual understanding, allowing learners to successfully integrate their background knowledge and personal experiences into relevant academic writing.

When evaluating relevant cognitive load (RQ5), students showed a tendency towards collaborative and emotional management measures. The highest social strategy was to work with peers while experiencing writing challenges. The lowest social approach was to ask for feedback after finishing an autonomous revision. In the affect domain, students depended on self-encouragement, although the dread of making mistakes and writing with complete ease and confidence was their lowest affective reaction. This finding is in line with the studies by Azmi and Fithriani (2025) and Derakhshan (2025), concluding that by unloading micro-level language mechanics, Gemini considerably reduces L2 writing anxiety and gradually increases learner confidence.

For student perceptions of Gemini in writing (RQ6), respondents assessed the usability of the instrument, provision of original ideas and utility in English language translation as high. However, the claims that Gemini is completely human-like and that it explores many points of view actively got the lowest scores. The tool did, nonetheless, encourage pupils to double - check facts when unsure. This finding is in line with the studies of Yao and Fan (2025) who found human-AI collaborative writing as a new demand. “Critical Evaluation” of AI outputs is the most cognitively demanding for users. Furthermore, the application of Gemini for strong writing advice and academic writing is consistent with the study of Akhoon et al. (2024) and Kawinkoonlasate (2025) demonstrating the dominance of Gemini in source integration, real-time data availability, and multimodal feedback.

Finally, considering the interaction between Gemini and writing strategies (RQ7), the correlation analysis demonstrated a highly significant positive relationship between the use of Gemini and the decrease in intrinsic, extraneous and germane cognitive loads. This result is consistent with the findings of Fang et al. (2026) that proactive, interactive human-LLM co-writing greatly decreases users’ cognitive editing work and promotes greater acceptance and a better writing flow.

5.2 Implications and Suggestions for Future Research

5.2.1 Theoretical and Conceptual Implications

The findings of this study contribute significantly to Cognitive Load Theory (Sweller, 1988) and metacognitive writing models (Raoofi et al., 2017) in the digital age. This research theoretically demonstrates that generative AI is more than simply automating writing but rather a dynamic “cognitive scaffold”. Gemini reduces the draining intrinsic and unnecessary burdens of L2 language mechanics (such as syntax translation and grammatical correction), freeing up limited working memory. This theoretically supports the premise that learners can successfully divert their mental energy to the germane load, for higher order critical thinking, affective self-regulation and collaborative social methods, instead of being stuck with language friction.

5.2.2 Pedagogical Implications

The findings confirm Gemini successfully mitigates linguistic fatigue and acts as a cognitive partner; teaching paradigms must shift. Writing instruction should pivot away from an exclusive focus on mechanical accuracy since tools like Gemini can reliably handle translation and grammar and move toward teaching critical assessment and creative synthesis. Educators must implement a "structured pedagogical workflow" that teaches "critical digital literacy." Since AI can cause passive acceptance of information or "cognitive debt" (Kosmyna et al., 2025), teachers should require students to brainstorm and plan using their own cognition first and only invoke Gemini later for structural refinement, targeted verification, and collaborative feedback.

5.2.3 Suggestions for Future Research

Due to the rapid evolution of generative AI, future researchers should look into the long-term neurocognitive impacts of continuous Gemini usage to see if it leads to cognitive atrophy or "cognitive debt" over an entire

academic year. Furthermore, since this study found a significant difference in how cognitive load is experienced across different academic disciplines (Science & Technology vs. Social Sciences), which points to the need for future studies to qualitatively investigate why these disciplinary differences exist and how subject-specific prompting changes the human-AI co-writing dynamic. Finally, an experimental study is needed to investigate the effect of explicit classroom training in AI "Prompt Management" on a learner's superfluous cognitive burden.

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APPENDIX

Writing Strategies & Gemini

(Adapted from Raoofi, et.al, 2017, and Youssef, et. al; 2024)

SECTION	VARIABLE	CONSTRUCT	NO OF ITEMS/ INDICATORS
B	Intrinsic Cognitive Load	Metacognitive	10
	Extraneous Cognitive Load	Effort Regulation	4
		Cognitive	6
	Germane Cognitive Load	Social	4
		Affective	3
C	GEMINI	Critical thinking abilities	4
		Academic achievement	4
		Gemini usage	5
		Student engagement	3

Section B-Intrinsic Cognitive Load Metacognitive (MWS)

ITEM	1	2	3	4	5
MWSQ 1 I organize my ideas prior to writing.					

MWSQ 2 I revise my writing to make sure that it includes everything I want to discuss in my writing.					
MWSQ 3 I check my spelling.					
MWSQ 4 I check my writing to make sure it is grammatically correct.					
MWSQ 5 I evaluate and re-evaluate the ideas in my essay.					
MWSQ 6 I monitor and evaluate my progress in writing.					
MWSQ 7 I revise and edit an essay two or more times before I hand it in to my teacher.					
MWSQ 8 I go through the planning stages in my writing.					
MWSQ 9 I go through the drafting stages in my writing.					
MWSQ 10 I go through the revising and editing stages in my writing.					

Section C- Extraneous Cognitive Load

(i) Effort Regulation (ERS)

ITEM	1	2	3	4	5
ERSQ 1I write a lot to develop my writing skills.					
ERSQ 2I often work hard to do well in my writing even if I don't like English writing tasks.					
ERSQ 3Even if the writing activities are difficult, I don't give up but try to engage in them.					
ERSQ 4I concentrate as hard as I can when doing a writing task.					
ERSQ I spend a lot of time and energy on writing good English assignments.					

(ii) Cognitive (CWS)

ITEM	1	2	3	4	5
CWSQ 1 I use memorized grammatical elements such as singular and plural forms, verb tenses, prefixes and suffixes, etc, in my writing					
CWSQ 2I put newly memorized vocabulary in my sentences.					
CWSQ 3In order to generate ideas for my writing, I usually engage myself in brainstorming.					
CWSQ 4I use different words that have the same meaning.					
CWSQ 5I use my experiences and knowledge in my writing.					
CWSQ 6I try to use effective linking words to ensure clear and logical relationship between sentences or paragraphs					

Germane Cognitive Load

(i) Social (SWS)

ITEM	1	2	3	4	5
SWSQ1 In order to generate ideas for my writing, I usually discuss the writing topic with a friend or classmate.					
SWSQ 2After revising and editing my essay thoroughly, I ask a friend or my classmate to read and comment on it.					
SWSQ 3I try to identify friends or classmates whom I can ask for help in my writing.					
SWSQ 4 When I have trouble writing my essay, I try to do it with my classmates or friends.					

(ii) Affective (AWS)

ITEM	1	2	3	4	5
AWSQ1I try to write an essay in class with confidence and ease					
AWSQ2I try to relax whenever I feel afraid of writing.					
AWSQ3I encourage myself to write even when I am afraid of making mistakes					

Section D-Gemini

(v) Critical Thinking Abilities (CT)

ITEM	1	2	3	4	5
CTQ1 I usually need clarification on the precision and reliability of information provided by Gemini, which enhances my critical thinking skills.					
CTQ2 Gemini's responses made me doubt their validity, leading me to seek further clarification or evidence.					
CTQ3 I actively explore alternative viewpoints or sources of information when using Gemini to ensure a comprehensive understanding of the topic.					
CTQ4I need clarification about the accuracy of Gemini's output, which often encourages me to evaluate the information and conduct additional research independently.					

(vi) Academic Achievements (AA)

ITEM	1	2	3	4	5
AAQ1 I actively explore alternative viewpoints or sources of information when using Gemini to ensure a comprehensive understanding of the topic.					
AAQ2 Gemini brings innovative ideas that are ready to be shared with students.					
AAQ3 Students can anticipate robust writing guidance from Gemini.					
AAQ4 Gemini has improved my academic performance.					

(vii) Gemini Usage (CU)

ITEM	1	2	3	4	5
CUQ1 Gemini is a state-of-the-art writing model that is favorably used today.					
CUQ2 Students seek help from Gemini's assistance in composing essays and articles.					
CUQ3 Gemini helps students in English language translation.					
CUQ4 Employing Gemini significantly improves human productivity.					
CUQ5 The advent of Gemini marks a groundbreaking transformation in Natural Language Processing capabilities.					

(viii) Student Engagement (SE)

ITEM	1	2	3	4	5
SEQ1 Gemini is more interactive, human-like, and engaging for the students.					
SEQ2 Gemini increases confidence in my ability to conduct research/to search for materials					
SEQ3 Gemini is easy to use and more engaging for me					