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Article

Metacognitive Strategies, AI-based Writing Self-efficacy and Writing Anxiety in AI-assisted Writing Contexts: A Structural Equation Modeling Analysis

Xiaolei Shen*
Universiti Putra Malaysia, Malaysia

Yahui Tao
Anyang University, China

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Abstract
Although the impact of Artificial Intelligence (AI) on English writing is significant, EFL learners' writing anxiety can adversely affect their performance. Much research has explored the individual effects of metacognitive strategies or writing self-efficacy on writing performance. However, there is limited investigation into how these constructs influence writing anxiety, particularly within AI-assisted writing contexts. This study aimed to investigate the effects of metacognitive strategies and AI-based writing self-efficacy on writing anxiety among EFL learners, as well as to explore the mediating role of AI-based writing self-efficacy in the interrelationship between metacognitive strategies and writing anxiety by structural equitation modeling (SEM). A total of 193 participants completed questionnaires on metacognitive strategies, AI-based writing self-efficacy, and writing anxiety. The results indicated that metacognitive strategies encompassing planning, monitoring, and evaluating, and AI-based writing self-efficacy have a negative impact on writing anxiety. Specifically, AI-based writing self-efficacy fully mediates the relationship between planning strategies and writing anxiety, while partially mediating the relationships between monitoring and evaluating strategies and writing anxiety. These findings underscored the crucial role of AI-based writing self-efficacy in alleviating writing anxiety among EFL learners in AI-assisted contexts and suggested that enhancing metacognitive strategies can reduce learners' writing anxiety by boosting their confidence in using AI-based tools.

Keywords
AI-assisted writing context, AI-based writing self-efficacy, metacognitive strategies, structure equation modeling, writing anxiety

*Corresponding author. Email: xiaoleishen93@gmail.com

1 Introduction

English writing is a multifaceted process (Rad et al., 2023) that requires learners to structure their compositions and present diverse perspectives on assigned topics (Lee & Yuan, 2021). This process can also be considered complex (Hartwell & Aull, 2023; Rasool et al., 2023) due to the writers' limited vocabulary and insufficient grammatical knowledge of the English language (Sabti et al., 2019). For most EFL learners, varying levels of language proficiency (Graham et al., 2021) and limited language input (Huang & Renandya, 2018; Zhang, 2018) significantly influence their writing performance. These limitations hinder their ability to express themselves cohesively and coherently, leading to a lack of confidence in writing tasks (Sabti et al., 2019).

In response to this challenge, the integration of artificial intelligence (AI) in writing classes offers a promising solution for EFL learners aiming to improve their language proficiency and writing skills. AI-assisted tools can be employed to revise and enhance writing skills, such as translation (Barrot, 2023; Marzuki et al., 2023) and grammar correction (Waer, 2021; Zhao, 2022) in language learning (Yamaoka, 2024). These tools are designed to support the writing process from generating topic ideas to ensuring grammatical accuracy and refining writing style (Hartwell & Aull, 2023). For instance, ChatGPT assists writers in generating coherent text and checking grammatical accuracy, thereby refining their writing and improving their use of language forms (Barrot, 2023). Zhao (2022) highlighted that AI-assisted tools are suitable for users with varying levels of English proficiency. Students can input sentences that contain phrases from their native language, and the AI generates rewritten or paraphrased versions in English based on those sentences. Additionally, AI-assisted tools enhance writing assessment by providing learners immediate, accurate, personalized, and contextualized feedback (Rad et al., 2023).

However, beyond concerns about language proficiency and writing evaluation, additional challenges arise from a limited understanding of AI utilization (Song & Song, 2023) among EFL learners. Learners may lack the motivation and confidence to use AI in writing activities, struggle with organizing their work, and ultimately experience negative emotions during the writing process. These negative emotions, such as fear, tension, and avoidance, often lead to anxiety in writing (Cheng, 2002; Yang & Wu, 2023). Writing anxiety significantly hampers learners' performance, particularly in traditional English as a Foreign Language (EFL) contexts. Learners suffering from writing anxiety often exhibit reluctance to confront writing difficulties, resulting in avoidance of writing activities (Blasco, 2016; Huerta et al., 2016; Zhang, 2019). Additionally, in AI-assisted learning contexts, learners face an overwhelming abundance of learning resources, making it difficult to effectively organize and utilize these materials, which increases cognitive load during the writing process (Sun & Fan, 2022; Zhang, 2019). Therefore, addressing the challenge of alleviating writing anxiety becomes a crucial consideration in AI-assisted learning environments.

Responding to these challenges, numerous studies have underscored the importance of effective metacognitive strategies for enhancing writing skills (Alfaifi, 2021; Qin & Zhang, 2019; Teng, 2021a; Teng et al., 2022) in a multimedia learning context. Metacognition reflects learners' beliefs and awareness regarding their cognitive processes. Metacognitive strategies for writing encompass planning, monitoring, and evaluating strategies to regulate learners' cognitive processes throughout the entire writing process (Alfaifi, 2021; Teng et al., 2022; Teng & Wang, 2022). In particular, before commencing a writing task, learners establish goals based on their knowledge and the given topic. They then meticulously track their progress through monitoring and controlling, and assess their writing outcomes through peer, teacher, or self-assessment (Qin & Zhang, 2019). Thus, learners with well-developed metacognitive strategies can manage writing anxiety more calmly and confidently, with fewer worries (Balsco, 2016).

Moreover, learners who effectively employ metacognitive strategies can navigate the complexities of AI-assisted writing contexts, such as in the flipped classroom model (Khodaei et al., 2022), whiteboard activities (Teng, 2021b), and automatic feedback systems (Sun & Fan, 2022; Waer, 2021). The use of

metacognitive strategies in flipped classrooms not only enhances learners' writing proficiency but also facilitates engagement in writing activities through extensive cooperation and collaboration with teachers and peers (Khosravi et al., 2023). Consequently, metacognitive strategies emerge as indispensable and effective tools for fostering writing proficiency. Despite cognitive awareness, learners often experience a lack of confidence and heightened anxiety during writing tasks, making the enhancement of self-confidence a critical area of concern.

Writing self-efficacy refers to one's confidence in organizing and accomplishing writing tasks (Khosravi et al., 2023). Learners with high confidence in their writing abilities experience a reduction in writing anxiety (Huerta et al., 2016). Furthermore, existing research indicated that learners with high self-efficacy in technology-based learning settings are more inclined to exert effort to solve problems (Teng et al., 2021; Teng & Yang, 2023) when they encounter learning difficulties. These learners are also more willing to utilize metacognitive strategies to enhance their self-efficacy in writing. For instance, the assistance of AI-assisted tools provides flexible online resources (Zhang, 2019) and checks the accuracy of language proficiency (Shen & Teng, 2024), enabling learners to effectively organize their compositions and reduce negative emotions associated with writing.

However, contemporary research has predominantly focused on investigating the impact of metacognitive strategies on writing performance or examining the role of writing self-efficacy in using AI-assisted tools to improve writing proficiency. A conspicuous gap exists, with a scarcity of studies examining the concurrent effects of metacognitive strategies and writing self-efficacy on writing performance, particularly within AI-assisted learning environments. In response to this gap, the present study examined the impact of metacognitive strategies and AI-based writing self-efficacy on writing anxiety. Moreover, it investigated the role of AI-based writing self-efficacy on metacognitive strategies and writing anxiety within an AI-based writing context. This research aims to contribute valuable insights into pedagogical approaches for reducing EFL learners' writing anxiety within AI-assisted educational settings.

2 Literature Review

2.1 Writing anxiety in AI-assisted learning context

Writing anxiety is a negative emotion related to self-awareness, manifesting as fear and tension when writers feel they cannot meet their expectations regarding writing tasks. Anxious students often experience low confidence in their writing abilities (Cheng, 2002; Cheng et al., 1999). This lack of confidence frequently leads to reluctance to participate in writing activities (Yang & Wu, 2023) and worries about evaluations from teachers and peers, which can impede their writing proficiency (Cheng, 2004a; Zhang & Zhang, 2022). Consequently, students with low confidence in writing tend to underestimate their abilities and harbor negative expectations about their performance.

Several factors influence anxiety related to learners' performance. Horwitz et al. (1986) identified three key components of foreign language anxiety affecting learning performance: communication apprehension, test anxiety, and fear of negative evaluation. Communication apprehension is defined as "a type of shyness characterized by fear of or anxiety about communicating with people" (p. 127). Similarly, test anxiety is closely interconnected to foreign language anxiety. Students who experience test anxiety often set unrealistic expectations for themselves, viewing anything less than perfect performance as a failure. In the same vein, fear of negative evaluation may arise, as anxious students may worry about being perceived as less competent by their peers or receiving negative judgments.

However, Horwitz et al.'s (1986) theory does not address learners' negative emotions in specific learning tasks, such as writing assignments. Building on this, Cheng (2002, 2004a) categorized writing anxiety into three types: somatic anxiety, cognitive anxiety, and avoidance anxiety. Somatic anxiety refers to physical symptoms, characterized by heightened sensitivity to negative emotions such as fear

and tension. Cognitive anxiety involves negative emotional experiences, including low expectations for writing output, excessive concern about others' perspectives, and negative self-appraisals of writing performance, particularly in linguistic and cognitive aspects. Anxious students often fear that they will not fully comprehend all language input. They are apprehensive about making mistakes in their writing and lack the confidence to confront language learning tasks (Horwitz et al., 1986). Avoidance behavior is characterized by procrastination and withdrawal from writing tasks. Therefore, writing anxiety is a form of negative self-awareness, reflected in behaviors that adversely affect writing performance (Rasool et al., 2023). Further, Cheng (2004b) explored learners' attitudes towards writing and their perceptions, categorizing writing anxiety into four areas: instructional practices, personal beliefs about writing and learning to write, self-perceived competence, and interpersonal threats. For example, when instructors assign topics that students are familiar with and provide reasonable time for completion, it can mitigate some anxiety. However, anxious students often focus on avoiding mistakes due to their limited writing proficiency and lack of experience with English writing. Consequently, these students fear that their mistakes and perceived inadequacies will be exposed and judged negatively by others.

Furthermore, writing anxiety highlights the importance of a non-threatening and supportive learning environment to boost self-confidence in writing (Cheng et al., 1999). With the rapid development of AI (Cotton et al., 2023), technology-based tools are increasingly integral to the writing process within AI-assisted contexts (Marzuki et al., 2023). For example, Zhang's (2019) study demonstrated that writing anxiety decreases with the effective use of online resources, promoting students' motivation and engagement. Students often utilize online resources to enhance their writing skills, recognizing the value of new knowledge gained through digital learning platforms to address their negative emotions associated with writing. A study by Waer (2021) on Egyptian university students indicated that automated writing evaluation tools, such as the *Write & Improve* software, offer numerous revision opportunities and immediate feedback, which help alleviate writing apprehension and improve grammar knowledge. Conversely, Huang and Renandya (2018), in their survey of 67 non-English major students, found that while automated feedback tools like *Pigai* assist in identifying and correcting lexical and mechanical errors, they did not improve the revised drafts of low-proficiency learners. This lack of improvement was attributed to inadequate language proficiency and unfamiliarity with the tools, leading to negative attitudes towards their use. Similarly, a quasi-experimental study by Sun and Fan (2022) investigated the impact of automated writing assessment tools on writing performance. The study unveiled that writing anxiety did not mediate the relationship between assessment approaches and writing performance. This lack of mediation was attributed to learners' moderate levels of writing anxiety prior to the experiment. Moreover, there was no evidence linking anxiety to writing performance, except for avoidance behaviors. Overall, the levels of writing anxiety significantly influence learners' writing performance and assessment outcomes.

While AI-assisted writing contexts can influence writing anxiety, there are drawbacks to these environments. Technology-based tools cannot replace human intelligence, and over-reliance on them can hinder learners' self-reflection during the writing process (Alharbi & Rahman, 2023; Barrot, 2023). In addition, since writing is a cognitive activity that reflects the writer's ability to organize structure and generate ideas (Lee & Mak, 2018; Marzuki et al., 2023), over-reliance on AI tools may cause writers to focus more on language accuracy than on the cognitive process involved in writing. Therefore, enhancing learners' cognitive awareness can improve writing performance and reduce writing anxiety in AI-based writing contexts.

2.2 Metacognitive strategies and writing anxiety

Metacognition refers to an individual's awareness and understanding of their own cognitive processes and thoughts (Teng, 2021a; Teng & Huang, 2021; Wenden, 1998). Cheng and Chan (2021) provided a comprehensive summary of metacognition as a higher-order cognitive process involving the critical

analysis of one's own knowledge and cognitive functions. They defined metacognition as "a mechanism for monitoring cognition, which encompasses mental processes such as memory, learning, problem-solving, attention, and decision-making" (p. 12). This mechanism enables learners to actively control their cognitive processes, thereby promoting the generation of new knowledge and the effective use of previously acquired information. Effective metacognitive control can significantly enhance learning achievements. Building on this foundation, metacognition comprises four key elements: metacognitive knowledge, experiences, cognitive goals, and cognitive strategies (Flavell, 1979). These elements govern the monitoring and regulation of cognitive processes to facilitate effective learning. Schraw and Dennison (1994) expanded on Flavell's theory by categorizing metacognition into two components: knowledge of cognition and regulation of cognition. The former refers to an individual's awareness of their own learning processes and the factors influencing performance, while the latter involves the methods used to regulate and control cognitive activities.

Metacognitive strategies, which regulate cognition, involve controlling cognitive activities by managing and directing cognitive processes (Teng, 2019; Teng & Huang, 2021; Wenden, 1998). Among these strategies, planning pertains to the selection of strategies and allocation of resources necessary for effectively accomplishing a task or achieving a specific goal (Qin & Zhang, 2019). Monitoring involves "analyzing the effectiveness of the strategies or plan being used" (Harris et al., 2009, p. 134). Evaluation refers to "determining progress being made toward the goal, resulting in revisions or modifications to the initial plan, further monitoring, and further evaluation" (Harris et al., 2009, p. 134). Moreover, writing, as a cognitive process (Lee & Mak, 2018; Shen & Teng, 2024), involves planning, translating, and revising to generate well-organized compositions, making it a complex activity for most writers (Rowe, 2022). These complex writing processes can be regulated by metacognitive strategies to manage cognitive load, including working and long-term memory, thereby reducing negative emotions associated with writing activities (Teng & Qin, 2024; Teng & Zhang, 2024). In other words, "a metacognitive learner possesses self-awareness and accurate self-knowledge regarding their learning style, strength and weakness, beliefs and motivation, strong knowledge of different strategies and the ability to apply and transfer these strategies" (Cheng & Chan, 2021, p. 16). Thus, the utilization of metacognitive strategies in writing, by monitoring and controlling one's cognitive processes and performance, can help reduce cognitive load and facilitate more effective writing.

Most research has investigated the effect of metacognitive strategies on writing performance, particularly in technology-based writing settings (Balta, 2018; Qin & Zhang, 2019; Teng & Qin, 2024; Teng et al., 2022). For example, using the Mann-Whitney U Test method, Qin and Zhang (2019) surveyed 126 EFL learners and found a significant relationship between metacognitive strategies and academic writing performance in multimedia writing contexts across different language proficiency levels. Using the *Pigaiwang* technology-based platform, learners with high writing proficiency demonstrated a clear understanding of goals and better preparation before writing. They effectively managed their thoughts and actions during the writing process and used appropriate strategies to revise their writing content and organization. Further studies by Teng and Qin (2024) indicated that metacognitive regulatory strategies, including planning, monitoring, and evaluating, positively impact writing performance. In addition, metacognitive knowledge, learning motivation, and interest influence writing performance. However, emotional control, corrective feedback, and information management strategies did not predict writing performance, likely due to the Chinese examination-oriented environment. This leads to a lack of confidence in using technology to manage and process writing information.

Some research has also gradually explored the combination of metacognitive strategies and writing anxiety. As stated by Balta (2018), there is a relationship between writing anxiety, metacognitive awareness, and writing performance. Argumentative writing skills are improved by increasing metacognitive awareness and decreasing writing anxiety. Khosravi et al. (2023) revealed that cognitive and metacognitive strategies decrease learners' writing anxiety and enhance writing performance. Learners who are well-prepared, more knowledgeable about writing, and engaged in writing tasks

through cooperation tend to experience reduced writing anxiety. These studies examined the impact of metacognitive strategies on learners' writing performance and writing anxiety. However, a lack of confidence can also influence the effectiveness of metacognitive instruction on writing and writing anxiety. Therefore, learners' self-confidence should be a key focus in efforts to reduce their writing anxiety.

2.3 AI-based writing self-efficacy as a mediator

Self-efficacy relates to one's confidence in performing a learning task, referring to "beliefs about one's capabilities to organize and implement actions necessary to attain designated performance of skills for specific tasks" (Zimmerman, 2000, p. 14). Self-efficacy in writing specifically refers to "learners' evaluation of their writing skills and their confidence in successfully accomplishing writing tasks" (Khosravi et al., 2023, p. 7). Learners with low self-efficacy often struggle to manage negative emotions in their language learning process. These students tend to lack confidence in their ability to use strategies effectively in language learning and show little motivation to engage in learning tasks (Piechurska-Kuciel, 2019). Besides, the structure of self-belief systems and their influence on individuals' confidence in their writing abilities were also examined. For instance, Bandura (2012) identified four key mechanisms through which these beliefs are shaped: mastery experience, social modeling, cognitive, motivational, affective, and decision processes, and self-development and changes related to choice processes. Mastery experiences, where individuals overcome obstacles through persistent effort, significantly enhance their self-efficacy. Success achieved through perseverance boosts one's aspirations and confidence in their capabilities. Additionally, motivation and persistence during challenges in the learning process play crucial roles in sustaining effort.

With advancements in technology, Holden and Rada (2011) introduced the concept of technology-based self-efficacy, which refers to an individual's belief in their ability to use technology effectively. Those with high self-efficacy believe they can successfully utilize technology in their learning. However, Holden and Rada's study primarily focused on teachers as participants. Wang and Chuang (2023) identified several factors that influence an individual's AI self-efficacy, including assistance, anthropomorphic interaction, comfort with AI, and technological skills. The first two dimensions reflect an individual's perception of using technologies as valuable tools or interacting with AI technology. The last two dimensions represent an individual's emotions and confidence when using AI technology. Therefore, AI-based self-efficacy plays a crucial role in influencing learners' self-confidence.

Several studies have explored the impact of self-efficacy on writing anxiety. Effective use of online resources has been shown to reduce writing anxiety by enhancing learners' motivation and engagement (Zhang, 2019). According to Huerta et al. (2016), self-efficacy significantly influences learners' writing proficiency, with those possessing high self-efficacy experiencing lower levels of writing anxiety. Gender differences are evident, as females tend to exhibit higher levels of writing anxiety compared to males. Furthermore, self-efficacy affects the use of metacognitive strategies in language learning and writing performance among EFL learners (Teng & Wang, 2022). Teng et al. (2021) conducted a cross-sectional survey involving 590 Chinese students, revealing that learners with high self-efficacy invest greater effort in overcoming challenges within remote learning environments. Conversely, learners with low self-efficacy frequently question their ability to employ metacognitive strategies effectively. A longitudinal study by Teng and Yang (2023) involving 590 undergraduate students found that metacognitive strategies mediate the relationship between self-efficacy and learning performance. Learners with high self-confidence are more likely to share their knowledge with peers in online settings, build confidence through their learning experiences, and regulate their emotions through cognitive development. Training in planning, goal-setting, and reflection before and after writing positively impacts self-efficacy and writing outcomes (Chung et al., 2021). Also, the use of metacognitive strategies in a flipped classroom setting increases learners' writing self-efficacy and decreases writing anxiety (Khosravi et al., 2023).

Therefore, while most studies emphasized the crucial role of self-efficacy in improving learners' writing performance or alleviating writing anxiety in both online and offline contexts, there is a notable scarcity of research focusing on the investigation of learners' negative emotions, such as anxiety, specifically within AI-assisted learning environments. Greater attention is needed to explore how cognitive and affective factors can be integrated to mitigate writing anxiety effectively.

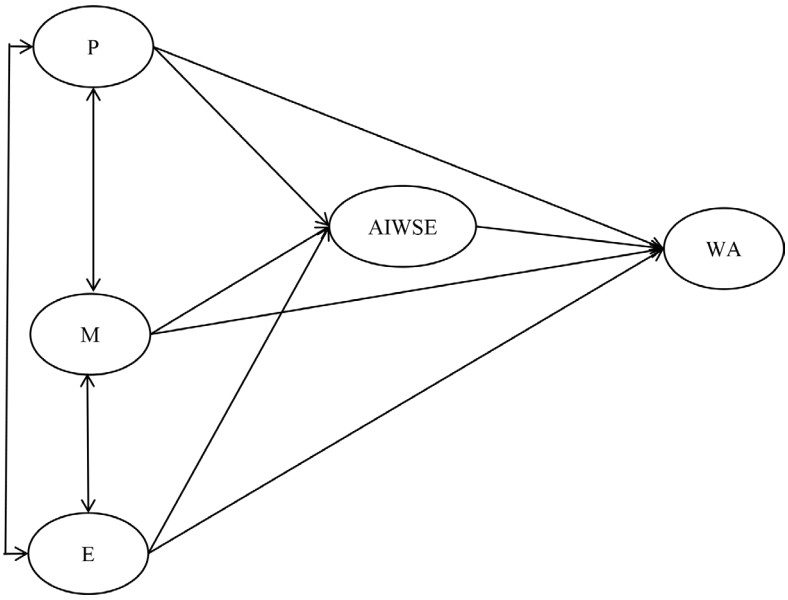
2.4 Rationale of the study

Several studies have investigated the role of metacognitive strategies in writing performance and writing anxiety, highlighting their importance in regulating learners' cognitive processes during writing tasks to reduce writing anxiety (Alfaifi, 2021; Qin & Zhang, 2019; Teng, 2021b; Teng & Qin, 2024; Teng et al., 2022). Metacognitive strategies facilitate learners' understanding of the requirements of a learning task, help them identify various problems and challenges encountered during the learning process, and enable them to select and apply appropriate strategies. By monitoring and regulating cognitive processes, these strategies guide learners in effectively organizing and structuring their writing tasks. Other research has demonstrated the impact of writing self-efficacy on learners' writing performance and anxiety in both online and offline learning contexts (Chung et al., 2021; Huerta et al., 2016; Khosravi et al., 2023; Teng & Wang, 2022). The relationship between writing self-efficacy and metacognitive strategies has also been shown to influence writing performance and reduce writing anxiety across these settings.

However, these studies have primarily focused on the effects of metacognitive strategies or writing self-efficacy on writing performance within online or offline contexts, with limited exploration of their impact on writing anxiety, especially in AI-assisted learning environments. Consequently, the present study aimed to examine the effects of metacognitive strategies and AI-based writing self-efficacy on EFL learners' writing anxiety. Beyond that, this study investigated the role of AI-based writing self-efficacy in relation to metacognitive strategies and writing anxiety within the context of AI-assisted writing, as illustrated in Figure 1.

Figure 1

The Role of AI-based Writing Self-efficacy on Metacognitive Strategies and Writing Anxiety



Note. P= Planning; M=Monitoring; E=Evaluating; AIWSE=AI-based writing self-efficacy; WA=Writing anxiety.

Based on the preceding discussion, the research questions for this study were outlined as follows:

1. To what extent do metacognitive strategies and EFL learners' AI-based writing self-efficacy impact their writing anxiety in an AI-assisted writing context?
2. To what extent can AI-based writing self-efficacy mediate the relationship between metacognitive strategies and writing anxiety among EFL learners in an AI-assisted writing context?

3 Method

3.1 Participants

The study's population consisted of 193 undergraduate undergraduate students from northern China, all English as a Foreign Language (EFL) learners. Participants were selected through convenience sampling and were aged between 18 and 22. They were chosen because most had passed the College English Test Band 4 (CET-4), indicating that they had achieved a basic level of English proficiency. All participants had completed a writing course during their first year of English studies, which provided instruction on writing strategies. Furthermore, they utilized AI-based applications such as *Quillbot* and *DeepL* to revise and refine their writing in a writing course. However, they had not received formal training in how to effectively use these tools or in applying metacognitive strategies to their writing.

3.2 Instruments

3.2.1 Metacognitive Strategies Questionnaire

The Metacognitive Strategies Questionnaire was adapted from the research of Zhang and Qin (2018) to assess learners' use of metacognitive strategies in multimedia writing environments. Our study combined similar items (e.g., items 12, 13, and 14) into a single item (e.g., "I consider how to connect different parts of my essay using transitional words, correct grammar, and appropriate punctuation and letter case"). The questionnaire consists of three dimensions: planning strategy, with 7 items that focus on how learners set writing goals before beginning a task; monitoring strategy, with 10 items that track learners' management of the writing process; and evaluating strategy, with 4 items that involve learners assessing their writing outcomes after completion. Participants responded using a 5-point scale, ranging from 1 (strongly disagree) to 5 (strongly agree). In this study, the Cronbach's alpha coefficient was .900, indicating high internal consistency.

3.2.2 AI-based Writing Self-Efficacy Questionnaire

The AI-Based Writing Self-Efficacy Questionnaire was adapted by Lung-Guang (2019) from Hood et al.'s (2015) self-regulated learning questionnaire to evaluate learners' beliefs and confidence in their ability to utilize AI-based learning tools for writing tasks. This questionnaire comprises 6 items (e.g., "I set goals to help me manage study time using AI-assisted writing tools for my writing"). Participants responded using a 5-point scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The Cronbach's alpha coefficient for this study was .888, indicating strong internal consistency.

3.2.3 Writing Anxiety Questionnaire

The Writing Anxiety Questionnaire, developed by Cheng (2004a), is designed to assess the extent of learners' anxiety related to writing. It comprises three dimensions: somatic anxiety, cognitive anxiety, and avoidance behavior. Somatic anxiety, measured by 7 items, refers to physical manifestations of anxiety. Cognitive anxiety, measured by 8 items, pertains to individual perceptions of anxiety, particularly fears of receiving negative evaluations from peers and teachers. Avoidance behavior, assessed through 7

items, relates to passive behaviors exhibited during writing tasks. Participants respond on a 5-point scale, ranging from 1 (strongly disagree) to 5 (strongly agree). In this study, the Cronbach's alpha coefficient was .924, indicating excellent internal consistency.

3.3 Data collection

Before conducting the study, the ethical considerations and purpose were thoroughly explained to all participants to ensure the validity and confidentiality of the research (Sun & Wang, 2020). Subsequently, participants completed the AI-Based Writing Self-Efficacy Questionnaire, the Metacognitive Writing Strategies Questionnaire, and the Writing Anxiety Questionnaire, each within a 15-minute timeframe. Upon completion, the questionnaires were reviewed by the instructor to ensure their quality.

3.4 Data analysis

After data collection, descriptive analysis was conducted to assess the means, standard deviations, and the normality of the data distribution. Pearson correlational analysis was then employed to explore the relationships between AI-based writing self-efficacy, metacognitive strategies, and writing anxiety within the AI-based learning environment. Prior to conducting structural model analysis, confirmatory factor analysis was performed to verify the model's validity and reliability. This includes checking model fit, convergent validity, and construct reliability. Model fit was assessed using the following indices: Chi-Square (X^2) < 5.0, Goodness-of-Fit Index (GFI) > .90, Comparative Fit Index (CFI) > .90, Tucker-Lewis Index (TLI) > .90, and Root Mean Square Error of Approximation (RMSEA) < .08 (Hair et al., 2010). Convergent validity is confirmed by ensuring that all factor loadings were greater than .50 and that the Average Variance Extracted (AVE) exceeded .50. Construct Reliability (CR) is deemed satisfactory if the value is above .70. Finally, structural model analysis was conducted using Amos 24.0 to assess the impact of metacognitive strategies on writing anxiety, with particular emphasis on the mediating role of AI-based writing self-efficacy (Kline, 2011).

4 Results

4.1 Descriptive analysis

Table 1 presents the means and standard deviations for various metacognitive strategies, including planning, monitoring, and evaluating, which range from 3.18 (SD = .89) to 3.22 (SD = .89). These results indicated that EFL learners have a basic understanding of metacognitive strategies in writing within an AI-based context. The mean score for AI-based writing self-efficacy is 3.28, reflecting a moderate level of confidence among learners in using AI-based tools for writing. The mean score for writing anxiety is 2.63, suggesting a relatively low level of writing anxiety within the AI-assisted writing environment. Skewness values for these dimensions range from -0.515 to -0.078, and kurtosis values range from -1.070 to -0.616, indicating that the data follows a normal distribution (Wu & Leung, 2017).

Table 1

Descriptive Analysis of Metacognitive Strategies, AI-based Writing Self-efficacy and Writing Anxiety

	M	SD	Skewness	Kurtosis
P	3.18	.78	-.143	-1.070
M	3.17	.61	-.396	-.718
E	3.22	.82	-.515	-.873
AIWSE	3.28	.94	-.078	-.901
WA	2.63	.73	-.257	-.616

Note. P= Planning; M=Monitoring; E=Evaluating; AIWSE=AI-based writing self-efficacy; WA=Writing anxiety.

4.2 Correlational analysis

Table 2 illustrates the correlations between metacognitive strategies, AI-based writing self-efficacy, and writing anxiety. Specifically, metacognitive strategies including planning, monitoring, and evaluating showed positive correlations with AI-based writing self-efficacy, ranging from .317 to .356. Conversely, these strategies were negatively correlated with writing anxiety, with correlations ranging from -.552 to -.506. Moreover, AI-based writing self-efficacy demonstrated a negative correlation with writing anxiety, at -.549. These findings collectively indicated significant relationships between writing anxiety, metacognitive strategies, and the writing performance of EFL learners.

Table 2

Correlational Analysis of Metacognitive Strategies, AI-based Writing Self-efficacy and Writing Anxiety

	P	**M**	**E**	**AIWSE**	**WA**
P	1				
M	.583**	1			
E	.408**	.355**	1		
AIWSE	.356**	.381**	.317**	1	
WA	-.519**	-.506**	-.552**	-.549**	1

4.3 Confirmatory factor analysis

The confirmatory factor analysis results are presented in Table 3. The analysis revealed that the factor loadings for P1 in the planning strategy and for M1, M2, and M3 in the monitoring strategy were below .50. These items were subsequently removed from the model. The factor loadings of the planning, monitoring, evaluating strategies, AI-based writing self-efficacy, and writing anxiety, range from .56 to .83, all surpassing the threshold of .50. This indicates a satisfactory fit for the model. Furthermore, the average variance extracted (AVE) for these factors ranges from .457 to .574, which is close to or exceeds the acceptable level of .50. Besides, the composite reliability (CR) values range from .713 to .880, demonstrating convergent solid validity for the model.

Table 3

Confirmatory Factor Analysis

	Items	**Factor loadings**	**AVE**	**CR**
P	P2	.78	.523	.880
	P3	.77		
	P4	.72		
	P5	.79		
	P6	.77		
	P7	.78		
M	M4	.72	.501	.875
	M5	.67		
	M6	.73		
	M7	.75		
	M8	.69		
	M9	.71		

	M10	.68		
E	E1	.75	.555	.833
	E2	.74		
	E3	.76		
	E4	.74		
AIWSE	AIWSE1	.83	.574	.889
	AIWSE2	.78		
	AIWSE3	.65		
	AIWSE4	.74		
	AIWSE5	.78		
	AIWSE6	.75		
WA	SoA	.71	.457	.713
	CoA	.56		
	AoB	.75		

4.4 Mediating analysis of structural model

The direct effects of metacognitive strategies on writing anxiety are detailed in Table 4. In other words, planning (β = -.208, p = .025), monitoring (β = -.244, p = .009), and evaluating (β = -.621, p = .000) each have a negative impact on writing anxiety. These results suggested that when EFL learners effectively plan their writing goals, continuously monitor their writing process to adjust strategies, and evaluate their writing outcomes to make revisions, their writing anxiety decreases.

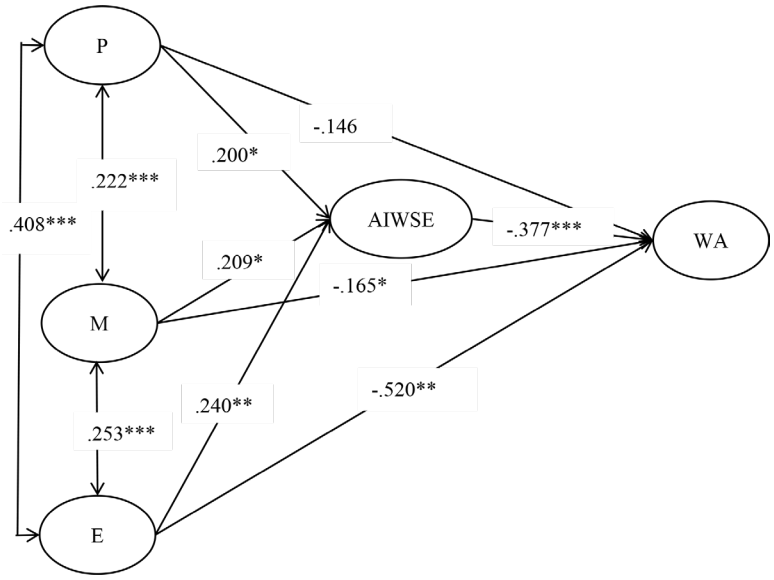
Table 4

Results of the Mediating Model

Mediating model	**Beta**	**P**	**95% CI**		**Decision**
			LL	**UL**	
Direct model					
P →WA	-.208	.025			
Mediating model					
P→AIWSE	.200	.021			
AIWSE→WA	-.377	.000			
P →AIWSE WA	-.146	.082			
Std. Indirect Effect (SIE)	-.076	.012	-.167	-.017	Full Mediation
Direct model					
M→WA	-.244	.009			
Mediating model					
M→AIWSE	.209	.013			
AIWSE→WA	-.377	.000			
M→AIWSE→WA	-.165	.048			
Std. Indirect Effect (SIE)	-.079	.009	-.164	-.021	Partial Mediation
Direct model					
M→AIWSE	-.621	.000			
Mediating model					
E→AIWSE	.240	.009			
AIWSE→E	-.377	.000			
E→AIWSE→WA	-.520	.009			
Std. Indirect Effect (SIE)	-.091	.005	-.174	-.027	Partial Mediation

Figure 2

Mediating Model Results



The mediating model presented in Table 4 and Figure 2 demonstrates that planning (β=.200, p=.021), monitoring (β=.209, p=.013), and evaluating strategies (β=.240, p=.009) positively influence AI-based writing self-efficacy, suggesting that these metacognitive strategies enhance learners' self-confidence in writing. Furthermore, AI-based writing self-efficacy is found to negatively impact writing anxiety (β=-.377, p=.000), indicating that learners with higher confidence in using AI tools exhibit lower levels of writing anxiety, and vice versa. Notably, while monitoring (β=-.165, p=.048) and evaluating strategies (β=-.520, p=.009) have a negative effect on writing anxiety when accounting for AI-based writing self-efficacy, the planning strategy (β=-.146, p=.082) does not significantly affect learners' writing anxiety.

Thus, AI-based writing self-efficacy fully mediates the relationship between planning strategies and writing anxiety (SIE=-.076, p=.012). The 95% confidence interval, ranging from -0.167 to -0.071 and excluding zero, indicates that only learners with high levels of AI-based writing self-efficacy can effectively set goals to reduce their anxiety prior to writing. Conversely, AI-based writing self-efficacy partially mediates the relationship between monitoring (SIE=-.079, p=.000), and evaluating strategies (SIE=-.091, p=.005) and writing anxiety. The 95% confidence intervals for these strategies also exclude zero, showing that while monitoring and evaluating strategies can directly reduce writing anxiety, high levels of AI-based writing self-efficacy enhance learners' confidence in using AI tools. This, in turn, helps them manage their writing tasks and evaluate their writing outcomes more effectively, thereby further decreasing their anxiety.

5 Discussion

This study primarily explored the impact of metacognitive strategies and AI-based writing self-efficacy on EFL learners' writing anxiety. Additionally, it examined the mediating role of AI-based writing self-efficacy in the relationship between metacognitive strategies and writing anxiety within AI-assisted writing environments.

The results indicated that planning, monitoring, and evaluating strategies can negatively predict EFL learners' writing anxiety in AI-assisted settings. These findings expand on the concept of metacognition as articulated by Cheng and Chan (2021), Schraw and Dennison (1994) and Wenden (1998). They described metacognition as a higher-order thinking that involves learners critically analyzing and regulating their cognitive processes, thereby enhancing their ability to manage cognitive regulation.

This perspective aligns with previous research (Balta, 2018; Qin & Zhang, 2019; Teng & Qin, 2024; Teng et al., 2022; Waer, 2021). Our study builds on the research of Qin and Zhang (2019) and Teng and Qin (2024), revealing that learners who set clear goals, engage in effective planning, and actively monitor and evaluate their writing processes to reduce anxiety. This active engagement enables learners to manage cognitive load and enhance their writing capabilities in multimedia contexts. Qin and Zhang (2019) described metacognitive strategies as a "fundamental skill" (p. 404), with monitoring referred to as a "cluster of online resources" (p. 405), and evaluating as an effective skill for refining automated writing proficiency in multimedia learning contexts. These insights supported our findings, showing that metacognitive strategies can be developed and utilized to mitigate writing apprehension. Furthermore, Waer (2021) corroborated our results by illustrating that evaluative methods can automatically alleviate writing anxiety and boost motivation, particularly for struggling and apprehensive writers in technology-based settings. These studies collectively highlighted that planning, monitoring, and evaluating strategies enhance learners' awareness of appropriate strategy selection, thereby reducing anxiety by setting goals, monitoring progress, and appraising outcomes in supportive environments (Cheng et al., 1999).

Conversely, our findings contrasted with those of Sun and Fan (2022), and Huang and Renandya (2019), who found that the automated feedback and assessment tools were not associated with reduced writing anxiety among learners. This discrepancy may be attributed to differences in language proficiency among individuals. In particular, learners with lower writing proficiency tend to emphasize grammatical accuracy and sentence structure, which can exacerbate anxiety (Huang & Renandya, 2018). According to the studies by Qin and Zhang (2019) and Teng and Qin (2024), metacognitive strategies significantly impact writing performance in multimedia contexts by enhancing learners' metacognitive awareness. These studies highlighted the importance of thorough preparation before writing and the regulation of the writing process to identify strengths and weaknesses. In the context of AI-assisted writing, such strategies can help mitigate negative emotions and improve overall writing effectiveness. In our study, however, participants had prior experience with AI-assisted learning tools, leading them to focus more on producing well-organized writing rather than on anxiety. Consequently, our findings suggested that metacognitive strategies can effectively mitigate writing anxiety for EFL learners in AI-assisted contexts.

Secondly, the findings revealed that AI-based writing self-efficacy negatively predicts writing anxiety within AI-assisted contexts, aligning with the results of previous research by Chung et al. (2021), Hurta et al. (2016), Teng and Wang (2022), and Zhang (2019). Building on Zhang's (2019) assertion that the use of online resources enhances learners' confidence and motivation in writing activities, our study found that learners with high AI-based writing self-efficacy experience lower levels of anxiety. Furthermore, our research extended the work of Hurta et al. (2016) and Teng and Wang (2022) by highlighting the role of self-efficacy as a key factor in both improving writing proficiency and alleviating writing anxiety. Our findings also advanced Holden and Rada's (2011) concept of technology self-efficacy in AI-assisted writing contexts by reflecting learners' confidence in utilizing AI-based tools for their essays.

Conversely, Teng and Qin (2024) observed that emotional factors did not predict writing proficiency in Chinese examination-oriented contexts, where learners face increased pressure. This discrepancy in our study can be attributed to the fact that most EFL learners are engaged in more flexible and less threatening writing environments with the aid of AI tools. Hence, learners with higher AI-based writing self-efficacy experience reduced writing anxiety. Writers are more likely to leverage AI-based tools to integrate ideas, organize information, and clarify their viewpoints to achieve their writing objectives.

Finally, these findings indicated that AI-based writing self-efficacy fully mediates the relationship between planning strategies and writing anxiety. Additionally, AI-based writing self-efficacy partially mediates the relationships between monitoring strategies and writing anxiety, as well as between evaluating strategies and writing anxiety. These results were consistent with the studies of Teng et al. (2021), Teng and Yang (2023), Teng and Wang (2022), Chung et al. (2021), and Khosravi et al. (2023). Our research advanced the understanding of AI-based writing self-efficacy in metacognitive strategies and writing anxiety under AI-based contexts. Building on the research of Teng et al. (2021), which

employed a cross-sectional design, and Teng and Yang (2023), which utilized a longitudinal approach, we found that metacognitive strategies mediate the relationship between EFL learners' self-efficacy and their academic achievement. These studies suggested that learners with lower levels of metacognitive strategies may experience diminished self-efficacy in online learning environments. Furthermore, Teng and Wang (2022) examined several dimensions of L2 learners' writing self-efficacy, including linguistic knowledge efficacy, information organization efficacy, rehearsal and memory efficacy, self-regulatory efficacy, and writing performance efficacy. They identified metacognitive mechanisms as essential for enhancing writing performance. These studies predominantly investigated the mediating role of metacognitive strategies in learners' self-efficacy and its impact on learning outcomes. Our research built on this by examining the influence of metacognitive strategies on writing anxiety, with AI-based writing self-efficacy serving as a mediator. Learners employing metacognitive strategies can "direct and regulate cognitive, motivational, and behavioral processes" (Teng et al., 2021, p. 5) to enhance writing proficiency. Besides, learners with high AI self-efficacy are more likely to exert effort in managing their negative emotions when facing challenges in AI-assisted writing contexts.

Our study incorporated the role of AI-based writing self-efficacy in addressing writing anxiety, highlighting the importance of emotional factors in AI-assisted learning contexts. In addition, it aligned with Chung et al. (2021), which found that learners adept in goal setting, planning, reflection, and self-evaluation exhibit greater self-efficacy and reduced writing anxiety. In our study, students with high AI-based self-efficacy are more motivated to manage their writing process through metacognitive strategies, "such as monitoring, regulating, setting goals, and organizing information" (Teng & Yang, 2023, p. 13). This increased confidence in their abilities contributes to enhanced control over their writing process and a reduction in writing anxiety in AI-assisted contexts. Thus, this study integrated previous research on the impact of metacognitive strategies on self-efficacy and writing performance, demonstrating how AI-assisted learning contexts can enhance EFL learners' writing self-efficacy and mitigate anxiety through the strategic use of metacognitive approaches to regulate cognitive processes.

6 Conclusion

This study revealed metacognitive strategies including planning, monitoring and evaluating, and AI-based writing self-efficacy have a negative impact on EFL learners' writing anxiety in AI-assisted writing contexts. In addition, AI-based writing self-efficacy fully mediates the relationship between planning strategies and learners' writing anxiety. It also partially mediates the relationships between monitoring strategies and writing anxiety, as well as between evaluating strategies and writing anxiety within AI-assisted writing contexts.

However, there are several limitations to this study. It employed quantitative research methods to investigate the effects of AI-based writing self-efficacy and metacognitive strategies on writing anxiety among EFL learners. Future research could benefit from incorporating qualitative methods, such as interviews, to gain deeper insights into learners' perspectives on using AI-assisted tools in writing, thereby enhancing the understanding of writing proficiency. In addition, this study primarily focused on the impact of metacognitive strategies on writing anxiety. Future research could include experimental studies on metacognitive training during writing tasks to evaluate its effects on learners' writing achievements and self-efficacy. Combining quantitative and qualitative approaches in future studies could provide a more comprehensive analysis of cognitive factors.

These findings have several implications for writing pedagogy. Emotional factors, such as writing anxiety, should be addressed in writing instruction. Educators should incorporate appropriate learning strategies, such as metacognitive approaches, to enhance learners' cognitive awareness and improve their writing proficiency. Metacognitive strategies facilitate the organization of information from various sources, aiding learners in achieving their writing goals on specific themes. Additionally, with

advancements in technology, AI-assisted tools should be considered in writing tasks. These tools can assist learners in producing automated assessments independently, reducing anxiety related to peer or teacher feedback, and offering diverse methods to enhance language proficiency. This is particularly beneficial for learners with varying language backgrounds, as AI tools can support more fluent expression. Consequently, this study contributes to the field of writing instruction by promoting increased learner confidence and cognitive capability within AI-assisted learning environments.

References

Alfaifi, M. J. (2021). A suggested model for metacognitive strategy instruction in EFL writing classrooms. *Reading & Writing Quarterly, 38*(4), 323-339. https://doi.org/10.1080/10573569.2021.1954569

Alharbi, W., & Rahman, M. M. (2023). AI in the foreign language classroom: A pedagogical overview of automated writing assistance tools. *Education Research International, 2023* (1), 1-15. https://doi.org/10.1155/2023/4253331

Balta, E. (2018). The relationships among writing skills, writing anxiety and metacognitive awareness. *Journal of Education and Learning, 7*(3), 233-241. https://doi.org/10.5539/jel.v7n3p233

Bandura, A. (2012). On the functional properties of perceived self-efficacy revisited. *Journal of management, 38*(1), 9-44.

Barrot, J. S. (2023). Using ChatGPT for second language writing: Pitfalls and potentials. *Assessing Writing, 57,* 100745. https://doi.org/10.1016/j.asw.2023.100745

Blasco, J. A. (2016). The relationship between writing anxiety, writing selfefficacy, and Spanish EFL students' use of metacognitive writing strategies: a case study. *Journal of English Studies, 14,* 7-45. https://doi.org/10.18172/jes.3069

Cheng, Y. S. (2002). Factors associated with foreign language writing anxiety. *Foreign Language Annals 35*(5), 647-656.

Cheng, Y. S. (2004a). A measure of second language writing anxiety: Scale development and preliminary validation. *Journal of Second Language Writing, 13*(4), 313-335. https://doi.org/10.1016/j.jslw.2004.07.001

Cheng, Y. S. (2004b). EFL students' writing anxiety: Sources and implications. *English Teaching & Learning, 29*(2), 41-62.

Cheng, E. C., & Chan, J. K. (2021). *Developing metacognitive teaching strategies through lesson study.* Springer Singapore.

Cheng, Y. S., Horwitz, E. K., & Schallert, D. L. (1999). Language anxiety: Differentiating writing and speaking components. *Language Learning, 49*(3), 417-446.

Chung, H. Q., Chen, V., & Olson, C. B. (2021). The impact of self-assessment, planning and goal setting, and reflection before and after revision on student self-efficacy and writing performance. *Reading and Writing, 34*(7), 1885-1913. https://doi.org/10.1007/s11145-021-10186-x

Cotton, D. R. E., Cotton, P. A., & Shipway, J. R. (2023). Chatting and cheating: Ensuring academic integrity in the era of ChatGPT. *Innovations in Education and Teaching International*, 1-12. https://doi.org/10.1080/14703297.2023.2190148

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive–developmental inquiry. *American Psychologist, 34*(10), 906.

Graham, S., Camping, A., Harris, K. R., Aitken, A. A., Wilson, J. M., Wdowin, J., & Ng, C. (2021). Writing and writing motivation of students identified as English language learners. *International Journal of TESOL Studies, 3*(1), 1-13.

Hair, J. F., Anderson, R. E., Tatham, R. L. & Black W. C. (2010). *Multivariate data analysis: A global perspective (7th Edition)*. Pearson Prentice Hall.

Harris, K. R., Graham, S., Brindle, M., & Sandmel, K. (2009). Metacognition and children's writing. *In Handbook of metacognition in education* (pp. 131-153). Routledge.

Hartwell, K., & Aull, L. (2023). Editorial Introduction–AI, corpora, and future directions for writing assessment. *Assessing Writing, 57,* 100769.

Holden, H., & Rada, R. (2011). Understanding the influence of perceived usability and technology self-efficacy on teachers' technology acceptance. *Journal of research on technology in education, 43*(4), 343-367.

Hood, N., Littlejohn, A., & Milligan, C. (2015). Context counts: How learners' contexts influence learning in a MOOC. *Computers & Education, 91,* 83-91.

Horwitz, E. K., Horwitz, M. B., & Cope, J. (1986). Foreign language classroom anxiety. *The Modern Language Journal, 70*(2), 125-132.

Huang, S., & Renandya, W. A. (2018). Exploring the integration of automated feedback among lower-proficiency EFL learners. *Innovation in Language Learning and Teaching, 14*(1), 15-26. https://doi.org/10.1080/17501229.2018.1471083

Huerta, M., Goodson, P., Beigi, M., & Chlup, D. (2016). Graduate students as academic writers: writing anxiety, self-efficacy and emotional intelligence. *Higher Education Research & Development, 36*(4), 716-729. https://doi.org/10.1080/07294360.2016.1238881

Khodaei, S., Hasanvand, S., Gholami, M., Mokhayeri, Y., & Amini, M. (2022). The effect of the online flipped classroom on self-directed learning readiness and metacognitive awareness in nursing students during the COVID-19 pandemic. *BMC Nursing, 21*(1), 22. https://doi.org/10.1186/s12912-022-00804-6

Khosravi, R., Dastgoshadeh, A., & Jalilzadeh, K. (2023). Writing metacognitive strategy-based instruction through flipped classroom: an investigation of writing performance, anxiety, and self-efficacy. *Smart Learning Environments, 10*(1), 1-26. https://doi.org/10.1186/s40561-023-00264-8

Kline, R. B. (2011). *Principles and practice of structural equation modeling.* The Guilford Press.

Lee, I., & Mak, P. (2018). Metacognition and Metacognitive Instruction in Second Language Writing Classrooms. *TESOL Quarterly, 52*(4), 1085-1097. https://doi.org/10.1002/tesq.436

Lee, I., & Yuan, R. (2021). Understanding L2 writing teacher expertise. *Journal of Second Language Writing, 52,* 100755. https://doi.org/10.1016/j.jslw.2020.100755

Lung-Guang, N. (2019). Decision-making determinants of students participating in MOOCs: Merging the theory of planned behavior and self-regulated learning model. *Computers & Education, 134*, 50-62.

Marzuki, Widiati, U., Rusdin, D., Darwin, & Indrawati, I. (2023). The impact of AI writing tools on the content and organization of students' writing: EFL teachers' perspective. *Cogent Education, 10*(2). https://doi.org/10.1080/2331186x.2023.2236469

Piechurska-Kuciel, E. (2019). Mediation effect of self-efficacy in the relationship between neuroticism and L2 attainment. *Journal of Multilingual and Multicultural Development, 42*(3), 262-274. https://doi.org/10.1080/01434632.2019.1684929

Qin, L., & Zhang, L. J. (2019). English as a foreign language writer's metacognitive strategies knowledge of writing and their writing performance in multimedia environment. *Journal of Writing Research, 12*(2), 393-413.

Rad, H. S., Alipour, R., & Jafarpour, A. (2023). Using artificial intelligence to foster students' writing feedback literacy, engagement, and outcome: A case of Wordtune application. *Interactive Learning Environments,* 1-21.

Rasool, U., Qian, J., & Aslam, M. Z. (2023). An investigation of foreign language writing anxiety and its reasons among pre-service EFL teachers in Pakistan. *Frontiers in Psychology, 13,* 947867.

Rowe, L. W. (2022). Google translate and biliterate composing: Second-graders' use of digital translation tools to support bilingual writing. *TESOL Quarterly, 56*(3), 883-906. https://doi.org/10.1002/tesq.3143

Sabti, A. A., Md Rashid, S., Nimehchisalem, V., & Darmi, R. (2019). The impact of writing anxiety, writing achievement motivation, and writing self-efficacy on writing performance: A correlational study of Iraqi tertiary EFL learners. *SAGE Open, 9*(4), 1-13. https://doi.org/10.1177/2158244019894289

Schraw, G., & Dennison, R. S. (1994). Assessing metacognitive awareness. *Contemporary educational psychology, 19*(4), 460-475.

Shen, X., & Teng, M. F. (2024). Three-wave cross-lagged model on the correlations between critical thinking skills, self-directed learning competency and AI-assisted writing. *Thinking Skills and Creativity, 52,* 101524.

Song, C., & Song, Y. (2023). Enhancing academic writing skills and motivation: assessing the efficacy of ChatGPT in AI-assisted language learning for EFL students. *Frontiers in Psychology, 14*, 1260843. https://doi.org/10.3389/fpsyg.2023.1260843

Sun, B., & Fan, T. (2022). The effects of an AWE-aided assessment approach on business English writing performance and writing anxiety: A contextual consideration. *Studies in Educational Evaluation, 72,* 101123. https://doi.org/10.1016/j.stueduc.2021.101123

Sun, T., & Wang, C. (2020). College students' writing self-efficacy and writing self-regulated learning strategies in learning English as a foreign language. *System, 90*, 102221.

Teng, M. F. (2019). The role of metacognitive knowledge and regulation in mediating university EFL learners' writing performance. *Innovation in Language Learning and Teaching, 14*(5), 436-450. https://doi.org/10.1080/17501229.2019.1615493

Teng, M. F. (2021a). Effects of individual and group metacognitive prompts on tertiary-level students' metacognitive awareness and writing outcomes. *The Asia-Pacific Education Researcher, 31*(5), 601-612. https://doi.org/10.1007/s40299-021-00611-8

Teng, M. F. (2021b). Interactive-whiteboard-technology-supported collaborative writing: Writing achievement, metacognitive activities, and co-regulation patterns. *System, 97,* 102426. https://doi.org/10.1016/j.system.2020.102426

Teng, M. F., & Huang, J. (2021). The effects of incorporating metacognitive strategies instruction into collaborative writing on writing complexity, accuracy, and fluency. *Asia Pacific Journal of Education, 43*(4), 1071-1090. https://doi.org/10.1080/02188791.2021.1982675

Teng, M. F., & Qin, C. (2024). Assessing metacognitive writing strategies and the predictive effects on multimedia writing. *Asia Pacific Journal of Education*, 1-24. https://doi.org/10.1080/02188791.2024.2325132

Teng, M. F., Qin, C., & Wang, C. (2022). Validation of metacognitive academic writing strategies and the predictive effects on academic writing performance in a foreign language context. *Metacognition Learning, 17*(1), 167-190. https://doi.org/10.1007/s11409-021-09278-4

Teng, M. F., & Wang, C. (2022). Assessing academic writing self-efficacy belief and writing performance in a foreign language context. *Foreign Language Annals, 56*(1), 144-169. https://doi.org/10.1111/flan.12638

Teng, M. F., Wang, C., & Wu, J. G. (2021). Metacognitive strategies, language learning motivation, self-efficacy belief, and english achievement during remote learning: A structural equation modelling approach. *RELC Journal, 54*(3), 648-666. https://doi.org/10.1177/00336882211040268

Teng, M. F., & Yang, Z. (2023). Metacognition, motivation, self-efficacy belief, and English learning achievement in online learning: Longitudinal mediation modeling approach. *Innovation in Language Learning and Teaching, 17*(4), 778-794. https://doi.org/10.1080/17501229.2022.2144327

Teng, M. F., & Zhang, L. J. (2024). Validating a new method for assessing young foreign language learners' metacognitive knowledge. *Research Methods in Applied Linguistics, 3*(2), 100121. https://doi.org/10.1016/j.rmal.2024.100121

Waer, H. (2021). The effect of integrating automated writing evaluation on EFL writing apprehension and grammatical knowledge. *Innovation in Language Learning and Teaching, 17*(1), 47-71. https://doi.org/10.1080/17501229.2021.1914062

Wang, Y. Y., & Chuang, Y. W. (2024). Artificial intelligence self-efficacy: Scale development and validation. *Education and Information Technologies, 29*(4), 4785-4808.

Wenden, A. L. (1998). Metacognitive knowledge and language learning. *Applied Linguitic, 19*(4), 515-537.

Wu, H., & Leung, S. O. (2017). Can likert scales be treated as interval scales?—A simulation study. *Journal of Social Service Research, 43*(4), 527-532. https://doi.org/10.1080/01488376.2017.1329775

Yamaoka, K. (2024). ChatGPT's Motivational effects on Japanese university EFL learners: A qualitative analysis. *International Journal of TESOL Studies, 6*(3), 24-35.

Yang, H., & Wu, X. (2023). Foreign language anxiety, motivation and intercultural communication competence of Chinese top university students. *International Journal of TESOL Studies, 5*(3), 88-107.

Zhang, C., & Zhang, W. (2022). The Impact of academic procrastination on second language writing: The mediating role of l2 writing anxiety. *Frontiers in Psychology, 13*, 851120. https://doi.org/10.3389/fpsyg.2022.851120

Zhang, L. J., & Qin, T. L. (2018). Validating a questionnaire on EFL writers' metacognitive awareness of writing strategies in multimedia environments. In Haukås, Å., Bjørke, C., & Dypedahl, M. (Eds.). *Metacognition in language learning and teaching* (pp. 157-178). Routledge.

Zhang, M. (2018). Collaborative writing in the EFL classroom: The effects of L1 and L2 use. *System, 76*, 1-12. https://doi.org/10.1016/j.system.2018.04.009

Zhang, X. (2019). Exploring the relationship between college students' writing anxiety and the pedagogical use of online resources. *International Journal of Educational Technology in Higher Education, 16*(1), 1-18. https://doi.org/10.1186/s41239-019-0149-y

Zhao, X. (2022). Leveraging Artificial Intelligence (AI) technology for english writing: Introducing Wordtune as a digital writing assistant for efl writers. *RELC Journal, 54*(3), 890-894. https://doi.org/10.1177/00336882221094089

Zimmerman, B. J. (2000). Self-efficacy: An essential motive to learn. *Contemporary educational psychology*, *25*(1), 82-91.

Xiaolei Shen is a PhD candidate in TESL at the University of Putra Malaysia at the Faculty of Educational Studies. She is fascinated about learning strategies such as metacognitive strategies and critical thinking skills.

ORCID: https://orcid.org/0000-0002-8112-6179.

Yahui Tao is a lecturer at the Faculty of Foreign Languages of Anyang University. His research includes translation theory and EFL learners' writing performance.

ORCID: https://orcid.org/0009-0000-3869-4368.