

Influence of Self-Regulated Learning Strategies on L2 Writing Performance in AI-Assisted Writing: The Serial Mediating Roles of Writing Self-Efficacy and Writing Engagement

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Abstract: Generative AI tools are increasingly integrated into EFL writing instruction. However, within AI-assisted writing contexts, the relationship between self-regulated learning (SRL) strategies and L2 writing performance, and its underlying mechanisms, has received limited empirical attention. To address this gap, the present quantitative study, grounded in social cognitive theory, investigated the relationship between SRL strategies and L2 writing performance and tested whether writing self-efficacy and writing engagement mediated it. A sample of 304 second-year Business English majors who used AI tools in their English writing course participated in the study. Structural equation modeling (SEM) analysis indicated that writing self-efficacy and writing engagement mediated the relationship between SRL strategies and L2 writing performance. Specifically, neither the direct effect of SRL strategies on L2 writing performance nor the indirect effect through writing self-efficacy alone was significant. The indirect effect through writing engagement was marginally significant. Writing self-efficacy and writing engagement had a serial mediating effect on the relationship between SRL strategies and L2 writing performance. The study also discusses the practical implications of these findings and its limitations.

Keywords: Self-regulated learning strategies; Writing self-efficacy; Writing engagement; L2 writing performance; AI-assisted writing

1. Introduction

Artificial intelligence (AI) has advanced rapidly in recent years, and AI-assisted writing tools are now widely integrated into language education, changing how EFL learners compose, revise, and develop their writing [1][2]. Within AI-assisted writing settings, learners' L2 writing performance plays an important role in reflecting their language proficiency and determining their academic success [3][4]. In EFL writing courses, AI tools have become an important factor in developing students' writing, and studies have found that instruction supported by these tools can improve learners' writing performance [1][2]. In addition, it is important to recognize the factors that contribute to writing performance and to identify instructional practices that can enhance it [5][6]. For decades, writing performance has drawn sustained attention in second language research [7], not least because it is closely tied to learners' writing self-efficacy and self-regulatory capacities [8][9]. Therefore, understanding how writing performance can be improved in AI-assisted courses has become a shared concern of writing researchers and language teachers [10][3].

Among the factors that shape L2 writing performance, the strategies learners use to regulate their own writing process are of particular interest [11][9]. Among these, self-regulated learning (SRL) strategies stand out as one of the most significant factors, referring to learners' self-generated thoughts and actions to regulate their English writing, including cognitive, metacognitive, social-behavioral, and motivational regulation strategies [11][12]. With the support of AI tools in such environments, these strategies help learners plan, monitor, evaluate, and revise their writing [10][1]. Drawing on Social Cognitive Theory (SCT) [13], this study sets out to investigate how SRL strategies relate to learners' L2 writing performance, with the aim of improving learners' writing outcomes and offering new

insights into AI-assisted writing instruction.

Social Cognitive Theory posits triadic reciprocity among personal factors, behavioral patterns, and environmental events as interacting determinants of human functioning [13]. From an SCT perspective, learners' behavioral practices influence their personal beliefs, which in turn shape subsequent behaviors and ultimately affect academic performance [14][15]. Grounded in SCT, Zimmerman's [15][12] cyclical model further delineates how self-regulatory strategy use during the performance phase generates enactive mastery experiences that strengthen self-efficacy in the self-reflection phase, which then deepens engagement in subsequent writing tasks. Writing engagement refers to learners' active involvement and investment in writing tasks, comprising behavioral, emotional, cognitive, and agentic dimensions [16][17]. This study proposes to examine whether the relationship between SRL strategies and L2 writing performance in AI-assisted English writing environments can be explained by two sequential mediators, namely writing self-efficacy and writing engagement.

In AI-assisted writing environments, writing self-efficacy plays an important role in promoting students' active writing engagement [10]. Writing self-efficacy is a key factor affecting L2 writing effectiveness [7]. Previous findings show that writing self-efficacy is positively correlated with students' writing performance in university English writing [8][18], and significantly predicts learners' engagement in L2 writing [19]. However, how SRL strategies, writing self-efficacy, writing engagement, and writing performance interconnect in AI-assisted writing remains poorly understood.

Although SRL strategies have been shown to predict students' writing performance [8][20], which variables mediate this relationship, and how they relate to one another, is still far from clear. Previous evidence suggests that both writing self-efficacy and writing engagement are positively associated with writing performance [21][3]. SRL strategies are also positively related to writing self-efficacy [22][8]. Writing self-efficacy, in turn, fosters writing engagement [10][19], and writing engagement positively predicts L2 writing performance [21][3]. Recent work has begun to test sequential mediation involving self-efficacy and self-regulation in AI-assisted EFL writing engagement [10], but whether writing self-efficacy and writing engagement jointly form a sequential bridge between SRL strategies and L2 writing performance in AI-assisted English writing remains an open question. For this reason, the present study takes the relationship between SRL strategies and L2 writing performance as its starting point, and examines the mechanism through which SRL strategies operate on L2 writing performance in AI-assisted English writing courses, approached from the perspective of self-regulated learning. The present study focuses on the following four research questions.

RQ1: Do SRL strategies directly predict L2 writing performance?

RQ2: Does writing self-efficacy mediate the relationship between SRL strategies and L2 writing performance?

RQ3: Does writing engagement mediate the relationship between SRL strategies and L2 writing performance?

RQ4: Do writing self-efficacy and writing engagement have a serial mediating effect on the relationship between SRL strategies and L2 writing performance?

2. Literature Review

2.1 Theoretical Background and Hypothesis

Social cognitive theory holds that human learning arises not from personal factors, behavior, or the environment alone, but from the continuous interaction of the three. Bandura [13] terms this view triadic reciprocal determinism, which constitutes the overarching framework of the present study. Within this framework, self-efficacy represents a central personal factor, influencing the tasks learners choose, the effort they expend, and the persistence they show when confronted with difficulty.

Zimmerman and Risemberg [9] extended this theory to the domain of writing and formulated a triadic model of writing self-regulation. In this model, the regulation of environmental, behavioral, and personal processes proceeds through a recurring cycle of self-observation, self-judgment, and self-reaction. Seen from this perspective, SRL writing strategies constitute the behavioral component of the triad, because they capture what learners actually do during writing. Successful use of these strategies in writing tasks gives learners mastery experience, which in turn strengthens their writing self-efficacy. Learners with stronger writing self-efficacy then tend to participate more actively in writing activities,

and such behavioral participation ultimately contributes to writing performance. In the present study, the environmental side of this triad is represented by an AI-assisted EFL writing course, in which generative AI tools are integrated across different stages of the whole writing process. As learning resources within this environment, these tools change the feedback and support available to writers [23]. Social cognitive theory further suggests that environmental changes of this kind can reshape learners' strategy use, writing self-efficacy, and engagement in writing.

2.2 Self-Regulated Learning Strategies and L2 Writing Performance

L2 writing performance is influenced by a wide range of learner factors, among which self-regulation has been shown to be closely associated with writing achievement [24][20]. As generative AI tools enter writing instruction, they offer powerful affordances for L2 writers but also raise concerns about student learning [23]. Teng and Zhang [11] defined SRL writing strategies as learners' proactive regulation of cognition, metacognition, social behavior, and motivational processes in L2 writing. Building on this definition, Teng and Huang [24] tested the predictive effects of these strategies among secondary school EFL learners. Nine SRL writing strategies jointly predicted writing proficiency, and goal-oriented monitoring emerged as the strongest predictor. Teng, Wang, and Zhang [20] extended this line of research to young EFL learners in China, where self-regulatory writing strategies significantly and positively predicted writing performance. These studies establish a positive relationship between SRL strategies and writing outcomes. In AI-assisted writing, Jin, Lin, and Lai [25] explored how self-regulated learning influences writing outcomes among 1,073 postgraduate students. SRL strategies positively predicted all three types of AI use, and the most advanced type, namely using AI to transform one's writing, significantly enhanced writing quality. These studies, though, focused on the direct relationship, and the internal mechanisms through which SRL writing strategies lead to better L2 writing performance have rarely been examined. In AI-assisted writing, where AI tools are changing how learners use strategies, examining these mechanisms is particularly important. Accordingly, the present study introduces the first hypothesis.

H1: SRL strategies directly predict L2 writing performance.

2.3 The Mediating Role of Writing Self-Efficacy

Of the motivational factors that shape L2 writing, writing self-efficacy occupies an important position. It refers to learners' beliefs in their capability to accomplish specific writing tasks, beliefs tied to particular domains and tasks rather than a general trait [7]. Bandura [14] identified four major sources of self-efficacy, among which mastery experience, namely successful performance that learners have personally accomplished, is the most influential.

As defined above [11], SRL strategies help learners plan, monitor, and complete writing tasks successfully. Effective use of SRL writing strategies can serve as an important source of mastery experience that strengthens writing self-efficacy. In a sample of 155 fourth-grade students in Hong Kong (China), Bai and Guo [22] investigated the relationship between SRL strategy use and self-efficacy in English writing. The use of SRL strategies, particularly planning and self-monitoring strategies, was significantly and positively related to students' self-efficacy. In AI-assisted writing contexts, Liu and Zhang [26] identified distinct profiles of GenAI-assisted writing self-efficacy among language learners, and these profiles were closely related to learners' use of writing SRL strategies. Even when writing is mediated by generative AI, strategy use and writing self-efficacy remain connected.

The relationship between writing self-efficacy and L2 writing performance has also been extensively investigated. From a social cognitive perspective, Teng, Sun, and Xu [27] divided EFL writing self-efficacy into linguistic, self-regulatory, and performance dimensions, and these dimensions correlated with L2 writing performance to varying degrees. A meta-regression of 76 primary studies with 565 effect sizes confirmed a moderate correlation between writing self-efficacy and writing achievement, and this correlation was significantly larger among L2 writers [18].

Overall, the evidence indicates that SRL writing strategies are positively related to writing self-efficacy [22][26] and that writing self-efficacy is associated with L2 writing performance [18][27]. To date, these two relationships have been examined separately rather than within a single model. Joint modeling of the two paths is needed to clarify whether writing self-efficacy carries the influence of SRL writing strategies on writing performance, and evidence from AI-assisted writing contexts remains limited. Therefore, we put forward the second hypothesis.

H2: Writing self-efficacy mediates the relationship between SRL strategies and L2 writing performance.

2.4 The Mediating Role of Writing Engagement

Writing self-efficacy is closely related to L2 writing performance [27][18]. Despite this close relationship, the internal mechanism that translates writing self-efficacy into writing performance remains insufficiently understood. In social cognitive theory, Bandura [14] stated that self-efficacy shapes the courses of action people choose to pursue, how much effort they put forth, and how long they will persevere in the face of obstacles. In writing, learners with stronger writing self-efficacy tend to participate more actively, invest more effort, and persist longer in writing tasks [7].

In educational research, these patterns of participation, effort, and persistence are examined under the construct of engagement [16], which is widely conceptualized as a multidimensional construct. Its behavioral, emotional, and cognitive dimensions refer to participation and effort in learning tasks, affective reactions to learning activities, and psychological investment in mastering difficult skills, respectively [16]. This three-dimensional structure has also been validated among Chinese EFL university students receiving teacher written corrective feedback [28].

In an early study, Lo and Hyland [29] reported that a new writing programme with topics of interest and genuine audiences enhanced primary students' writing engagement and motivation in Hong Kong (China). Their work indicates that engagement is malleable through instruction, which makes it a meaningful target in L2 writing research.

A growing body of studies has closely tied writing engagement to learners' writing performance. Tsao [30] found that EFL learners' cognitive engagement with teacher written corrective feedback was directly linked to their self-reported writing proficiency. Extending this result, Li and Yuan [31] showed that affective and behavioral engagement with feedback significantly predicted English writing achievement. Beyond this direct link, Cai and Xing [32] confirmed among 692 Chinese first-year EFL students that self-efficacy was indirectly related to English achievement through engagement, with only cognitive engagement serving as the mediator.

As regards the antecedents of writing engagement, writing self-efficacy and SRL strategies both play a role. Tsao [33] reported that EFL learners' L2 writing self-efficacy, particularly self-efficacy for writing self-regulation, predicted their engagement with teacher and peer written corrective feedback. In GenAI-assisted writing, Xue and Chen [34] tested this relationship among 564 Chinese postgraduate students, and writing self-efficacy significantly predicted feedback engagement, which in turn predicted writing SRL strategies. Zhou and Hiver [35] similarly documented that among 816 Chinese English majors, SRL strategy use in L2 writing was an important predictor of students' engagement in the writing class. Further support comes from Xu, Li, and Yang [36], who surveyed 1,107 Chinese EFL undergraduates in smart classrooms. In their study, SRL strategies did not directly predict learning engagement, and self-efficacy fully mediated the relationship between the two. This result provides preliminary evidence for the sequence from SRL strategies through self-efficacy to engagement.

In sum, writing engagement is associated with writing performance [30][31][32], and writing self-efficacy and SRL strategies are related to writing engagement [33][34][35][36]. Nevertheless, most studies tested only one side of this relationship, and evidence from AI-assisted writing is still scarce. On this basis, the present study advances the third hypothesis.

H3: Writing engagement mediates the relationship between SRL strategies and L2 writing performance.

2.5 The Serial Mediating Mechanism of Writing Self-Efficacy and Writing Engagement

The preceding sections have shown that SRL writing strategies are positively related to both writing self-efficacy [22] and writing engagement [35], and that these two factors are each associated with L2 writing performance [18][30]. On this basis, these findings suggest that writing self-efficacy and writing engagement may each mediate the relationship between SRL writing strategies and L2 writing performance. The order of the chain follows social cognitive theory, in which personal factors, behavior, and the environment influence one another reciprocally [15]. SRL writing strategies serve as the behavioral starting point, because their successful use provides mastery experience that strengthens writing self-efficacy [14]. Writing self-efficacy then shapes subsequent learning behavior, and in writing this behavior takes the form of engagement [16]. Engagement represents the actual investment

in writing activities, so it is the most proximal behavioral contributor to writing performance [32][31].

The closest empirical investigation comes from Xu, Li, and Yang [36], in which self-efficacy fully mediated the relationship between SRL strategies and learning engagement. Serial mediation has been introduced into L2 writing research, as in the model from the ideal L2 writing self through writing enjoyment and strategy use to integrated writing performance [37]. Although the variable order differs from the present model, their study confirms that sequential mechanisms can be examined in L2 writing. It should also be noted that Zhou et al. [19] and Xue and Chen [34] reported the reverse direction from writing self-efficacy to SRL strategy use. The causal order between SRL writing strategies and writing self-efficacy deserves further examination rather than being taken for granted.

On the one hand, whether each mediator carries the effect of SRL writing strategies on L2 writing performance is still unclear in AI-assisted writing contexts. On the other hand, investigations of the two mediators cannot show the process, because they do not answer through which path and in which order SRL writing strategies are converted into writing performance. A full understanding of how SRL writing strategies work in L2 writing requires testing the sequential chain. Thus, the present study examines the relationship between SRL writing strategies and L2 writing performance in an AI-assisted writing context. It further tests the mediating roles of writing self-efficacy and writing engagement in this relationship. On these grounds, we put forward the fourth hypothesis.

H4: Writing self-efficacy and writing engagement have a serial mediating effect on the relationship between SRL strategies and L2 writing performance.

3. Methods

3.1 Context and Participants

The study was conducted in an English writing course at a Chinese college, in which generative AI tools were integrated into regular writing instruction. Convenience sampling was used in this study, with second-year Business English majors enrolled in the course chosen as research participants. All were native Chinese speakers learning English as a foreign language. Data were collected in Week 15 of the 16-week course. Altogether 410 students completed the online questionnaire and the writing task. Before analysis, the questionnaire responses were screened. Invalid questionnaires, including duplicate submissions and those showing invariant responding, were removed, leaving 304 valid cases and a valid response rate of 74.1%. Reverse-worded items were reverse-scored prior to analysis. The final sample comprised 58 males (19.1%) and 246 females (80.9%). Before data collection, all students were informed of the purpose of the research. They were assured that their responses would remain confidential and would have no effect on their course grades. Participation was voluntary, and informed consent was obtained from every participant.

3.2 Instruments

All self-report measures were completed in Chinese via an online survey platform. Scales originally developed in English underwent translation into Chinese and subsequent back-translation in accordance with the procedure recommended by Brislin [38].

3.2.1 Questionnaire of English Writing Self-Regulated Learning Strategies (QEWSRLS)

The QEWSRLS [8] was used to assess students' use of self-regulated learning (SRL) strategies in English writing. This instrument was adapted from Wang and Bai's [39] English SRL strategies questionnaire. Its 26 items fall into three subscales, namely environmental strategies (8 items, structuring surroundings and using external resources), behavioral strategies (8 items, monitoring and regulating composing actions), and personal strategies (10 items, goal setting, planning, and self-evaluation). All items were rated on a 5-point Likert scale (1 = never, 5 = always), and the item scores were averaged, with higher scores indicating more frequent SRL strategy use. In this study, the scale demonstrated excellent internal consistency (Cronbach's $\alpha = .908$).

3.2.2 English Writing Self-Efficacy Scale

Writing self-efficacy was measured with the English Writing Self-Efficacy Scale developed and validated in Chinese by Tang and Xu [40]. The full scale contains 14 items in two subscales, namely writing skill self-efficacy (9 items) and writing task self-efficacy (5 items). The five task items concern everyday practical genres such as forms, letters, and e-mails. Because the outcome of the present study

was an argumentative essay, these five items were removed, and only the nine skill items were used in the analyses. Responses were given on a 5-point scale (1 = completely untrue of me, 5 = completely true of me), and the nine-item scale showed good internal consistency in this study (Cronbach's $\alpha = .855$).

3.2.3 L2 Writing Engagement Scale (L2WES)

Writing engagement was measured with the 14-item L2 writing engagement scale adapted by Gu [41] from Hiver et al.'s [42] 24-item L2 classroom engagement scale. The items were reworded to refer specifically to English writing, and those with satisfactory psychometric properties were retained. The scale consists of five behavioral, five emotional, and four cognitive engagement items, and one emotional item is negatively worded. Responses were given on a 6-point scale (1 = strongly disagree, 6 = strongly agree) to discourage central-tendency answering. The scale showed good internal consistency in this study (Cronbach's $\alpha = .894$).

3.2.4 Writing Performance

Writing performance was measured with an argumentative essay of about 250 words, written in class within 45 minutes without access to AI tools or any other assistance. This design ensured that the writing scores reflected students' true L2 writing proficiency rather than the quality of AI-generated output. Each essay was scored on a 100-point scale with the analytic rubric of Jacobs et al. [43]. The rubric assigns 30 points to content, 20 to organization, 25 to language use, 20 to vocabulary, and 5 to mechanics. Two experienced EFL teachers, each with more than five years of English writing teaching experience, rated the essays independently, and the mean of the two ratings was used as the writing performance score.

3.3 Procedure

During the course, generative AI tools were used to support regular writing instruction, for example to help students brainstorm ideas and obtain feedback on their drafts. Data were collected in Week 15 of the course. The students completed the online questionnaire (the SRL strategy, writing self-efficacy, and writing engagement scales, together with demographic items, all administered in Chinese) and wrote the argumentative essay under test conditions. All data were anonymized before analysis.

3.4 Data Analysis

The analysis proceeded in three stages. First, SPSS 26.0 was used for data screening, descriptive statistics, reliability analysis, Harman's single-factor check for common method bias, and zero-order correlations among the study variables. Second, following the two-step strategy recommended by Anderson and Gerbing [44], a confirmatory factor analysis (CFA) was carried out in Amos 24.0 to evaluate the measurement model. SRL strategies were indicated by three parcels corresponding to their a priori subscales (environmental, behavioral, personal), and writing engagement by three parcels (behavioral, emotional, cognitive). Writing self-efficacy was indicated directly by its nine skill items, without parceling. Model fit was judged against conventional cut-offs, namely χ^2/df below 3, GFI, TLI, and CFI of .90 or higher, and RMSEA of .08 or lower [45][46]. Convergent validity was examined through composite reliability ($CR \geq .70$) and average variance extracted ($AVE \geq .50$), and discriminant validity through the Fornell-Larcker criterion [47].

Third, the structural model was estimated with maximum likelihood, and the mediation hypotheses were tested with 5,000 bias-corrected bootstrap samples. Because the model contains two sequentially linked mediators, the total indirect effect was decomposed into three specific indirect effects. These are the path through writing self-efficacy alone (a1b1), the path through writing engagement alone (a2b2), and the sequential path through writing self-efficacy and then writing engagement (a1d21b2). Each was computed as the product of its constituent paths and tested with its own bootstrap confidence interval, and an effect was considered significant when its 95% CI excluded zero. The overall pattern of mediation was classified with reference to Zhao, Lynch, and Chen [48].

4. Results

4.1 Common Method Bias

Harman's single-factor test showed that the first unrotated factor explained 28.60% of the total variance, so that no single factor accounted for the majority of the covariance among the measures [49]. Common method bias was therefore not a serious concern in this study. In addition, the outcome variable was an objectively scored essay rather than a self-report measure, and this further mitigates the concern.

4.2 Descriptive Statistics and Correlations

Sampling adequacy was satisfactory and Bartlett's test of sphericity was significant, supporting the factorability of the item set ($KMO = .919$, $\chi^2(1176) = 6943.783$, $p < .001$). Means, standard deviations, and correlations among the study variables are reported in Table 1. The largest absolute skewness and kurtosis across the analysis items were 0.746 and 1.306, respectively. Both were well within the ± 2 range recommended by George and Mallery [50], so the variables were treated as approximately normal. As shown in Table 1, writing performance correlated positively with SRL strategies ($r = .151$, $p = .008$), writing self-efficacy ($r = .148$, $p < .01$), and writing engagement ($r = .199$, $p < .001$). The three psychological variables intercorrelated moderately to strongly ($r_s = .476-.670$, $ps < .001$), which provided an initial basis for testing the hypothesized mediation model.

Table 1. Means, standard deviations, and correlations among the study variables ($N = 304$)

Variable	<i>M</i>	<i>SD</i>	1	2	3	4
1. Writing score	54.08	10.46	—			
2. SRL strategies	3.39	0.48	.151**	—		
3. Writing self-efficacy	3.59	0.51	.148**	.537***	—	
4. Writing engagement	4.48	0.57	.199***	.670***	.476***	—

Note. SRL strategies and writing self-efficacy are on 5-point scales, writing engagement is on a 6-point scale, and the writing score is on a 100-point scale. ** $p < .01$, *** $p < .001$.

4.3 Measurement Model

All fit indices of the CFA measurement model met the conventional cut-offs, indicating an acceptable fit to the data ($\chi^2(87) = 220.713$, $p < .001$, $\chi^2/df = 2.537$, GFI = .911, TLI = .924, CFI = .937, RMSEA = .071, 90% CI [.060, .083], Table 2). All standardized loadings fell between .530 and .871 and were significant ($p < .001$). Composite reliabilities ranged from .835 to .896, exceeding the .70 benchmark (Table 3). The AVE values of SRL strategies (.741) and writing engagement (.627) exceeded the .50 benchmark, whereas the AVE of writing self-efficacy (.400) fell slightly below it. Because the composite reliability of writing self-efficacy was high (.856), its convergent validity was still considered adequate, following the guideline that an AVE slightly below .50 remains acceptable when composite reliability is satisfactory [47][51]. The square roots of the AVEs (.861 for SRL strategies, .633 for writing self-efficacy, .792 for writing engagement) were compared with the latent correlations (.60 between SRL strategies and writing self-efficacy, .79 between SRL strategies and writing engagement, and .58 between writing self-efficacy and writing engagement). Each $\sqrt{AVE}$ exceeded its corresponding correlations, the only close call being the SRL–writing engagement pair (.792 versus .79). Given the clear theoretical distinction between the two constructs, discriminant validity was judged acceptable.

Table 2. Fit indices for the measurement and structural models

Model	χ^2	<i>df</i>	<i>p</i>	χ^2/df	GFI	TLI	CFI	RMSEA [90% CI]
Measurement model (CFA)	220.713	87	< .001	2.537	.911	.924	.937	.071 [.060, .083]
Structural model	237.705	99	< .001	2.401	.911	.922	.935	.068 [.057, .079]

Note. Values in brackets are 90% confidence intervals for RMSEA.

Table 3. Standardized loadings, composite reliability (CR), and average variance extracted (AVE)

Construct	Indicator	Std. loading	CR	AVE	√AVE
SRL strategies	Environmental strategies	.858	.896	.741	.861
	Behavioral strategies	.853			
	Personal strategies	.871			
Writing self-efficacy	SEF1	.689	.856	.400	.633
	SEF2	.742			
	SEF3	.639			
	SEF4	.565			
	SEF5	.677			
	SEF6	.645			
	SEF7	.599			
	SEF8	.581			
	SEF9	.530			
Writing engagement	Behavioral engagement	.805	.835	.627	.792
	Emotional engagement	.757			
	Cognitive engagement	.813			

Note. Internal consistency of the full scales (Cronbach's α) was .908 for SRL strategies (26 items), .855 for writing self-efficacy (9 items), and .894 for writing engagement (14 items).

4.4 Structural Model and Direct Effects

The fit indices of the hypothesized structural model met the conventional cut-offs ($\chi^2(99) = 237.705$, $p < .001$, $\chi^2/df = 2.401$, GFI = .911, TLI = .922, CFI = .935, RMSEA = .068, 90% CI [.057, .079], Table 2). The significant chi-square can be attributed to its known sensitivity to sample size. All incremental and absolute indices met the conventional criteria.

Table 4 and Figure 1 summarize the standardized solution. SRL strategies strongly predicted writing self-efficacy ($\beta = .599$, $p < .001$) and writing engagement ($\beta = .685$, $p < .001$), and writing self-efficacy predicted writing engagement over and above SRL strategies ($\beta = .168$, $p = .011$). Writing engagement, in turn, positively predicted writing performance, although this path fell just short of the .05 level ($\beta = .227$, $p = .062$). Two paths were clearly nonsignificant. The path from writing self-efficacy to writing performance was small ($\beta = .063$, $p = .447$), and the direct path from SRL strategies to writing performance was virtually zero and negative ($\beta = -.055$, $p = .649$). The model accounted for 35.9% of the variance in writing self-efficacy, 63.5% in writing engagement, and 5.2% in writing performance.

Table 4. Direct effects in the structural model

Path	B	S.E.	C.R.	β	p	Decision
SRL strategies $\rightarrow$ Writing self-efficacy (a_1)	0.644	0.074	8.681	.599	< .001	Supported
SRL strategies $\rightarrow$ Writing engagement (a_2)	0.726	0.077	9.458	.685	< .001	Supported
Writing self-efficacy $\rightarrow$ Writing engagement (d_{21})	0.165	0.065	2.540	.168	.011	Supported
Writing engagement $\rightarrow$ Writing performance (b_2)	4.724	2.533	1.865	.227	.062	Marginal
Writing self-efficacy $\rightarrow$ Writing performance (b_1)	1.288	1.693	0.761	.063	.447	Not supported
SRL strategies $\rightarrow$ Writing performance (c')	-1.202	2.643	-0.455	-.055	.649	Not supported

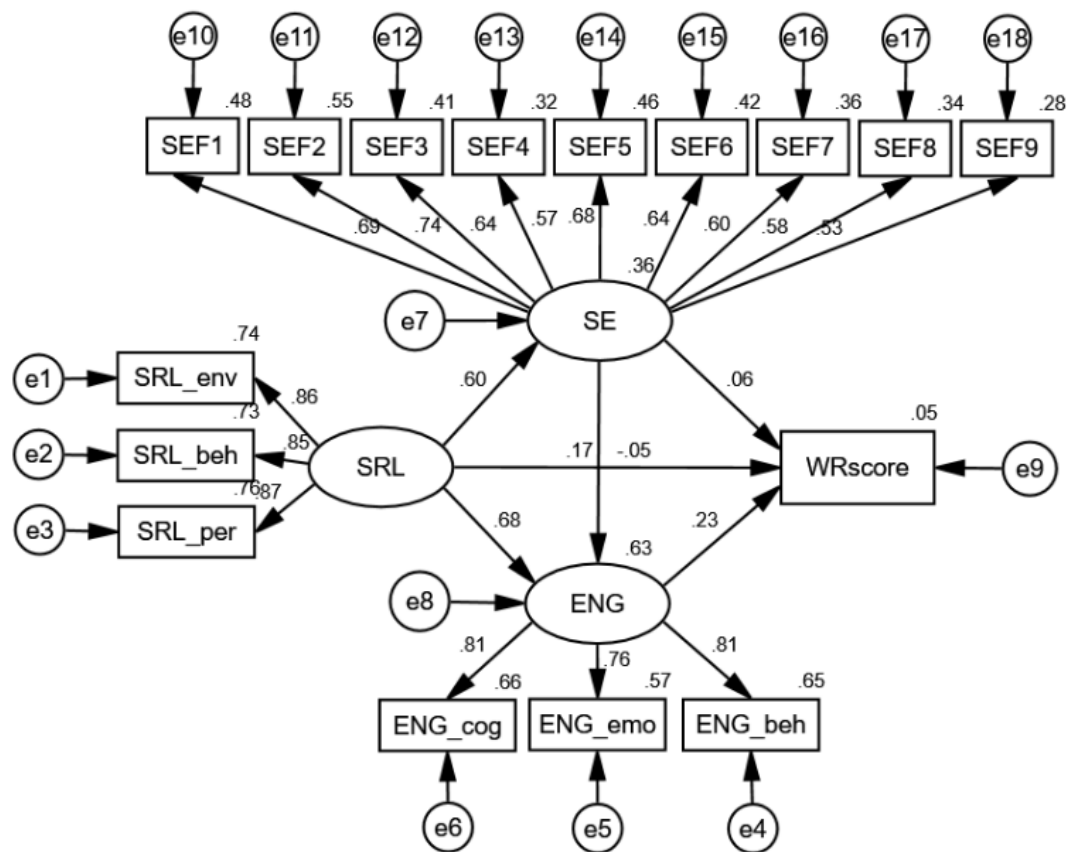


Figure 1. Standardized path diagram of the hypothesized serial mediation model ($N = 304$)

Note. SRL = self-regulated learning strategies, SE = writing self-efficacy, and ENG = writing engagement. Values on single-headed paths are standardized coefficients, and values beside the indicators and latent variables are squared multiple correlations. Residual terms $e1$ – $e18$ are shown for completeness.

4.5 Mediation Analyses

Four research questions guided the analysis. They asked whether SRL strategies directly predict writing performance (RQ1), whether writing self-efficacy mediates the relationship between SRL strategies and writing performance (RQ2), and whether writing engagement also mediates this relationship (RQ3). The fourth question asked whether writing self-efficacy and writing engagement have a serial mediating effect on this relationship (RQ4). Mediation was tested with 5,000 bias-corrected bootstrap samples, and the total indirect effect was decomposed into three specific indirect effects (Table 5).

For RQ1, the direct effect of SRL strategies on writing performance was not significant (standardized $c' = -.055$, $p = .649$), while the total effect was positive (standardized $c = .161$, $p = .008$). The total indirect effect was significant ($B = 4.763$, $\beta = .216$, 95% CI [0.347, 9.556], $p = .037$). Because the total indirect effect reached significance while the direct effect did not, the overall pattern can be characterized as indirect-only (full) mediation [48].

RQ2 examined the specific indirect effect through writing self-efficacy alone. This effect proved small and nonsignificant ($B = 0.830$, $\beta = .038$, 95% CI [-1.525, 3.186], $p = .456$), indicating that writing self-efficacy by itself did not transmit the effect of SRL strategies to writing performance. For RQ3, the indirect path through writing engagement was positive but only marginally significant ($B = 3.430$, $\beta = .155$, 95% CI [-0.135, 7.695], $p = .059$), with the lower bound of its confidence interval falling just below zero. RQ4 tested the sequential indirect path from SRL strategies through writing self-efficacy and then writing engagement to writing performance. This effect was positive and significant ($B = 0.503$, $\beta = .023$, 95% CI [0.011, 1.514], $p = .046$), and its confidence interval excluded zero, lending support to the serial mediation hypothesis.

Table 5. Bootstrap tests of the direct and indirect effects (5,000 bias-corrected samples)

Effect	Path	<i>B</i>	β	95% CI for <i>B</i>	<i>p</i>	Proportion of total indirect effect
Direct effect	SRL strategies → Writing score	-1.202	-.055	—	.649	—
Specific indirect	SRL strategies → Writing self-efficacy → Writing score	0.830	.038	[-1.525, 3.186]	.456	17.4%
	SRL strategies → Writing engagement → Writing score	3.430	.155	[-0.135, 7.695]	.059	72.0%
	SRL strategies → Writing self-efficacy → Writing engagement → Writing score	0.503	.023	[0.011, 1.514]	.046	10.6%
	SRL strategies → Writing engagement → Writing score	0.503	.023	[0.011, 1.514]	.046	10.6%
Total indirect effect		4.763	.216	[0.347, 9.556]	.037	100%
Total effect	SRL strategies → Writing score	3.561	.161	—	.008	—

Note. *B* = unstandardized estimate, β = standardized estimate, and CI = bias-corrected bootstrap 95% confidence interval of *B*. Proportion of total indirect effect = unstandardized effect ÷ unstandardized total indirect effect (4.763).

The specific indirect effects in Table 5 form a pattern that deserves attention. Writing self-efficacy, taken alone, did not mediate the association between SRL strategies and writing performance. Nevertheless, it constituted the first step of the serial pathway that reached significance, and its path to writing engagement was also significant (d21). Writing self-efficacy serves an enabling rather than a direct function within the model. SRL strategies first strengthen students' writing self-efficacy, and the benefit for writing performance materializes only when this stronger efficacy is converted into active engagement with writing. Of the three indirect paths, the one through writing engagement alone was the largest, accounting for 72.0% of the total indirect effect, although it fell just short of significance at the .05 level. Together with the nonsignificant direct effect, these findings suggest that SRL strategies contribute to writing performance primarily through this enabling route rather than directly. A fuller interpretation of this pattern is provided in the Discussion.

5. Discussion

This study examined how SRL strategies predict L2 writing performance among university students enrolled in an EFL writing course that had integrated generative AI into regular instruction. Its principal contribution lies in an empirical test of a hypothesized model in which writing self-efficacy and writing engagement mediate, separately and serially, the relationship between SRL strategies and L2 writing performance. Although SRL strategies correlated significantly with L2 writing performance, their direct effect was nonsignificant. The influence instead operated indirectly through writing self-efficacy and writing engagement. These findings extend current understanding of how SRL strategies influence L2 writing performance [13][15].

5.1 SRL Strategies and L2 Writing Performance

The first research question concerned the relationship between SRL strategies and L2 writing performance. A significant zero-order correlation emerged between the two. Once the two mediators were entered, however, the direct path became non-significant, whereas the total indirect effect remained significant. This suggests that the influence of SRL strategies on L2 writing performance is indirect.

In some respects, this finding converges with previous literature, while in others it departs from it. Sun and Wang [8] found that writing self-regulated learning strategies significantly predicted the writing proficiency of Chinese college students. Teng and Huang [24] reported similar predictive effects of writing strategies for self-regulated learning on secondary school learners' EFL writing proficiency. In contrast to these earlier findings, the direct predictive power of SRL strategies disappeared once writing self-efficacy and writing engagement were entered into the model. In line with this account, Luo et al. [52] found that learning engagement mediated the relationship between academic self-efficacy and academic achievement among Chinese college students.

This pattern is consistent with social cognitive theory [13][15], which holds that learning outcomes arise from the interplay of personal, behavioral, and environmental factors rather than from any single factor. Although SRL strategies equip students with procedural knowledge for planning, monitoring, and regulating writing, such knowledge must be enacted through sustained effort and actual writing behavior before it can be reflected in performance gains. In AI-assisted writing classrooms, generative AI offers immediate assistance with language polishing and idea generation, allowing students to complete writing tasks with relatively limited internalization of strategies. This may partly account for the nonsignificant direct path.

Overall, the contribution of SRL strategies to L2 writing performance is neither simple, direct, nor linear. Therefore, strategy instruction should be combined with opportunities that strengthen students' confidence and foster their active engagement in writing tasks.

5.2 The Mediating Role of Writing Self-Efficacy

The second research question focused on the mediating role of writing self-efficacy in the relationship between SRL strategies and L2 writing performance. The specific indirect effect through writing self-efficacy alone failed to reach significance in this model. Although SRL strategies strongly predicted writing self-efficacy, the latter did not directly predict L2 writing performance.

Specifically, the strong predictive effect of SRL strategies on writing self-efficacy is not surprising from the perspective of the social cognitive model of writing [9]. SRL strategies offer students repeated mastery experience, the most influential source of self-efficacy [14], so that successful writing experiences gradually build the belief that one can write well. In the same vein, Zhou, Wang, and Wang [19] reported a significant positive correlation between L2 writing self-regulated strategies and L2 writing self-efficacy among Chinese high school students.

By contrast, the failure of writing self-efficacy to directly predict L2 writing performance differs from previous reports that writing self-efficacy significantly predicted writing achievement [7]. Despite this divergence, a growing body of research indicates that self-efficacy affects academic achievement mainly through students' learning behavior. Luo et al. [52] confirmed that learning engagement mediated the relationship between academic self-efficacy and academic achievement. In EFL smart-classroom contexts, Xu, Li, and Yang [36] further demonstrated that self-efficacy fully mediated the relationship between self-regulated learning strategies and learning engagement. The present results add further evidence to this trend within the context of L2 writing [14][53]. Within the present model, writing self-efficacy serves primarily as an antecedent of writing engagement, paving the way for students' subsequent investment in writing tasks.

The implication for teaching is that building writing confidence is necessary but not sufficient, because confidence contributes to performance only when it is channeled into learners' engagement in writing tasks.

5.3 The Mediating Role of Writing Engagement

The third research question addressed the mediating role of writing engagement in the relationship between SRL strategies and L2 writing performance. Notably, the specific indirect effect through writing engagement alone was the largest of the three indirect paths and accounted for more than 70% of the total indirect effect. However, this effect reached only marginal significance, with a positive estimate and a p-value slightly above the .05 threshold ($p = .059$).

The finding that SRL strategies strongly predicted writing engagement echoes previous findings in L2 writing research. Zhou, Wang, and Wang [19] revealed that L2 writing self-regulated strategies significantly predicted L2 writing engagement, and Zhou and Hiver [35] also noted that the more students applied self-regulated writing strategies, the higher their L2 writing engagement and, in turn, the less their writing procrastination. Zimmerman [15] argues that SRL strategies supply the structural framework within which learners organize their learning activities. Students who possess such strategies are more willing to invest effort, sustain interest, and regulate themselves during writing tasks.

For the second half of this path, engagement is best treated as multidimensional rather than unitary. Fredricks et al. [16] distinguish its behavioral, emotional, and cognitive components. Only when engagement is enacted in actual writing behavior, however, can it produce tangible gains in performance. It is worth noting that the prediction of L2 writing performance by writing engagement

reached only marginal significance in the present model. This result in fact resembles the finding of Zhu et al. [54] that only behavioral engagement significantly predicted integrated writing performance, whereas the emotional and cognitive components did not. From the perspective of social cognitive theory [13], the environment shapes whether engagement can be translated into outcomes. In the present study, students wrote with generative AI support during the course but completed the outcome essay without AI. Engagement formed through AI-assisted collaboration may not have fully carried over to independent writing, weakening the conversion of engagement into performance. Engagement formed with AI support, that is, does not automatically translate into independent writing ability.

These findings further suggest that SRL strategies alone cannot enhance L2 writing performance unless students actively engage in writing. Pedagogically, writing tasks should be designed to require sustained behavioral investment rather than superficial, AI-aided completion.

5.4 The Serial Mediating Roles of Writing Self-Efficacy and Writing Engagement

Finally, the serial mediation hypothesis was supported. The serial indirect effect of SRL strategies on L2 writing performance through writing self-efficacy and then writing engagement reached significance, and its bootstrap confidence interval excluded zero. Put differently, SRL strategies may first strengthen students' writing confidence, then promote their deeper engagement in writing, and eventually culminate in better performance.

This result accords well with the cyclical model of self-regulated learning [15]. In that model, learning is conceptualized as a recurring process in which students apply strategies, evaluate their performance, and allow the resulting beliefs to shape subsequent learning. Following this logic, the contribution of SRL strategies reaches beyond a single writing task, since the successful experiences that students gain from using SRL strategies gradually build writing confidence [14]. In turn, this confidence encourages effortful and deep engagement in subsequent writing [14][7], and such engagement ultimately translates into progress in writing ability. Zare et al. [55] revealed, in the realm of L2 writing, that all the domains of self-efficacy and engagement were positively associated, a pattern consistent with the sequential link from confidence to engagement. For writing classrooms that integrate generative AI into instruction, this path carries particular practical significance. Students will engage in writing continuously only when they actively apply SRL strategies, gain successful experiences through collaboration with AI, and build confidence, and only then can AI assistance be converted into students' own writing ability. Corroboration comes from the intervention study of Lu et al. [56], which documented that although GenAI feedback improved students' writing interest and revision, their self-monitoring strategies slightly declined.

Comparing the three indirect paths further clarifies the distinct roles played by the two mediators. Writing engagement carried the largest share of the indirect effect. Writing self-efficacy, although unable to yield performance gains directly, laid the foundation for sustained engagement. SRL strategies enhance writing engagement directly on the one hand and consolidate it indirectly through writing self-efficacy on the other, and the two routes converge on writing engagement before jointly affecting L2 writing performance. Corroborating evidence for this serial path comes from several prior studies in general education and EFL learning. Bai et al. [57] found among sixth-grade students that the influence of desire for self-control on academic achievement was transmitted first through self-efficacy and then through learning engagement. Zou et al. [58] identified the same transmission order in a sample of nursing students. A similar mechanism was observed in EFL learning contexts, in which the influence of self-regulated learning strategies on learning engagement was fully mediated by self-efficacy [36]. However, none of these studies took L2 writing performance as the outcome variable or examined AI-assisted writing contexts. To the best of our knowledge, the present study is among the first to test and confirm this complete serial path in an AI-assisted L2 writing classroom, extending the evidence to objectively scored L2 writing performance. From a statistical perspective, the direct effect of SRL strategies ceased to be significant once the two mediators were included, a pattern that Zhao et al. [48] term indirect-only mediation. These findings indicate that SRL strategies do not automatically raise performance on their own, and that their beneficial effect on L2 writing performance depends entirely on students' beliefs and behavior. This accords with the social cognitive claim that personal factors, behavior, and the environment interact with one another [13].

As for explained variance, the model accounted for a substantial proportion of variance in writing self-efficacy and writing engagement, but its explanatory power for L2 writing performance was limited. A closer look at this pattern suggests that strategies, beliefs, and engagement are closely interrelated with one another. Writing performance, by contrast, is additionally shaped by factors

beyond the model, such as L2 proficiency, vocabulary and grammatical knowledge [54], AI literacy, and students' specific ways of using AI.

These results carry direct implications for writing instruction in university EFL contexts where generative AI tools are increasingly available. For teachers, this means going beyond the direct teaching of SRL strategies in their writing instruction. They also need to create opportunities for students to gain successful experiences with SRL strategies, so that students can gradually build writing confidence and convert it into actual engagement through appropriately challenging tasks. In AI-assisted classrooms in particular, students should be encouraged to treat AI as an aid rather than a substitute. For example, teachers can require students to complete planning and drafting independently before using AI feedback for revision. Regular writing practice without AI is also needed, so that students' engagement genuinely translates into their own writing ability.

6. Limitations and Future Research

Several limitations of this study should be noted. First, the cross-sectional data were obtained at a single time point, which precludes determination of the causal order among SRL strategies, writing self-efficacy, writing engagement, and writing performance, and the direction of influence may also be reversed. Students who attain high writing scores, for instance, may subsequently become more confident about their writing. Longitudinal data collected at several time points, or intervention studies such as SRL strategy training, would help to test whether the causal order of the serial pathway holds. Second, constrained by the timetable of a single course, our sample only included second-year Business English majors from one college recruited via convenience sampling, and the percentage of female participants was disproportionately high. The results may not generalize to students of other majors, grades, or colleges. This leaves room for future studies that recruit larger and more diverse samples through random or stratified sampling, with a more even gender ratio. Third, all three scales were completed by the students themselves, which means their answers may not fully reflect what they actually did in writing. Students may, for instance, report using strategies more often than they really do, and questionnaire scores cannot explain how self-efficacy turns into actual engagement in the writing process. In this regard, research that combines questionnaires with student interviews or classroom observation seems timely and significant, so that the results can be checked against more direct evidence.

7. Conclusion and Practical Implications

In general, this study constructed a serial mediation model which can help us understand the influence mechanism of SRL strategies on L2 writing performance in an AI-assisted EFL writing course. Our results confirmed that writing self-efficacy and writing engagement play the mediating roles between SRL strategies and L2 writing performance. These findings suggest that students who use SRL strategies in AI-assisted English writing courses are more likely to achieve desirable writing results. Although SRL strategies do not raise writing scores directly, they work through writing self-efficacy and writing engagement, and this offers practical implications for university EFL writing courses that integrate generative AI into regular instruction.

To promote self-regulation in writing, it is necessary for teachers to raise students' awareness of the importance of SRL strategies, introduce various SRL strategies, demonstrate how to use them, and support students while they are using them. The present study found that SRL strategies were significantly related to L2 writing performance in the AI-assisted environment, which suggests that such instruction is feasible there. For example, teachers can encourage students to make an outline and set goals before writing, and to keep a record during writing so that they can check their progress and notice the gap between where they are and where they want to be. Once a draft is finished, students can also turn to AI tools for feedback and revise on their own, and teachers should guide them to treat the suggestions critically rather than accept them all. Through practice of this kind, students gradually learn to plan, monitor, and evaluate their writing, so that SRL strategies turn into real writing behavior.

As for writing self-efficacy, the present study found that SRL strategies strongly predicted it, whereas it had no direct effect on writing performance and worked mainly by reinforcing writing engagement. For teachers, then, the emphasis should be placed on skill development through authentic mastery experience. Writing tasks can be broken into small achievable goals, so that students accumulate successful experiences step by step. AI tools can also aid practice and feedback, allowing

students to see their improvement in time. Students should be praised and encouraged honestly for their improvement, and guided to attribute their progress in writing to their own effort and use of SRL strategies rather than to comparison with others. It is worth noting, however, that confidence alone does not suffice, and only when confidence is turned into actual writing action can it show up in students' scores.

Equal attention should be paid to writing engagement, because it served as the main channel through which SRL strategies influenced writing performance, and writing self-efficacy also significantly predicted it. Only when students genuinely engage in writing can SRL strategies and confidence translate into better scores. Writing engagement includes behavioral, emotional, and cognitive aspects, each of which teaching can target. For behavioral engagement, writing tasks should require sustained effort, such as multiple drafting, in which students revise each draft carefully instead of generating a text with AI and submitting it after only minor changes. At the emotional level, students can be offered personally challenging, meaningful, and interesting topics and allowed to choose what truly interests them, while teachers strengthen communication with them so that they feel their effort is seen and valued. As for cognitive engagement, teachers can guide students to think deeply during writing and revision, for example, by asking them to consider the reasons behind each suggestion, to compare different ways of expressing the same idea, and to keep a record of their progress and problems. Once students are willing to invest in all three aspects, they will truly devote their time and energy to writing.

In order to improve L2 writing performance, instruction must integrate SRL strategy training with the cultivation of writing self-efficacy and the promotion of writing engagement. Writing instruction can enhance students' writing ability only when they are able to use SRL strategies, feel confident about writing, and genuinely engage in writing tasks.

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