ISSN 2522-6398 Vol. 9, Issue 8: 84-95, DOI: 10.25236/FER.2026.090812

Effects of Self-Regulated Learning Strategy Intervention on Chinese EFL Learners' Writing Performance in AI-Assisted Writing Context

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Abstract: *AI tools have become increasingly prevalent in foreign language writing education. However, the effects of self-regulated learning (SRL) strategy instruction in AI-assisted writing classes remain relatively underexplored, especially in the Chinese tertiary setting. To fill this gap, the present study examined the effects of an eight-week SRL strategy intervention embedded in an AI-assisted writing course on Chinese EFL learners' writing performance. A quasi-experimental design was employed with 359 second-year Business English majors from a Chinese college. The experimental group (n = 181) received strategy instruction designed around Zimmerman's three-phase model of self-regulation, whereas the control group (n = 178) attended the same course without strategy teaching. Writing performance was measured through pre- and post-tests. The results revealed that students' writing performance was moderate at the pre-test, with no significant difference between the two groups, but the experimental group improved significantly more in overall writing performance. Moreover, the gains were uneven across the dimensions, with the largest improvements in vocabulary and organization, and no significant group difference in mechanics. The findings offer practical implications for AI-assisted L2 and EFL writing instruction.*

Keywords: *Self-regulated learning strategy intervention; Writing performance; AI-assisted writing; Chinese EFL learners*

1. Introduction

Only a few years ago, artificial intelligence (AI) was still largely a research topic, yet it has since become part of the everyday language classroom [1][2]. Of the various language skills, writing has attracted the largest share of this attention, as reflected in a growing body of empirical research on AI-assisted writing in EFL contexts [3].

For Chinese university students, whose English writing performance has been reported to be only moderate [4], such tools arrive as timely support. They provide immediate feedback on drafts [5][6] and can assist the development of argumentative writing [5]. Experience with these tools in writing classrooms has nevertheless raised concerns. The feedback they provide tends to attend to surface features, such as grammar and spelling, rather than to ideas and structure [7]. Students may also submit better texts without measurable gains in learning, as they monitor their own thinking less when the tool does the work [8]. Part of the reason is that many students have no principled way of learning with these tools. Some students accept machine output with minimal revision [9] and may gradually develop a reliance on it [8]. Simply making AI assistance available, therefore, does not guarantee improved writing performance. In response to this problem, embedding SRL strategy instruction in AI-assisted writing classes may offer a viable solution, because self-regulated learning (SRL) equips learners to plan, monitor, and evaluate their own writing [10][11].

Research on L2 writing gives reason to expect this approach to work. SRL strategies have been shown to predict students' writing performance [12], and more proficient writers employ motivational regulation strategies more frequently than their less proficient peers [13]. On this basis, explicit strategy-based instruction has been proposed as an effective approach to fostering self-regulated L2 writers [10]. An intervention study with Chinese university students has since confirmed that such

ISSN 2522-6398 Vol. 9, Issue 8: 84-95, DOI: 10.25236/FER.2026.090812

instruction improved their writing performance [14].

Whether the above findings can be extended to AI-assisted writing classes, however, remains unclear. Previous intervention studies were conducted in conventional classrooms, in which students completed planning, drafting, and revising largely on their own. In AI-assisted classes, by contrast, these processes are shared between the learner and the machine, which may alter both the strategies that students need and the effectiveness of strategy instruction. Empirical studies that embed strategy instruction in AI-assisted writing courses are notably scarce [3]. Moreover, most earlier interventions reported writing performance as a single overall score, leaving it unclear whether strategy instruction benefits all dimensions of writing equally.

In light of this, this study aims to investigate the effects of SRL strategy instruction in AI-assisted writing classes on Chinese EFL learners' writing performance, both overall and across its key dimensions.

2. Literature Review

2.1 AI in ESL/EFL Writing Education

In ESL/EFL writing education, artificial intelligence (AI) covers tools such as chatbots, intelligent tutoring systems, and automated writing evaluation, all of which can produce or assess language much as a human would [15]. More recent generative AI (GenAI) tools go further, producing fluent text on demand and bringing both help and new problems for second language writers [16]. These tools are also changing how feedback works in writing classes. In traditional instruction, teacher time is limited and feedback often comes late, so students may wait days or even weeks for comments on a draft that is no longer fresh in their minds. AI tools, in contrast, answer at any time and as often as a student asks, which allows learners to revise their work again and again [7][17]. Beyond individual feedback, AI-supported peer feedback has been shown to improve both feedback quality and students' writing ability [18].

A growing body of studies has examined AI in ESL/EFL writing, asking whether such tools improve writing and how learners and teachers perceive them [3]. Overall, the results have been encouraging, with an AI-based writing assistant showing preliminary benefits for EFL learners' writing performance [19]. ChatGPT has also been used to support EFL students in outlining, revising, editing, and proofreading their argumentative essays [5]. In an 11-week trial with 150 Chinese EFL sophomores, a ChatGPT group also outperformed both automated writing evaluation and control groups [20]. However, two gaps remain in this line of research. Strategy instruction has rarely been built explicitly into AI-assisted classrooms. Short-term tool use together with perception-based designs still predominates in the field [3]. Writing performance is also commonly reported as a single overall score, while dimensional scores, such as content, organization, and mechanics, are seldom given, so that uneven effects may go unnoticed. These gaps are consequential, as Fan et al. [8] found that a ChatGPT group produced better texts while showing less metacognitive activity, such as self-assessment, a pattern they termed "metacognitive laziness". In other words, AI tools may improve texts while students think less about their own writing. How students regulate their writing in AI-assisted classrooms is thus an important question for both research and teaching.

2.2 Writing Self-regulated Learning Strategies

Self-regulated learning (SRL) strategies are generally understood as the "self-generated thoughts, feelings, and actions that are planned and cyclically adapted to the attainment of personal goals" [21]. In the field of writing, Zimmerman and Risemberg [22] defined writing SRL strategies as the thoughts, feelings, and actions that writers start on their own to reach literacy goals. Graham and Harris [23] then placed self-regulation at the heart of writing development. They listed strategies from goal setting and self-monitoring to seeking help from others, and showed that these strategies set skilled writers apart from less skilled ones. Zimmerman and Risemberg's [22] model groups writers' regulation into three parts, namely the environment, behavior, and the person. Building on this model, Teng and Zhang [24] proposed a framework for L2 learners that covers cognitive, metacognitive, social behavioral, and motivational regulation strategies. This wider view matters because writing involves more than producing text, as writers also need to plan ahead, control their emotions, and make use of social resources such as peer and teacher help. The framework is still developing, as Shen and Wang [25] recently combined the cyclical SRL model with the writing process and identified four dimensions and

ISSN 2522-6398 Vol. 9, Issue 8: 84-95, DOI: 10.25236/FER.2026.090812

twelve strategy types.

Empirical research in EFL contexts has linked writing SRL strategies to learners' motivational beliefs and learning experiences. Early work connected English majors' strategy use in academic writing to L2 motivation [26]. Among Hong Kong (China) secondary students, Bai and Wang [27] found that motivational beliefs, such as self-efficacy and task value, were closely tied to SRL strategy use in English writing. Xu and Wang [28] further showed that the ideal L2 writing self predicted environmental, behavioral, and personal strategies among Chinese undergraduates. These strategies also appear teachable, as process-based writing instruction has been associated with EFL students' stronger strategy use [29] and teacher feedback targeting the process and self-regulation levels has supported such growth [30]. This teachability is the basis for the strategy-based interventions reviewed in the next section. However, almost all of this evidence comes from regular classrooms where students write without intelligent tools. As generative AI tools now take over part of the writing work, little is still known about how learners use and adjust their strategies in such classrooms. Early evidence suggests that learners can stay in charge of such tools, as EFL writers have been found to work with machine translation and generative AI in active, self-directed ways [31][32].

2.3 Self-regulated Learning and L2 Writing Performance

SRL refers to "an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behavior, guided and constrained by their goals and the contextual features in the environment" [33]. This process moves in a cycle of forethought, performance, and self-reflection [34]. In L2 writing, self-regulated writers plan and set goals before drafting, monitor and evaluate their work while composing, and revise their texts and act on feedback afterwards [34]. Writing is by nature a self-planned, self-initiated, and self-sustained activity [22], so how well learners manage these processes should shape the quality of their texts.

Existing research has examined the SRL-writing performance link from two complementary perspectives. Predictive studies have shown that SRL writing strategies significantly account for individual differences in writing proficiency among Chinese tertiary EFL learners [24], that motivational regulation strategies influence performance both directly and indirectly through cognitive and metacognitive strategies [35], and that similar patterns hold among secondary school learners [36][37] and among college students [12]. More recently, Shen and Wang [25] also confirmed that SRL writing strategies significantly predict EFL learners' writing performance. Intervention studies point in the same direction. Instruction based on the self-regulated strategy development model improved Chinese EFL undergraduates' revision behaviour and text quality [38], and SRL strategy-based programmes of five months [39] and twelve weeks [14] yielded significant and durable writing gains.

In short, SRL strategies both predict and improve L2 writing performance in regular EFL classrooms. Whether this link holds in AI-assisted writing is still unknown, even though SRL strategies have been linked to more skillful AI use [40][41]. Moreover, because earlier interventions usually measured writing with a single overall score, it remains unclear whether strategy instruction benefits all dimensions of writing equally. To fill these research gaps, the present study investigates the effects of SRL strategy instruction in AI-assisted writing classes on EFL learners' writing performance, both overall and across its five dimensions. Specifically, the study addresses the following two research questions.

RQ1. Does SRL strategy intervention in an AI-assisted writing context improve students' overall writing performance?

RQ2. Which dimensions of writing performance (content, organization, vocabulary, language use, and mechanics) benefit most from the intervention?

3. Methods

3.1 Research Context and Participants

This study was conducted at a college in China, within a required English writing course for second-year Business English majors. Several intact classes of second-year Business English majors participated in the study. Random assignment was conducted at the class level, with several classes assigned to the experimental group (EG) of 181 students and the remaining classes to the control group

ISSN 2522-6398 Vol. 9, Issue 8: 84-95, DOI: 10.25236/FER.2026.090812

(CG) of 178 students, 359 participants in total. The study thus followed a quasi-experimental design with a pre-test and a post-test. As second-year Business English majors preparing for the Test for English Majors Band 4 (TEM-4), the participants had an intermediate level of English proficiency, and their writing skills were generally modest. All participants were native Chinese speakers learning English as a foreign language.

Prior to the intervention, all participants completed an online SRL strategy questionnaire and a writing pre-test. After the eight-week intervention, all participants completed a writing post-test. The study followed standard ethical procedures. Participation was voluntary, students were informed of the research purpose, and confidentiality of their data was assured.

3.2 Instruments

3.2.1 Writing Tests

Writing proficiency was assessed through a pre-test and a post-test, each requiring an argumentative essay of approximately 250 words within 45 minutes in the format of TEM-4, a nationally recognized proficiency test for second-year English majors in China. The pre-test topic was "Parents' Anxiety over Children's Education" and the post-test topic "The Impact of Mobile Phone Addiction upon People and Society". Both were drawn from standardized college-level English examinations to ensure comparable difficulty and topic familiarity across the two tests.

All essays were rated with the analytic rubric developed by Jacobs et al. [42], one of the most widely used analytic scales in ESL writing assessment [43]. The rubric distributes 100 points across five components, namely content (30), organization (20), language use (25), vocabulary (20), and mechanics (5). Two experienced EFL writing teachers, each with over five years of teaching experience, scored every essay independently, and the mean of the two ratings was used in the analyses.

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

Students' use of writing SRL strategies was measured with the Questionnaire of English Writing Self-Regulated Learning Strategies (QEWSRLS) [12], a 26-item instrument grounded in Zimmerman and Risemberg's [22] model of writing self-regulation. It consists of three subscales that assess environmental (8 items), behavioral (8 items), and personal SRL strategies (10 items). Two modifications were made for the present study. Because the original scale is in English, a Chinese version was produced through blind back-translation [44] to preserve the meaning of the original items, and the original 4-point response format was replaced by a 5-point Likert scale (1 = never, 5 = always) to allow finer differentiation. Item scores were averaged to form composites, with higher scores indicating more frequent strategy use. Sun and Wang [12] reported satisfactory reliability (Cronbach's $\alpha = .88$) and a CFA-validated three-factor structure. The scale also performed satisfactorily in the present sample (Cronbach's $\alpha = .869$, $n = 318$); its KMO value was .846, and Bartlett's test of sphericity was significant, $\chi^2(325) = 2428.25$, $p < .001$, which supports its construct validity in this context.

Returned questionnaires were screened against two criteria. A questionnaire was excluded when more than 10% of its items were unanswered or when the respondent showed no variation across items (a within-respondent standard deviation of zero). Of the 359 questionnaires returned, 318 met these criteria, giving a validity rate of 88.6%.

3.3 Research Procedure

A quasi-experimental design with intact classes was adopted, and the study spanned the autumn semester of 2025. Table 1 provides an overview of the procedure.

Table 1 Overview of the Research Procedure

Week	Experimental group	Control group
0 (pre-semester)	Online SRL questionnaire + writing pre-test	Online SRL questionnaire + writing pre-test
1–8	AI-assisted writing instruction + SRL strategy instruction (forethought, performance, self-reflection phases)	AI-assisted writing instruction (regular teaching)
8 (final session)	Writing post-test	Writing post-test

The eight instructional weeks were embedded in the regular sophomore writing course. Throughout

ISSN 2522-6398 Vol. 9, Issue 8: 84-95, DOI: 10.25236/FER.2026.090812

this period, both groups received the same AI-assisted English writing instruction, in which students composed argumentative essays with a generative AI writing assistant that provided automated feedback on their drafts. The sole difference between the groups lay in the strategy component. In addition to the regular instruction, the experimental group received systematic SRL strategy instruction integrated into the AI-assisted writing activities (see 3.4), whereas the control group continued with the regular AI-assisted instruction alone. Teaching content, writing tasks, the AI tool, and course progress were otherwise held identical across the two groups to minimize confounding influences. In the final session, all participants completed the writing post-test under the same conditions as the pre-test.

3.4 Intervention Design

The strategy instruction was designed around Zimmerman's [34] three-phase model of self-regulation, namely forethought, performance, and self-reflection. The three phases were mapped onto the pre-writing, while-writing, and post-writing stages of argumentative writing, following the intervention framework validated by Shen and Bai [14]. Throughout the three phases, the AI writing tool functioned as both a writing environment and a regulatory resource rather than a stand-alone correction aid.

Forethought phase (pre-writing). Planning and goal-setting strategies were the focus of this phase. With the teacher's guidance, students used the AI tool to brainstorm arguments, to generate and evaluate possible thesis statements, and to organize their ideas into outlines. They were also asked to set specific goals of their own for each essay instead of accepting AI-generated content uncritically.

Performance phase (while-writing). The emphasis of this phase was text generation and self-monitoring. During drafting with AI support, students practiced checking their writing against their goals by asking whether the arguments were logically sequenced, whether the lexical choices were appropriate, and whether the essay remained on topic. They were also taught to treat AI-generated feedback as one source of evidence rather than a final verdict, and model essays illustrated how proficient writers regulate their composing when AI support is available.

Self-reflection phase (post-writing). Self-evaluation and self-consequence strategies were trained in the final phase. Students first reviewed the AI-generated feedback on their drafts and decided which suggestions to accept or reject before revising their essays accordingly. They then evaluated their revised texts against the analytic rubric, with reflective self-assessment sheets provided to help them internalize the evaluation criteria.

Within each phase, individual strategies were taught in accordance with Zimmerman's [21] four-level developmental model, namely observation, emulation, self-control, and self-regulation, through which responsibility for strategy use was gradually transferred from teacher to students. The teacher first explained and modelled each strategy in the AI-assisted environment. This was followed by collaborative guided practice and, ultimately, independent application in complete essay writing.

3.5 Data Analysis

All statistical analyses were conducted with SPSS 26.0. Prior to the main analyses, the data were screened for outliers ($|z| > 3$) and normality ($|\text{skewness}| < 2$) [45]. First, baseline equivalence between the two groups was examined through independent samples t-tests on the pre-test writing scores, with the Welch adjustment applied whenever Levene's test indicated unequal variances [46]. Pre-test SRL strategy scores were compared with the same procedure as an additional control check. To address RQ1 and RQ2, within-group changes were examined through paired samples t-tests, and between-group differences through independent samples t-tests on gain scores (post-test minus pre-test). As RQ2 involved five dimension-level comparisons, the alpha level for these tests was Bonferroni-adjusted to .01 [47] and was otherwise set at .05. Cohen's d is reported as the effect size measure and interpreted following Cohen [48]. The analyses of writing scores covered all 359 participants, whereas those involving SRL scores drew on the 318 valid questionnaire respondents (listwise deletion).

4. Results

4.1 Preliminary Analysis: Baseline Equivalence

Before addressing the research questions, the data were screened for outliers and distributional

ISSN 2522-6398 Vol. 9, Issue 8: 84-95, DOI: 10.25236/FER.2026.090812

properties. No extreme outliers were detected, and the skewness of every baseline measure fell within the ±2 range regarded as acceptable [45][49], so parametric tests were used throughout. Of the 359 SRL questionnaires administered, 318 proved valid (88.6%) after incomplete or invalid forms had been removed (see the Instruments section). Their mean pre-test writing score was 53.61 (SD = 10.71), almost identical to that of the full sample (M = 53.68, SD = 10.74). Excluding invalid questionnaires thus did not systematically change the composition of the sample.

Prior to the main analyses, descriptive statistics and an independent samples t-test were computed for the pre-test writing scores (see Table 2). Initial writing performance was modest on the 100-point scale (overall M = 53.68, SD = 10.74), and the group difference was not significant, t(343.97) = −0.24, p = .813, d = −0.03, with the Welch adjustment applied [46]. Because the intervention targeted SRL strategies, initial SRL strategy use was also compared as a further control check. This difference was likewise non-significant, t(306.03) = −0.38, p = .701, d = −0.04. The two groups were thus well matched before the intervention, which provides a sound basis for attributing post-test differences to the intervention itself.

Table 2 Descriptive Statistics and Baseline Equivalence Tests for Pre-Test Writing Scores and SRL Strategy Scores

Measure	Group	*n*	*M*	*SD*	*t*	df	*p*	Cohen's *d*
Writing pre-test	Experimental	181	53.55	11.82	−0.24	343.97	.813	−0.03
	Control	178	53.81	9.54				
SRL strategies	Experimental	163	3.27	0.41	−0.38	306.03	.701	−0.04
	Control	155	3.29	0.46				

Note. Welch-adjusted t statistics and degrees of freedom are reported because Levene's tests were significant for both measures (writing: F = 7.50, p = .006; SRL: F = 4.18, p = .042) [46]. The 95% confidence intervals of the mean difference (experimental − control) were [−2.50, 1.96] for writing scores and [−0.12, 0.08] for SRL scores. SRL scores are the average of 26 items rated on a 5-point Likert scale (1 = never, 5 = always), with higher scores indicating more frequent use of writing self-regulated learning strategies. Effect sizes were computed and interpreted following Cohen [48]. The SRL analysis was based on 318 valid questionnaire respondents after the exclusion of 41 invalid responses (see the Instruments section). SRL = self-regulated learning.

4.2 RQ1: Effects of the Intervention on Overall Writing Performance

For RQ1, within-group change in overall writing performance was tested with paired samples t-tests. An independent samples t-test on gain scores (post-test minus pre-test) then compared how much the two groups had improved (see Table 3).

The experimental group improved significantly from pre-test (M = 53.55, SD = 11.82) to post-test (M = 57.92, SD = 13.37), t(180) = −22.94, p < .001, Cohen's d = 1.70, representing a large effect. The control group improved significantly as well, but by considerably less (pre-test: M = 53.81, SD = 9.54; post-test: M = 55.10, SD = 9.60), t(177) = −10.27, p < .001, d = 0.77.

The decisive test, however, is the between-group comparison of gain scores. The experimental group gained 4.37 points on average (SD = 2.56), against 1.28 (SD = 1.66) for the control group. This difference was significant, t(309.52) = 13.56, p < .001, 95% CI [2.64, 3.54], d = 1.43, with the Welch adjustment applied because Levene's test indicated unequal variances, F = 41.09, p < .001 [46]. Following Cohen's [48] conventions, this between-group effect was large. These results indicate that the SRL strategy instruction in the AI-assisted writing context produced significant gains in overall writing performance well beyond the natural progress observed under conventional instruction, providing an affirmative answer to RQ1.

Table 3 Pre- and Post-test Overall Writing Scores and Within-/Between-Group Comparisons

Group	*n*	Pre-test *M* (*SD*)	Post-test *M* (*SD*)	Paired *t* (df)	*p*	*d*	Gain *M* (*SD*)
Experimental	181	53.55 (11.82)	57.92 (13.37)	−22.94 (180)	< .001	1.70	4.37 (2.56)
Control	178	53.81 (9.54)	55.10 (9.60)	−10.27 (177)	< .001	0.77	1.28 (1.66)

Note. Between-group comparison of gain scores: t(309.52) = 13.56, p < .001, 95% CI [2.64, 3.54], d = 1.43 (Welch adjustment; Levene's F = 41.09, p < .001). For the paired tests, effect sizes were obtained by dividing the mean gain by the standard deviation of the difference scores.

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4.3 RQ2: Effects of the Intervention on the Five Dimensions of Writing

For RQ2, within-group changes on each of the five writing dimensions were examined with paired samples t-tests, and the dimension-level gain scores were compared between groups through independent samples t-tests. As five comparisons were involved, the alpha level was Bonferroni-adjusted to .01 (.05/5) for all dimension-level tests to control the Type I error rate [47], and effect sizes were interpreted according to Cohen's [48] conventions.

Within-group changes. As Table 4 shows, the experimental group improved significantly on all five dimensions, and every p value fell below .001, hence below the adjusted alpha. The largest gains appeared in vocabulary (M gain = 4.92, d = 1.31) and organization (M gain = 5.22, d = 1.29), followed by content (M gain = 4.58, d = 1.22) and language use (M gain = 3.55, d = 1.06), whereas mechanics improved the least (M gain = 2.17, d = 0.43). The control group also improved significantly on every dimension, but its gains were consistently smaller, with M gains between 1.06 and 1.66 and ds between 0.42 and 0.86.

Between-group comparisons. As shown in Table 5, the experimental group significantly outperformed the control group on four of the five dimensions (all ps < .001): vocabulary (d = 1.16), organization (d = 1.12), content (d = 1.06), and language use (d = 0.84). The exception was mechanics, on which the two groups' gains did not differ significantly, t(259.71) = 1.65, p = .100, d = 0.17.

Overall, the results provide a clear answer to RQ2. Within the experimental group, all five dimensions improved significantly, though to different degrees. Compared with conventional instruction, the intervention brought substantial additional gains in content, organization, vocabulary, and language use, but not in mechanics.

Table 4 Within-Group Paired Samples t-Test Results for the Five Writing Dimensions

Dimension	Group	Pre *M* (*SD*)	Post *M* (*SD*)	*t* (df)	*p*	*d*
Content	EG	56.40 (12.30)	60.98 (14.22)	−16.38 (180)	< .001	1.22
	CG	56.58 (10.00)	57.86 (10.03)	−7.50 (177)	< .001	0.56
Organization	EG	55.41 (12.68)	60.64 (14.26)	−17.30 (180)	< .001	1.29
	CG	55.74 (10.43)	57.39 (10.40)	−11.50 (177)	< .001	0.86
Language use	EG	49.04 (11.94)	52.59 (13.43)	−14.27 (180)	< .001	1.06
	CG	49.28 (9.67)	50.33 (9.60)	−5.55 (177)	< .001	0.42
Vocabulary	EG	51.27 (12.14)	56.18 (13.68)	−17.66 (180)	< .001	1.31
	CG	51.70 (9.86)	52.86 (9.59)	−5.91 (177)	< .001	0.44
Mechanics	EG	60.06 (11.02)	62.23 (13.37)	−5.79 (180)	< .001	0.43
	CG	60.26 (9.16)	61.75 (9.29)	−8.18 (177)	< .001	0.61

Note. EG = experimental group (n = 181); CG = control group (n = 178). A Bonferroni-adjusted alpha of .01 was applied; all p values reported are significant at this level. Effect sizes (d) were computed as the mean gain divided by the standard deviation of the difference scores.

Table 5 Between-Group Comparisons of Dimension-Level Gain Scores

Dimension	EG Gain *M* (*SD*)	CG Gain *M* (*SD*)	*t*	df	*p*	95% CI	Cohen's *d*
Content	4.57 (3.76)	1.28 (2.28)	10.06	297.55	< .001	[2.65, 3.94]	1.06
Organization	5.22 (4.06)	1.66 (1.92)	10.65	257.75	< .001	[2.91, 4.22]	1.12
Language use	3.55 (3.35)	1.06 (2.54)	7.97	335.28	< .001	[1.88, 3.11]	0.84
Vocabulary	4.92 (3.75)	1.16 (2.61)	11.04	322.10	< .001	[3.09, 4.43]	1.16
Mechanics	2.17 (5.04)	1.48 (2.42)	1.65	259.71	.100	[−0.13, 1.51]	0.17

Note. Welch-adjusted statistics [46] are reported because Levene's tests were significant for all five dimensions (all ps ≤ .006). CI = confidence interval of the mean difference (experimental − control). A Bonferroni-adjusted alpha of .01 was applied [47]; the between-group difference for mechanics was not significant. Effect sizes were computed and interpreted following Cohen [48]. EG = experimental group (n = 181); CG = control group (n = 178).

ISSN 2522-6398 Vol. 9, Issue 8: 84-95, DOI: 10.25236/FER.2026.090812

5. Discussion

The present study examined whether adding SRL strategy instruction to AI-assisted English writing classes would improve Chinese university students' writing performance more than AI-assisted instruction alone. To our knowledge, it is among the first attempts to test what strategy teaching can add to an AI-assisted writing classroom. Before the intervention, the two groups were statistically equivalent in writing proficiency at baseline. After eight weeks, both groups improved significantly, but the experimental group, which received SRL strategy instruction on top of AI-assisted learning, improved significantly more than the control group (RQ1). Across the five writing dimensions, the experimental group improved significantly on all of them, with the largest gains in organization and vocabulary. Its advantage over the control group appeared in content, organization, vocabulary, and language use, but not in mechanics (RQ2).

5.1 Initial Writing Performance and Overall Effects of the Intervention

Before turning to the intervention effects, it is worth noting that the students entered the study with a rather limited level of writing performance, as their scores were only slightly above the midpoint of the 100-point scale. This is not surprising, because similar patterns have been reported for Chinese EFL learners. Chinese university students' English writing proficiency has been reported to be only moderate [4], and university students have been found to use few self-regulatory strategies before receiving instruction [26][14]. One likely reason is that writing classes in Chinese universities have long focused on the finished product. Much attention goes to model essays and grammatical accuracy, and little to planning and revising, so students rarely receive explicit teaching of writing strategies [10]. In this regard, the limited starting level matters for the present study in two ways. It shows that there was considerable room for Chinese EFL learners' improvement of English writing and it confirms the practical need for teaching students strategies they can use on their own. Additionally, the two groups did not differ at the pre-test, so the differences at the post-test can be attributed to the intervention with reasonable confidence.

The favorable outcomes of the experimental group at the post-test were not unexpected, because most of the target strategies were reported to strongly predict students' writing performance [36][24]. Hence, cultivating students' use of these strategies would significantly contribute to their writing performance. Earlier classroom studies confirm this, as strategy-based writing instruction improved both students' writing and their ability to regulate it [39][14]. Therefore, it could be argued that by implementing self-regulated writing strategy development in AI-assisted writing classes, students may become more aware of their learning processes and better regulate their writing behaviors, which would consequently result in better writing outcomes [39]. Such independence matters even more in an AI-assisted classroom, because the tool can only offer suggestions and it is the student who must decide which ones to keep, change, or reject [40].

More interesting is the contrast between the two groups, which speaks directly to what strategy instruction adds in an AI-assisted classroom. The control group also improved significantly, though only modestly. This is consistent with recent findings that AI-based writing assistants show promise in improving English learners' writing performance [19] and with the reported benefits of collaborating with ChatGPT in argumentative writing classrooms [5]. The experimental group, however, gained more than three times as much, which suggests that the benefits of AI tools do not automatically translate into learning gains. Fan et al. [8] reported a similar pattern, in which students who use ChatGPT for writing show improved text quality, but they engage in less monitoring and regulation of their own cognitive processes. When no guidance is provided, students appear to take the tool's suggestions at face value instead of judging them, and habitual use of this kind may gradually hold back the growth of their own writing ability [16]. The strategy instruction in the present study appeared to work against exactly this tendency, because students learned to plan with the tool, monitor its output, and question its suggestions.

It is also noteworthy that the experimental group's gain was larger than that reported in earlier strategy interventions of similar length in regular classrooms [14][39]. A plausible explanation is that the AI tools gave students immediate feedback to work with, so they could try out each new strategy right away instead of waiting days for teacher comments [5]. In other words, the AI tools supplied rich feedback, and the strategy instruction taught students how to make good use of it. This combination may explain why an eight-week program could produce such a large effect, and it suggests that strategy teaching may matter even more when AI tools are present in the writing classroom. For writing curriculum design, the message is that AI tools and strategy instruction are not competing resources but

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complementary ones, and students benefit most when the two are planned together [40]. Particularly, the present study attests to the value of strategy instruction in AI-assisted writing classrooms, where such exploration is notably scarce.

5.2 Dimension-level Effects on Writing Performance

Within the experimental group, the largest gains appeared in organization and vocabulary, followed by content and language use, and the group also outperformed the control group on these four dimensions. This pattern can be understood from the perspective of writing self-regulation. Planning, goal setting, and self-evaluation are central strategies in this account [22], and they act mainly on the higher-order aspects of writing, like generating ideas, organizing them, and judging text quality. Such results were in line with earlier SRL strategy-based writing interventions with Chinese EFL learners, which likewise produced significant enhancement in L2 writing performance [14][39]. In practical terms, the intervention changed how students built their essays, not only how they polished them.

One possible reason for the strong gain in organization lies in the nature of argumentative writing as a self-planned and self-sustained activity [22], in which planning the whole text is both difficult and teachable. During the intervention, students practiced setting writing goals, building outlines, and checking whether their essays held together, all with AI support, and these are exactly the skills that text organization depends on. Meanwhile, the large vocabulary gain can be explained in a related way. The AI tools offered word choices on the spot, so students had concrete suggestions to compare and judge while revising. Earlier research has shown that self-regulated learners use AI feedback more selectively and end up with better writing [40], and EFL writers have been observed to manage machine translation and generative AI in similarly active ways [32]. The present students were taught to do just that, namely to question the tool's suggestions about ideas, structure, and wording rather than accept them. It is therefore hardly surprising that the gains concentrated in these dimensions, where strategy use and AI support reinforced each other.

Mechanics was the only dimension without a significant group difference, though the experimental group still improved on it. This is understandable, as both classes wrote with AI tools that corrected spelling, punctuation, and formatting, and little room was hence left for the strategy instruction to add anything further [7][17]. A ceiling effect may also come into play, as mechanics was already the strongest dimension in both groups prior to the intervention. Even so, this result points to a risk that teachers should note. When students let the tool handle surface accuracy for them, their own command of mechanics may cease to grow, and strategy teaching together with regular practice of language forms therefore needs to be built into instruction systematically.

6. Conclusion

The present study was grounded in Zimmerman's [34] model of self-regulated learning. Building on this model, it designed an eight-week strategy-based intervention for Chinese college EFL students in AI-assisted writing classes and examined its effects on students' writing performance in a quasi-experimental study. The two groups began at a similarly moderate level of performance. By the end of the program, the experimental group's writing had improved markedly, whereas the comparison group, attending the same course without strategy teaching, had made only modest progress. A more notable finding, nevertheless, is that the gains were not evenly distributed across the dimensions. The experimental group improved on all five dimensions, most strongly in vocabulary and organization, moderately in content and language use, and least in mechanics. Consequently, the experimental group outperformed the comparison group on every dimension except mechanics, where the two groups remained comparable.

Overall, these findings lead to a better understanding of how EFL learners can be prepared to write in AI-assisted classrooms. They offer valuable insights into the role of SRL strategy instruction in AI-assisted writing, where empirical evidence has been notably scarce. The dimension-level results further point to the unique value of strategy instruction in AI-assisted classes. The gains appeared in exactly the aspects that AI tools cannot improve for students, namely organizing ideas and choosing words, while surface accuracy was largely left to the tools. Strategy teaching and AI support thus seem to work best in combination.

The findings also carry practical implications for EFL writing teachers who use AI tools in their courses. The immediate instruction effects confirmed that SRL strategies are trainable and can be

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successfully taught in an AI-assisted writing course, even when writing is done with intelligent tools. Teachers should therefore set aside class time for explicit strategy instruction, guiding students to plan before turning to the tool and to evaluate machine suggestions critically. In other words, embedding strategy instruction in AI-assisted courses, rather than leaving students alone with the tools, will probably boost the efficacy of writing instruction.

Several limitations should be acknowledged. First, random assignment was conducted at the class level rather than the individual level, so unmeasured group differences cannot be entirely ruled out even though pre-test scores were comparable. Therefore, future research with randomization at the student level may help confirm the present findings. Second, the participants were Business English majors from one college, which may limit the explanatory power of the data. To address this limitation, future research should expand the participant pool to include students from diverse colleges and universities, of different proficiency levels, and at varied grade levels. Third, the intervention lasted only eight weeks without a delayed post-test, and SRL strategy use was measured only at the pre-test, so changes in strategy use over the intervention could not be tracked. Future research could endeavor to explore these changes with more qualitative instruments, including class observations, stimulated recalls, and reflective journals.

Acknowledgement

Funding: This work was funded by the Teaching Quality and Teaching Reform Project for Undergraduate Universities of Guangdong Province, “Research on the Mechanism of Self-Regulated Learning’s Influence on University Students’ English Writing Ability in AI-Assisted English Writing” (Grant number: Yuejiaogaohan [2024] No. 30), and the 2024–2025 Institutional Higher Education Teaching Reform Project of Guangzhou College of Technology and Business, “The Influence of Self-Regulated Learning on English Writing Ability in AI-Assisted English Writing: A Serial Mediation Effect” (Grant number: JXGG202422).

Data availability statement: The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation. Requests for the datasets should be directed to L.W. (LOUWei58@outlook.com).

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Jinghan Chen: Validation, Writing – review & editing.

Xiaojing Li: Validation, Writing – review & editing.

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