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Impact of AI-Assisted Peer Feedback on EFL Students' Self-Regulated Learning, Self-Efficacy, and Motivation in English Academic Writing

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Although the demand for English academic writing talents is growing, the teaching of English academic writing in China faces challenges such as students' lack of self-regulated learning, self-efficacy, and learning motivation. Therefore, this study aims to explore the impact of AI-assisted peer feedback with DeepSeek on Chinese EFL undergraduates' self-regulated learning, self-efficacy, and learning motivation. The researchers conducted a 16-week experiment on 60 third undergraduates majoring in English at a university in northern China, who were divided into an experimental group (EG, N=30) receiving AI-assisted peer feedback with DeepSeek, and a control group (CG, N=30) receiving teacher feedback. Mixed-design ANOVA results showed that both EG and CG students showed an upward trend in self-regulated learning, self-efficacy, and learning motivation, but EG students made greater progress than CG students. In addition, paired sample t-test results showed that EG students had significant self-regulated learning, self-efficacy, and learning motivation before, during, and after the questionnaire, and the effect size was medium to high. However, a small number of CG students were significant and the overall effect size was small. The results of the semi-structured interviews further verified the quantitative research findings that AI-assisted peer feedback was considered to be more helpful than traditional teacher feedback in improving different levels students' self-regulated learning, self-efficacy, and learning motivation. Implications and recommendations were proposed of this study.

Keywords: AI-assisted peer feedback with DeepSeek, EFL undergraduates, learning motivation, self-efficacy, self-regulated learning

INTRODUCTION

English is becoming more important in the context of globalization, and in the importance of English academic writing is higher than ever, so it is important to

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improve the current Chinese undergraduates' English academic writing. English academic writing is one of the skills that EFL/ESL undergraduates must master, and it is of great value to students' academic performance, career development and academic research (Hao & Razali, 2025). In English academic writing, students must not only have a language foundation, but also master critical thinking, logical expression and information integration. However, the teaching of English academic writing in EFL in China still faces challenges, such as large class size, untimely teacher feedback, and a single teaching method and evaluation method, which makes it difficult to meet students' learning needs and personalized development (Hao & Razali, 2025; Zhang et al., 2025).

Peer feedback refers to the mutual evaluation and feedback between students on each other's writing so as to obtain more opinions and suggestions from different aspects and improve their own English academic writing. Peer feedback is conducive to cultivating students' critical thinking, communication skills and cooperation skills (Xie et al., 2024), and enhancing students' self-regulated learning (Cahyono & Amrina, 2017). However, due to the limited language level and knowledge reserves of students, traditional peer feedback has challenges, such as uneven quality, delayed feedback and limited professionalism (Chen, 2016; Hao & Razali, 2022; Topping, 2009; Xu et al., 2023). In order to make up for the shortcomings of traditional peer feedback, this study uses artificial intelligence (AI)-assisted peer feedback (i.e., DeepSeek), which is an innovative method that uses AI technology to assist students in evaluation and improvement of writing. AI provides immediate, comprehensive and personalized feedback on students' writing based on technologies, such as natural language processing and machine learning (Alqahtani et al., 2023). AI-assisted peer feedback can stimulate students' interest and enthusiasm in writing and cultivate students' self-regulated learning and innovative thinking (Guo et al., 2024; Shofiah et al., 2023). AI-assisted feedback combines the advantages of AI technology with the advantages of peer feedback, offering potential applications for improving the quality of English academic writing teaching and students' development (Qazi et al., 2025).

Studies have shown that AI has a positive effect on improving EFL learners' self-regulated learning (Blackmore et al., 2021; Cui et al., 2021; Hopfenbeck et al., 2023; Wei, 2023; Zhu et al., 2022), and self-regulated learning has a positive predictive effect on the use of AI in writing (Jin et al., 2023). In addition, AI AI has been found to have a positive impact on learners' self-efficacy (Lee, 2023; Malik et al., 2023; Zheng et al., 2018), and online collaboration and peer feedback can improve students' self-efficacy (Hsia et al., 2016; Tseng & Tsai, 2010; Wei et al., 2024). Moreover, AI has a positive impact on students' academic performance, self-efficacy, and learning motivation (Fidan & Gencel, 2022; Zhai et al., 2024). Peer feedback can also enhance learners' motivation (Cui et al., 2021; Gong & Yan, 2023; Kerman et al., 2024; Tseng & Tsai, 2010). However, from the review of these studies and considering the importance of AI in the teaching and learning of English academic writing, the researchers believe that there is still a lack of research on the impact of AI-assisted peer feedback with DeepSeek on Chinese EFL undergraduates' self-regulated learning, self-efficacy, and motivation.

While existing research has examined artificial intelligence (AI) or peer feedback, there is currently a lack of research that uses mixed methods to investigate the impact of AI-assisted peer feedback on autonomous learning, self-efficacy, and motivation among Chinese EFL undergraduates. Furthermore, existing research on Chinese EFL undergraduates is limited in its breadth of theoretical and practical integration. Therefore, this study explores the impact of AI-assisted peer feedback with DeepSeek on Chinese EFL undergraduates' self-regulated learning, self-efficacy and motivation. In addition, this study provides ideas and suggestions for Chinese EFL English academic writing teachers to apply AI-assisted peer feedback with DeepSeek in practice. Moreover, this study helps Chinese EFL students better understand the impact of AI-assisted peer feedback with DeepSeek on their own learning, so that they can use this tool more effectively to improve their learning. This study uses AI-assisted peer feedback with DeepSeek to provide practical feedback and improvement directions for the development of educational technology. Finally, this study also provides reference for other teaching reforms in the subject and promote the innovation and development of education and teaching of English academic writing. The research questions of this study are as follows:

(1) How does AI-assisted peer feedback with DeepSeek affect Chinese EFL undergraduates' self-regulated learning in English academic writing?

(2) How does AI-assisted peer feedback with DeepSeek affect Chinese EFL undergraduates' self-efficacy in English academic writing?

(3) How does AI-assisted peer feedback with DeepSeek affect Chinese EFL undergraduates' motivation in English academic writing?

Literature Review

AI-assisted language learning is considered an important topic in the field of EFL/ESL education. Cultivating self-regulated learning in EFL undergraduates is very important for their academic development. AI can improve EFL learners' motivation and self-regulated learning (Wei, 2023). Self-regulated learning has a positive predictive effect on the use of AI in writing, so cultivating self-regulated learning is very important for improving writing outcomes (Jin et al., 2023). Learners' self-regulated learning and self-efficacy under feedback are very important for their effective learning (Blackmore et al., 2021). Moreover, formative assessment under AI can improve learners' self-regulated learning and critical thinking (Hopfenbeck et al., 2023). Peer feedback is also of great value to learners' writing development, self-efficacy, self-regulated learning, and learning motivation (Cui et al., 2021). Learners giving and receiving peer feedback can actively engage in self-regulation and co-regulation behaviors, and peer feedback is a mutually beneficial learning activity (Zhu et al., 2022). This being said, the researchers believe that the merge of both AI tools and peer feedback can be very helpful to ESL/EFL learners in learning English academic writing. The researchers believe that both AI and peer feedback can enhance undergraduates' English academic writing development, self-efficacy, self-regulated learning, and motivation.

The impact of AI-based peer feedback on the self-efficacy of EFL/ESL undergraduates is considered a popular topic in current research. Zheng et al. (2018) conducted an experimental study on 64 undergraduates and found that AI-based peer feedback improved learners' self-efficacy. Lee (2023) found that AI had a positive impact on learners' academic self-efficacy. Malik et al. (2023) showed that AI had a positive impact on learners' self-efficacy. In the context of EFL education, online collaboration and peer feedback have been found to improve learners' writing skills, motivation, and self-efficacy. Tseng and Tsai (2010) found that learners' self-efficacy had a positive impact on undergraduate online peer academic performance. Wei et al. (2024) found that providing peer feedback was very important for improving undergraduate self-efficacy. Hsia et al. (2016) found that online peer feedback had a positive impact on their self-efficacy. In summary, both AI and peer feedback can enhance undergraduate self-efficacy, but the research on AI-assisted peer feedback on learners' self-efficacy is currently underdeveloped.

In higher education, learners' learning attitude and motivation in peer feedback would affect their learning outcomes (Kerman et al., 2024). Tseng and Tsai (2010) conducted a study on 205 college students in Taiwan and found that students had strong intrinsic motivation in online peer assessment. The study found that peer feedback could significantly enhance learners' motivation and had long-term effects (Cui et al., 2021). Gong and Yan (2023) found that students generally liked to give and receive peer feedback, thereby improving satisfaction and enthusiasm in the learning process. In addition, Fidan and Gencel (2022) found that the use of AI and peer feedback could improve learners' performance and intrinsic motivation. Although AI-assisted peer feedback has a positive effect on improving students' self-regualted learning, self-efficacy and motivation, it also has potential drawbacks. It is important to note that although AI has been shown to have a positive impact on learners' academic performance, self-efficacy, and learning motivation, over-reliance on AI may reduce learners' critical thinking and motivation (Zhai et al., 2024). AI-assisted feedback may limit students' effectiveness in complex writing tasks (Alqahtani et al., 2023). Furthermore, algorithmic bias in AI tools may lead to misjudgments of student writing, thereby affecting the fairness of feedback.

To compensate for the limitations of AI tools, peer intervention and feedback are crucial to achieving a balance. When designing AI-assisted peer feedback, teachers must consider both the immediacy and personalization of AI feedback and the psychological changes of students. While existing research has examined artificial intelligence (AI) or peer feedback, there is currently a lack of research that uses mixed methods to investigate the impact of AI-assisted peer feedback on autonomous learning, self-efficacy, and motivation among Chinese EFL undergraduates. Furthermore, existing research on Chinese EFL undergraduates is limited in its breadth of theoretical and practical integration. Therefore, this study was conducted to address this research gap. From the previous studies, the researchers believe that there is lack of research on the impact of AI-assisted peer feedback on Chinese EFL undergraduates' self-regulated learning, self-efficacy and motivation, within a quasi-experimental mixed methods framework. This study aims to fill this gap through further in-depth exploration and

empirical research to promote the theoretical and practical development of the use of AI tool in this field.

Both sociocultural theory and social cognitive theory emphasize that learning is a process of interaction between tools, environment and individuals, which is conducive to a comprehensive understanding of the impact of AI-assisted peer feedback on EFL students' self-regulated learning, self-efficacy and motivation. In sociocultural theory, learning is the result of interaction and mediation, learners internalize external help into their Zone of Proximal Development (ZPD). As a cognitive mediator, AI-assisted peer feedback plays an important role in students' internalization of feedback into their proximal development zone (Vygotsky, 1978). In this study, students used AI-assisted peer feedback (a cultural tool) to externally regulate their learning through social interaction and internalized it into self-regulated learning strategies (planning, monitoring, and reflection). According to sociocultural theory, students who receive positive feedback and see progress through interaction with AI-assisted peer feedback will successfully complete tasks beyond their current level within their zone of proximal development (ZPD) and internalize this feedback, which in turn boosts their confidence and self-efficacy. Under sociocultural theory, AI-assisted peer feedback increases students' desire to perform better during this collaborative interaction, thereby enhancing their learning motivation.

In addition, in social cognitive theory, behavior, cognition and environment interact (Bandura, 1986). In this study, AI-assisted peer feedback, as an important factor in the environment, is conducive to providing strong support for learners' self-regulated learning, self-efficacy, and motivation. According to social cognitive theory, students can better set personal goals, monitor, and adjust their behavior in an AI-assisted peer feedback environment. AI-assisted peer feedback is a crucial environmental factor, significantly contributing to improving students' confidence in their ability to complete writing tasks-that is, their sense of self-efficacy. According to sociocultural theory, self-efficacy influences students' motivation, effort, and persistence. Therefore, the combination of sociocultural theory and social cognitive theory provides a framework for this study to accept AI feedback, participate in peer feedback, reflect and internalize (self-regulated learning), and establish self-efficacy and motivation. This helps to have a deeper understanding of how AI-assisted peer feedback affects students' psychological changes.

METHOD

This study aims to explore the effects of AI-assisted peer feedback with DeepSeek on Chinese EFL undergraduates' self-regulated learning, self-efficacy, and learning motivation.

Research Samples and Sampling Techniques

The participants of this study are third-year English major students at a university in northern China. There are 7 classes of third-year English major students in the university, with a total of 224 students. The researchers purposely selected two classes, the experimental group (EG) to receive AI-assisted peer feedback (N=30), and the

control group (CG) to receive teacher feedback (N=30), for a 16-week study. In EFL teaching, 60 students is a common number, and the collected data can be used for ANOVA and t-test. Although this study has the sample size limitation of exploratory research, the results are suggestive. The students are between 18 and 22 years old, including 9 male and 51 female. The selected English majors were all from the same university and 85% were female, which fully reflects the typical characteristic of Chinese universities that English majors have a large number of female students. In addition, this study adopted a purposive sampling procedure, which not only took into account the convenience and feasibility of sampling, but also took into account the requirements of homogeneity and heterogeneity of the sample. The researchers conducted purposive sampling to ensure that students had similar academic backgrounds, academic writing courses, experimental feasibility, and control of variables. Therefore, the findings of this study have important implications for how EFL/ESL college students with similar backgrounds understand AI-assisted peer feedback on their self-regulated learning, self-efficacy, and motivation.

Research Procedures and Interventions

DeepSeek is an AI-assisted tool that provides immediate and personalized feedback on students' writing. DeepSeek can provide feedback on language (grammar, vocabulary, clarity), content and structure (argumentation, logic, organization, coherence), and thought (relevance). EG students work in groups of three for peer feedback and discussion. They upload different writings to DeepSeek and compare DeepSeek feedback with peer feedback. This helps students critically reflect on the strengths and weaknesses of AI and peer feedback and formulate their final peer feedback opinions. EG students received AI-assisted peer feedback in a 16-week English academic writing class. Before the experiment, the teacher trained EG students on AI-assisted peer feedback and conducted a pre-intervention survey questionnaire. In addition, the teacher also assigned academic writing tasks related to academic topics to students every week, using AI-assisted peer feedback with DeepSeek, and students revised their writing based on AI-assisted peer feedback with DeepSeek. After the end of the 8th week, the teacher conducted a mid-intervention survey questionnaire. Finally, after 16 weeks, the teacher conducted a post-intervention survey questionnaire and conducted semi-structured interview sessions on EG students to ask whether their self-regulated learning, self-efficacy, and motivation have improved.

CG students only received teacher feedback in a 16-week English academic writing class. CG students submit their writing to their teachers, who provide written feedback on language, content, and other issues. Teacher feedback is delayed and superficial, but it enhances the depth of student argumentation. Before the experiment, the teacher conducted a pre- intervention survey questionnaire on CG students. The teacher assigned academic writing tasks related to academic topics to students every week. Students submitted their academic writing to the teacher for feedback, and students revised it based on teacher feedback. In addition, after the 8th week, the teacher conducted a mid- intervention survey questionnaire on CG students. Finally, after the intervention, the teacher conducted post- intervention survey questionnaire and semi-structured interviews with CG students to ask whether their self-regulated learning, self-

efficacy, and motivation have improved. In order to intuitively compare the differences between AI-assisted peer feedback and traditional teaching methods, the EG and CG designs were selected. Therefore, teacher feedback is more prominent for contextualized instruction, while DeepSeek-assisted peer feedback can provide immediate and personalized feedback, which is conducive to improving students' self-regulated learning, self-efficacy and motivation.

Data Collection

The survey questionnaires and semi-structured interviews as research instruments would be used to collect data. The researchers used survey questionnaires to collect students' self-regulated learning (goal setting, self-monitoring, and self-reflection), self-efficacy (facing complex English academic writing tasks, solving English academic writing problems, and improving writing quality), and motivation (intrinsic motivation and extrinsic motivation). Each part has 6 questions, a total of 18 questions, and students need to complete them within 20 minutes. Before, during, and after the experiment, the researchers conducted survey questionnaires on students in EG and CG respectively. The questionnaire was designed and adapted according to Zimmerman (2002), Schunk and DiBenedetto (2020), and Pintrich (2004). The items in the questionnaire are responded to using a five-point Likert scale ranging from 1 to 5. The scale values are as follows: A=Completely Disagree; B = Disagree; C=Neutral; D=Agree; E=Strongly Agree. Students answered anonymously online through Questionnaire Star. Two experts in the field were invited to analyze the questionnaire for clarity and applicability to ensure its content validity. A pilot test was conducted with 30 students not participating in this study, and minor revisions were made to assess correlations. Cronbach's alpha coefficients for the three subscales — self-regulated learning (α = 0.77), self-efficacy (α = 0.81), and motivation (α = 0.79)—were all above 0.7, indicating good internal consistency. Exploratory factor analysis (EFA) was performed to test construct validity, confirming a three-factor structure consistent with the theoretical framework.

The content of the semi-structured interview is mainly open-ended questions designed according to the research objectives. The researchers mainly set questions from three dimensions: self-regulated learning, self-efficacy, and learning motivation. The researchers purposely selected three representatives from each class as interviewees based on their high, medium, and low English academic writing scores. The selection criteria for high, medium and low students were based on the students' writing test scores, with the top 15% of the class being high, the bottom 15% being low, and the rest being medium. The interview sessions were conducted in a quiet and comfortable meeting room after class and would last for 30-40 minutes for each of these respondents. Audio recordings and notes were used during the interview. After the interview, these data were organized and analyzed in detail, and the students' responses were classified and coded to extract key themes and information related to the research objectives.

Data Analysis

The researchers used mixed-design ANOVA results, as well as paired sample t-test to analyze the pre-, mid-, and post-questionnaires of the two classes. The researchers also used thematic analysis to analyze the content of the semi-structured interviews of six students with high, medium, and low grades. Braun and Clarke's (2006) six-stage thematic analysis framework was used: familiarizing the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and generating a report. Two researchers independently conducted coding and ultimately reached consensus. Cohen's kappa value (κ = 0.82) indicated high agreement between the two researchers.

FINDINGS

Results of Survey Questionnaires

According to Table 1 mixed-design ANOVA results, there was no significant difference in the self-regulated learning (goal setting, self-monitoring, self-reflection) between EG and CG students in the group main effect ($p > .05$), but there was a significant difference in the time main effect ($p < .001$, Partial Eta Squared =.195–.373) and the time and group interaction ($p < .05$, Partial Eta Squared= .034–.140). This showed that the two groups of students had significantly improved their self-regulated learning in the pre-, mid-, and post-tests, but as time progresses, EG students had made greater progress and improvement than CG students. Partial η-squared ($\eta^2 p$) values for the mixed-design ANOVA were calculated and interpreted according to Richardson (2011) , i.e., small ($\eta^2 p \approx .01$), medium ($\eta^2 p \approx .06$), and large ($\eta^2 p \approx .14$).

Table 1
Mixed-design ANOVA Results for Self-regulated learning (SR)

QS	Effect	F	p	Partial Eta Squared
SR1	Group	.078	.781	.001
	Time	24.828	< .001	.300
	Time × Group	7.455	< .001	.114
SR2	Group	.406	.527	.007
	Time	21.453	< .001	.270
	Time × Group	6.121	.003	.095
SR3	Group	.431	.514	.007
	Time	14.008	< .001	.195
	Time × Group	6.785	.002	.105
SR4	Group	.078	.781	.001
	Time	34.516	< .001	.373
	Time × Group	2.049	.013	.034
SR5	Group	.236	.629	.004
	Time	16.204	< .001	.218
	Time × Group	8.311	< .001	.125
SR6	Group	.200	.656	.003
	Time	18.813	< .001	.245
	Time × Group	9.438	< .001	.140

According to Table 2 mixed-design ANOVA results, the self-efficacy of EG and CG students (facing complex English academic writing tasks, solving English academic writing problems, and improving writing quality) was not significant in the group main effect ($p > .05$), but was significant in the time main effect ($p < .001$, Partial Eta Squared= .143–.311), and the effect size was medium to large. The interaction between time and group was significant, with a small to medium effect size ($p < .05$, Partial Eta Squared= .007–.155). This showed that the self-efficacy of both groups of students improved significantly in the pre-, mid-, and post-tests, but as time progressed, EG students showed greater progress and improvement than CG students.

Table 2
Mixed-design ANOVA results for Self-efficacy (SE)

QS	Effect	F	p	Partial Eta Squared
SE1	Group	.448	.506	.008
	Time	9.705	< .001	.143
	Time × Group	.397	.003	.007
SE2	Group	.541	.465	.009
	Time	20.481	< .001	.261
	Time × Group	6.150	.003	.096
SE3	Group	.150	.700	.003
	Time	26.129	< .001	.311
	Time × Group	10.624	< .001	.155
SE4	Group	.741	.393	.013
	Time	21.858	< .001	.274
	Time × Group	5.335	.006	.084
SE5	Group	1.294	.260	.022
	Time	20.052	< .001	.257
	Time × Group	4.803	.006	.046
SE6	Group	.351	.556	.006
	Time	13.700	< .001	.191
	Time × Group	4.567	.012	.073

According to Table 3 mixed-design ANOVA results, the learning motivation (intrinsic motivation and extrinsic motivation) of EG and CG students was not significant at the initial level of the group main effect ($p > .05$), but was significant in the time main effect ($p < .001$, Partial Eta Squared= .176–.412), with medium to large effect sizes. The interaction between time and group was significant, with small to medium effect sizes ($p < .05$, Partial Eta Squared= .033–.100). This showed that the learning motivation of both groups of students increased significantly at the pre-, mid-, and post-tests, but as time progressed, EG students showed greater progress and improvement than CG students.

Table 3
Mixed-design ANOVA results for motivation (MV)

QS	Effect	F	p	Partial Eta Squared
MV1	Group	.377	.542	.006
	Time	15.932	.004	.193
	Time × Group	3.977	.013	.033
MV2	Group	.112	.739	.002
	Time	24.762	< .001	.412
	Time × Group	4.408	.012	.035
MV3	Group	.106	.745	.002
	Time	16.364	< .001	.220
	Time × Group	6.421	.002	.100
MV4	Group	.374	.543	.006
	Time	12.371	< .001	.176
	Time × Group	5.678	.004	.089
MV5	Group	.664	.418	.011
	Time	21.750	< .001	.273
	Time × Group	4.444	.014	.071
MV6	Group	.613	.437	.010
	Time	23.757	< .001	.291
	Time × Group	3.690	.028	.060

In summary, the self-regulated learning, self-efficacy and motivation of both groups of students improved over time, but the improvement of EG students was more significant than that of CG students. This further confirmed that AI-assisted peer feedback was conducive to improving students' self-regulated learning, self-efficacy and motivation. The possibility of type I error inflation was considered under multiple comparisons, and future studies need to adopt more rigorous procedures to minimize type I error.

According to the paired sample t-test results (Table 4), the self-regulated learning (SR1–SR6) of EG students before, during, and after the experiment was significant ($p < .005$), and the effect size was medium-to-high. Cohen's d values in paired sample t tests were reported and interpreted according to Cohen's (1988) benchmarks, i.e., small ($d \approx 0.20$), medium ($d \approx 0.50$), and large ($d \approx 0.80$). This confirmed that AI-assisted peer feedback could significantly improve students' self-regulated learning in goal setting, self-monitoring, and self-reflection. However, a small number of CG students' self-regulated learning (SR1–SR6) before, during, and after the experiment were significant, and the overall effect size was small. This confirmed that traditional teacher feedback has limited effect on improving students' self-regulated learning in goal setting, self-monitoring, and self-reflection. Therefore, AI-assisted peer feedback could improve students' self-regulated learning more than teacher feedback.

Table 4
Paired sample T-test results for Self-regulated learning (SR)

	D	Item	MD	t	Sig.	Cohen's d		MD	t	Sig.	Cohen's d
EG	SR1	Pre-mid	-.300	-3.525	< .001	.466	CG	-.067	-1.439	.161	.254
		Pre-post	-.567	-6.158	< .001	.504		-.167	-2.408	.023	.379
		Mid-post	-.267	-3.247	.003	.450		-.100	-1.795	.083	.305
	SR2	Pre-mid	-.300	-3.525	< .001	.466		-.233	-2.971	.006	.430
		Pre-post	-.533	-5.113	< .001	.571		-.167	-2.408	.023	.379
		Mid-post	-.233	-2.971	.006	.430		-.067	1.439	.161	.254
	SR3	Pre-mid	-.167	-1.720	.048	.531		-.167	-2.408	.023	.379
		Pre-post	-.467	-5.037	< .001	.507		-.067	-1.000	.326	.365
		Mid-post	-.300	-3.525	.001	.466		-.233	-2.971	.006	.430
	SR4	Pre-mid	-.267	-3.247	.003	.450		-.200	-2.693	.012	.407
		Pre-post	-.700	-5.887	< .001	.651		-.433	-3.791	< .001	.626
		Mid-post	-.433	-4.709	< .001	.504		-.233	-2.536	.017	.504
	SR5	Pre-mid	-.333	-3.808	< .001	.480		-.000	000	1.000	.371
		Pre-post	-.533	-5.757	< .001	.507		-.100	-1.140	.264	.481
		Mid-post	-.200	-2.693	.012	.407		-.100	-1.795	.083	.305
	SR6	Pre-mid	-.233	-2.971	.006	.430		-.067	-1.439	.161	.254
		Pre-post	-.567	-5.461	< .001	.568		-.100	-1.361	.184	.403
		Mid-post	-.333	-3.808	< .001	.480		-.033	-.571	.573	.320

According to the results of the paired sample t-test (Table 5), the self-efficacy (SE1–SE6) of EG students before, during, and after the experiment were significant ($p < .005$), and the effect size was medium-to-high. This confirmed that AI-assisted peer feedback could significantly improve students' self-efficacy in facing complex English academic writing tasks, solving English academic writing problems, and improving writing quality. However, a small number of CG students' self-efficacy (SE1–SE6) before, during, and after the experiment were significant, and the effect size was generally small. This confirmed that traditional teacher feedback had limited effect on improving students' self-efficacy. Therefore, AI-assisted peer feedback could improve students' self-efficacy more than teacher feedback.

Table 5
Paired sample T-test results for self-efficacy (SE)

	D	Item	MD	t	Sig.	Cohen's d		MD	t	Sig.	Cohen's d
EG	SE1	Pre-mid	-.167	-1.980	.047	.461	CG	-.133	-2.112	.053	.346
		Pre-post	-.300	-3.071	.005	.535		-.200	-2.693	.012	.407
		Mid-post	-.133	-1.278	.021	.571		-.067	-1.439	.161	.254
	SE2	Pre-mid	-.267	-3.247	.003	.450		-.100	-1.795	.083	.305
		Pre-post	-.567	-5.461	< .001	.568		-.167	-1.980	.057	.461
		Mid-post	-.300	-3.525	.001	.466		-.067	-1.000	.326	.365
	SE3	Pre-mid	-.300	-3.525	.001	.466		-.033	-1.000	.326	.183
		Pre-post	-.600	-6.595	< .001	.498		-.133	-2.112	.043	.346
		Mid-post	-.300	-3.525	.001	.466		-.100	-1.179	.083	.305
	SE4	Pre-mid	-.400	-4.397	< .001	.498		-.067	-.701	.489	.520
		Pre-post	-.633	-5.461	< .001	.615		-.233	-2.249	.032	.568
		Mid-post	-.233	-2.971	.006	430		-.167	-2.408	.023	.379
	SE5	Pre-mid	-.333	-3.808	< .001	.480		-.133	-2.112	.062	.346
		Pre-post	-.500	-5.385	< .001	.509		-.233	-2.971	.006	.430
		Mid-post	-.167	-1.542	.013	.592		-.100	-1.795	.083	.305
	SE6	Pre-mid	-.133	-1.278	.021	.571		-.033	-.441	.662	.414
		Pre-post	-.500	-4.785	< .001	.572		-.133	-1.439	.161	.507
		Mid-post	-.367	-4.097	< .001	.490		-.100	-1.795	.083	.305

According to the paired sample t-test results (Table 6), the learning motivation (MV1–MV6) of EG students before, during, and after the experiment was significant ($p < .005$), and the effect size was medium-to-high. This confirmed that AI-assisted peer feedback could significantly improve students' learning motivation in terms of intrinsic motivation and extrinsic motivation. However, a small number of CG students' learning motivation (MV1–MV6) before, during, and after the experiment were significant, and the effect size was small. This confirmed that traditional teacher feedback had limited effect on improving students' learning motivation. Therefore, AI-assisted peer feedback could improve students' learning motivation more than teacher feedback.

Table 6
Paired sample T-test results for motivation (MV)

	D	Item	MD	t	Sig.	Cohen's d		MD	t	Sig.	Cohen's d
EG	MV1	Pre-mid	-.200	-2.693	.012	.407	CG	.000	.000	1.000	.263
		Pre-post	-.300	-2.757	.010	.596		-.100	-1.361	.184	.403
		Mid-post	-.200	-2.693	.012	.607		-.100	-1.795	.083	.305
	MV2	Pre-mid	-.233	-2.971	.006	.548		-.100	-1.000	.326	.547
		Pre-post	-.300	-2.340	.026	.702		-.033	-.254	.801	.679
		Mid-post	-.200	-2.693	.012	.407		-.067	.701	.489	.521
	MV3	Pre-mid	-.333	-3.808	< .001	.629		-.067	-1.000	.326	.365
		Pre-post	-.533	-5.757	< .001	.507		-.133	-1.682	.103	.434
		Mid-post	-.400	-4.397	< .001	.498		-.067	-1.439	.161	.254
	MV4	Pre-mid	-.200	-2.693	.012	.407		-.067	-.701	.489	.521
		Pre-post	-.500	-5.385	< .001	.509		-.100	-1.000	.326	.548
		Mid-post	-.300	-3.525	.001	.466		-.033	-.571	.572	.320
	MV5	Pre-mid	-.200	-2.693	.012	.407		-.067	-1.000	.326	.365
		Pre-post	-.533	-5.757	< .001	.571		-.200	-2.693	.012	.407
		Mid-post	-.333	-3.808	< .001	.492		-.133	-2.112	.103	.346
	MV6	Pre-mid	-.333	-3.808	< .001	.479		-.100	-1.795	.083	.305
		Pre-post	-.500	-5.385	< .001	.509		-.233	-2.971	.043	.430
		Mid-post	-.167	-2.408	.023	.461		-.133	-2.112	.043	.346

Therefore, in the pre-, mid- and post-tests, the self-regulated learning, self-efficacy and motivation of both groups of students improved, but the improvement of EG students was more significant than that of CG students. This further confirmed that AI-assisted peer feedback was conducive to improving students' self-regulated learning, self-efficacy and motivation.

Results of Semi-structured Interviews

Semi-structured interviews were used to explore students' experience with AI-assisted peer feedback. It mainly includes three themes: self-regulated learning, self-efficacy, and learning motivation.

According to the results of the semi-structured interviews (theme 1), it was confirmed that AI-assisted peer feedback with DeepSeek can help English students of different levels set clear writing goals, develop specific writing plans, monitor writing progress, and identify and reflect on their own writing. As Student B said: "I set clear goals, proactively monitor, revise and reflect my writing." However, single teacher feedback has limited effect on students' setting clear writing goals, developing specific writing plans, monitoring writing progress, and identifying and reflecting. As Student D said: "I am not very clear about the goal. I don't monitor and revise my writing." This further confirms the quantitative results that AI-assisted peer feedback can improve students' self-regulated learning in goal setting, self-monitoring, and self-reflection more than single teacher feedback. Therefore, AI-assisted peer feedback can improve students' self-regulated learning at different levels more than single teacher feedback.

According to the results of the semi-structured interviews (theme 2), it was confirmed that AI-assisted peer feedback with DeepSeek can help English students of different levels improve their confidence in facing complex English academic writing tasks, solving English academic writing problems, and improving writing quality. As student C said: "I am not so afraid of complex and difficult tasks. I believe I can finish writing successfully." However, single teacher feedback has limited effect on students' confidence in facing complex English academic writing tasks, solving English academic writing problems, and improving writing quality. As student F said: "The teacher feedback has no effect on my confidence in dealing with writing tasks." This further confirms the quantitative results that AI-assisted peer feedback can improve students' confidence in facing complex English academic writing tasks, solving English academic writing problems, and improving writing quality more than single teacher feedback. Therefore, AI-assisted peer feedback can improve the self-efficacy of students of different levels more than single teacher feedback.

According to the results of the semi-structured interviews (theme 3), it is confirmed that AI-assisted peer feedback with DeepSeek can help English students of different levels improve their intrinsic motivation (such as their own abilities, enjoyment of the writing process, and self-satisfaction) and extrinsic motivation (such as recognition from teachers and classmates). As student A said: "I feel accomplishment, which make me eager to improve my motivation. I look forward to being recognized by teacher and classmates." However, single teacher feedback has limited effect on students' intrinsic motivation (such as their own abilities, enjoyment of the writing process, and self-

satisfaction) and extrinsic motivation (such as recognition from teachers and classmates). As student E said: "I don't feel satisfaction. Teacher feedback don't have a significant positive impact on my writing." This further confirms the quantitative results that AI-assisted peer feedback can improve students' intrinsic motivation and extrinsic motivation more than single teacher feedback. Therefore, AI-assisted peer feedback can improve the learning motivation of students of different levels more than single teacher feedback.

Therefore, according to the results of the semi-structured interviews, the self-regulated learning, self-efficacy and motivation of the two groups of students under different teaching methods had improved, but the improvement of EG students was more significant than that of CG students. This further confirmed that AI-assisted peer feedback was conducive to improving students' self-regulated learning, self-efficacy and motivation.

DISCUSSION

This study used a mixed method to explore the impact of AI-assisted peer feedback with DeepSeek on Chinese EFL undergraduates' self-regulated learning, self-efficacy, and motivation in English academic writing. The discussion includes the findings on the impact of AI-assisted peer feedback with DeepSeek on Chinese EFL undergraduates' self-regulated learning, self-efficacy, and motivation in English academic writing.

Self-regulated Learning

AI-assisted peer feedback with DeepSeek had significant advantages for Chinese EFL undergraduates' self-regulated learning. The results of the mixed-design ANOVA results showed that there were significant differences and improvements in the main effect of time and the interaction of time and group in self-regulated learning (goal setting, self-monitoring, and self-reflection) between EG and CG students before, during, and after the questionnaire, but EG students made greater progress than CG students. In addition, the results of the paired sample t-test showed that the self-regulated learning of EG students before, during, and after the questionnaire was significant and the effect size was medium-to-high. However, a small number of CG students were significant and the overall effect size was small. This confirmed that AI-assisted peer feedback could improve Chinese EFL undergraduates' self-regulated learning in goal setting, self-monitoring, and self-reflection more than single teacher feedback. The results of the semi-structured interview further verified the results of the survey questionnaire, that was, AI-assisted peer feedback was considered to be more helpful in improving Chinese EFL undergraduates' self-regulated learning of different levels in setting writing goals, monitoring progress, summarizing and reflecting on the advantages and disadvantages of writing, and improving methods than teacher feedback. The results of this study were consistent with the results of Darvishi et al. (2022), that was, AI assistance could improve self-regulated learning of peer feedback. Hopfenbeck et al. (2023) also found that AI-assisted formative assessment could promote learners' self-regulated learning. This showed that AI-assisted peer feedback could more effectively improve Chinese EFL undergraduates' self-regulated learning than traditional teacher feedback.

Self-efficacy

AI-assisted peer feedback with DeepSeek had a significant advantage in improving Chinese EFL undergraduates' self-efficacy. According to the mixed-design ANOVA results, there were significant differences and improvements in the self-efficacy of EG and CG students before, during and after the questionnaire (coping with complex academic writing tasks, solving writing problems and improving writing quality) in terms of the main effect of time and the interaction of time and group, but EG students made greater progress than CG students. In addition, the results of the paired sample t-test showed that the self-efficacy of EG students before, during and after the questionnaire was significant and the effect size was medium-to-high. However, a small number of CG students were significant and the overall effect size was small. This demonstrated that AI-assisted peer feedback could improve Chinese EFL undergraduates' self-efficacy more than single teacher feedback. The results of the semi-structured interview further proved the results of the questionnaire, that was, AI-assisted peer feedback was considered to be more helpful in improving the self-efficacy of Chinese EFL undergraduates' of different levels in coping with complex academic writing tasks, solving writing problems and improving writing quality than teacher feedback. The findings of this study validated the findings of Zheng et al. (2018) that peer feedback based on artificial intelligence can improve learners' self-efficacy. The results of this study were in line with Lee (2023), which showed that artificial intelligence has a positive impact on learners' self-efficacy.

Motivation

AI-assisted peer feedback with DeepSeek had a significant advantage in improving Chinese EFL undergraduates' learning motivation. According to the results of the mixed-design ANOVA results, there were significant differences and improvements in the learning motivation (intrinsic motivation and extrinsic motivation) of EG and CG students before, during and after the questionnaire in terms of the main effect of time and the interaction of time and group, but EG students made greater progress than CG students. In addition, the paired sample t-test results showed that the learning motivation of EG students before, during and after the questionnaire was significant and the effect size was medium to high. However, a small number of CG students were significant and the overall effect size was small. This indicated that AI-assisted peer feedback can improve students' learning motivation more than single teacher feedback. The results of the semi-structured interview further revealed the results of the questionnaire, that was, AI-assisted peer feedback was considered to be more helpful than teacher feedback in improving the intrinsic motivation and extrinsic motivation of Chinese EFL undergraduates at different levels. The findings of this study supported the research of Cui et al. (2021), that was, peer feedback could significantly improve learners' learning motivation and had a long-term effect. Fidan and Gencel (2022) also found that the combination of artificial intelligence and peer feedback could improve learners' learning motivation.

In a summary, the mutual confirmation of the survey questionnaires and semi-structured interviews showed that AI-assisted peer feedback had obvious advantages on Chinese

EFL undergraduates' self-regulated learning, self-efficacy and motivation than traditional teacher feedback.

CONCLUSIONS, IMPLICATIONS, LIMITATIONS, RECOMMENDATIONS

This study used a mixed research method to explore the impact of AI-assisted peer feedback with DeepSeek on Chinese EFL undergraduates' self-regulated learning, self-efficacy, and motivation. After 16-weeks of experiment, this study found that AI-assisted peer feedback with DeepSeek could significantly enhance Chinese EFL undergraduates' self-regulated learning, self-efficacy, and motivation more than traditional teacher feedback in one public university.

This study is helpful to the development of sociocultural theory and sociocognitive theory, and this theoretical integration provides a new model for human-machine peer collaboration in L2 writing development. This study is helpful to fill the previous research gap in the impact of AI-assisted peer feedback on EFL students' self-regulated learning, self-efficacy, and motivation. This is conducive to expanding AWE-related research from the dimension of psychological variables. This study is conducive to the innovation of academic writing courses and the creation of a multi-source feedback ecosystem for educators. Course arrangements can be diversified and tiered, with AI, peer feedback, and teacher feedback. This study helps English teachers use AI-assisted feedback in teaching practice and innovation. Teachers can encourage students to reflect on AI suggestions by demonstrating the revision process, designing structured activities, and emphasizing the use of effective feedback. They can also discuss and revise through AI and peer feedback, thus forming a circular learning mechanism. This study is conducive to improving students' overall academic development. Students can modify the feedback and suggestions of AI-assisted writing tools and adjust their learning strategies in real time, which helps improve their independence. The interface of AI tools needs to remain simple and easy to use to improve students' self-regulation. This study is helpful for the innovation of educational technology to promote the deep integration of education and technology, improve the quality of education training, and meet the needs of talents in the new era.

This study was conducted in only two classes of English majors in one university, which are homogeneous. The results of the study are suitable for EFL students in Chinese universities. This study only focuses on the impact of AI-assisted peer feedback and teacher feedback on students' self-regulated learning, self-efficacy, and motivation, but lacks a direct comparison of feedback quality and an in-depth analysis of the quantity, type, or depth of feedback. In addition, algorithmic biases in AI tools can lead to uneven feedback on students' writing, which could affect the research results. AI tools can also lead to students becoming overly dependent on them, thereby reducing their independent thinking. Therefore, future research can further study the impact of AI-assisted feedback on students from different schools and majors to enhance the generalizability of the results. Future research can further extend the research time to explore the impact of AI-assisted feedback on students' long-term learning outcomes. Future research can further explore the combination of DeepSeek and other AI tools to compare the effects of different AI tools on students' academic

writing. Future research can also further explore the combination of teacher feedback and AI-assisted feedback. Future research should balance the relationship between AI feedback and other feedback to enhance students' learning autonomy, and continue to pay attention to ethical issues in research to ensure the safe, transparent and fair use of AI in educational practice.

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DECLARATION OF AI USE

This manuscript uses AI-assisted tools (e.g., DeepSeek) solely as part of the teaching and feedback interventions for students. No generative AI or AI tools were used for writing, data analysis, or manuscript preparation.

DECLARATION OF INTEREST STATEMENT

No potential conflict of interest was reported by the authors.

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