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# The Mediating Effect of Metacognitive Strategies for Self-Efficacy and Chinese Character Learning Achievement

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Chinese character acquisition remains a major challenge for learners of Chinese as a Foreign Language (CFL), particularly in blended learning environments that demand high levels of learner autonomy and self-regulation. This study aimed to investigate the relationships among self-efficacy, metacognitive strategies, and Chinese character learning achievement, with a specific focus on the mediating role of metacognitive strategies. Data was collected from 201 CFL learners using validated self-report questionnaires measuring self-efficacy and metacognitive strategies, together with a Chinese Character Recognition Test. The data were analysed using Partial Least Squares Structural Equation Modelling (PLS-SEM) with bootstrapping procedures. The results indicate that self-efficacy significantly predicts metacognitive strategy use, while metacognitive strategies positively influence learning achievement. However, self-efficacy does not exert a significant direct effect on achievement. Mediation analysis reveals that metacognitive strategies fully mediate the relationship between self-efficacy and Chinese character learning achievement. These findings contribute to the literature by clarifying the mechanism through which self-efficacy influences learning achievement in non-alphabetic language contexts and highlights the critical role of metacognitive strategies in AI-supported learning environments. Practical implications are provided for language instruction and AI-assisted educational design.

Keywords: metacognitive strategies, self-efficacy, Chinese character learning achievement, ai-supported blended learning, Chinese, learning

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## INTRODUCTION

Chinese character acquisition is widely recognized as one of the top challenging aspects for learners of Chinese as a Foreign Language (CFL) (Gong et al., 2020; Zhang et al., 2023). Unlike alphabetic systems, Chinese characters are logographic and visually complex, requiring learners to integrate orthographic, phonological, and semantic information simultaneously (Zhang & Xing, 2023). This multidimensional processing imposes a heavy cognitive load on learners and often results in slower learning progress and lower achievement. With the increasing global demand for Chinese language learning (DeWitt et al., 2022), improving Chinese character learning achievement has become a critical concern in Teaching Chinese as a Foreign Language (TCFL). To address these learning challenges, technology-enhanced instructional approaches have increasingly been adopted to support Chinese character acquisition. Among these approaches, AI-supported blended learning has emerged as a promising educational model.

Against this background, AI-supported blended learning, which integrates face-to-face instruction with AI-enhanced digital resources, has gradually become a dominant instructional model (Cao & Phongsatha, 2025; Dziuban et al., 2018; Graham, 2013). AI-driven tools, such as intelligent tutoring systems and large language models, provide personalized feedback, adaptive scaffolding, and real-time support, thereby enhancing students' engagement and learning efficiency (Adiguzel et al., 2023; Hwang et al., 2015). Although AI-supported environments offer new opportunities, they also impose greater demands on learners' autonomy and self-regulation. Similar to remote learning contexts, learners are required to be "confident, willing, and able to self-manage their learning process" (Lin et al., 2017). Learners with low confidence are more likely to disengage, participate less actively, and ultimately achieve unsatisfactory outcomes (Teng et al., 2023). This highlights the importance of self-efficacy, defined as individuals' belief in their capability to accomplish specific learning tasks (Bandura, 1977). Self-efficacy has been consistently identified as a key predictor of learning achievement, influencing learners' effort, persistence, and strategic behavior (Britner & Pajares, 2006; Tenaw, 2013).

At the same time, metacognitive strategies, including planning, monitoring, and evaluating one's learning, play a crucial role in language acquisition. Learners' use of metacognitive strategies not only directly affects learning performance but also shapes their self-efficacy beliefs (Barnard et al., 2009). In AI-supported learning environments, these strategies become even more essential, as learners must independently regulate their learning, assess progress, and adjust strategies when necessary (Anupan & Chimmalee, 2024; Carter Jr et al., 2020). However, many learners lack sufficient metacognitive awareness and struggle to effectively apply these strategies in less structured learning contexts (Hadwin et al., 2017).

While prior research has established positive relationships among these variables, most studies have relied on simple correlational analyses and have not adequately explored their direct and indirect effects (Teng et al., 2023). In particular, metacognitive learning strategies have been identified as a key pathway through which self-efficacy influences

learning achievement (Hayat et al., 2020). Furthermore, while AI-supported environments have been widely studied (Alshahrani, 2025), little attention has been given to how learners in these environments develop their perceptions, regulate their learning strategies, and achieve outcomes specifically in Chinese character learning, which involves unique orthographic and cognitive demands.

Based on the identified research gaps, this study aims to investigate the relationships among self-efficacy, metacognitive strategies, and Chinese character learning achievement in an AI-supported blended learning environment. More specifically, the study seeks to examine the direct effect of self-efficacy on Chinese character learning achievement and to determine whether metacognitive strategies mediate this relationship. To achieve these objectives, the following research questions were proposed:

RQ1: What are the relationships among self-efficacy, metacognitive strategies, and Chinese character learning achievement in an AI-supported blended learning environment?

RQ2: What is the mediating role of metacognitive strategies in the relationship between self-efficacy and Chinese character learning achievement in an AI-supported blended learning environment?

## LITERATURE REVIEW

### Metacognitive Strategies and Learning Achievement

Metacognitive strategies refer to the conscious regulation of cognitive processes by learners through planning, monitoring, and evaluation (Flavell, 2024; Schraw, 2007). In language learning research, these strategies are widely regarded as the core component of self-regulated learning and are positively correlated with learning achievement (Teng, 2020; Teng & Huang, 2019; Thitipraserth & Manosuthikit，2025).

Previous studies have shown that metacognitive strategies can enhance learners' ability to regulate cognition and improve learning achievement, especially in complex learning tasks and digital learning environments (Cai & Kunnan, 2020; Chero, 2023; Muhid et al., 2020; Sen & Yilmaz, 2016). However, metacognitive strategies may also have a weak or insignificant direct impact on general foreign language learning achievement (Cai et al., 2019; Phakiti, 2006). The effectiveness of metacognitive strategies varies among learners, as successful strategy implementation usually depends on learners' autonomy and self-regulation abilities. In technology-assisted learning environments, many learners struggle to effectively implement these strategies due to insufficient self-regulation skills (Lehmann et al., 2014). This indicates that although metacognitive strategies are positively correlated with learning achievement, their effectiveness may depend on individual psychological factors.

### Self-efficacy and Learning Achievement

Self-efficacy refers to the belief that an individual has in their ability to organize and carry out the actions necessary to achieve their learning goals (Bandura, 1997). It is

widely regarded as a key predictor of learning achievement as it influences learners' effort, persistence, and task engagement (Pintrich, 2003)

Empirical studies consistently show that learners with high self-efficacy tend to achieve better learning achievement, demonstrate greater perseverance, and possess more effective problem-solving abilities (Mohsen, 2017; Alshahrani,2025). On the contrary, learners with low self-efficacy are more likely to avoid challenging tasks, exhibit lower motivation, and achieve poorer academic results (Bandura, 1997). Therefore, self-efficacy is generally regarded as an important determinant of learning achievement.

However, the predictive power of self-efficacy for learning achievement is not always direct or stable (Teng & Yang, 2023). Although self-efficacy is positively correlated with learning motivation and engagement, in an environment with abundant technological resources where independent learning behaviours are required, its direct impact on learning achievement may weaken (Kuo et al., 2014; Lin et al., 2017). In some foreign language writing studies, self-efficacy has not been found to affect writing ability (Jiang & Zhang, 2023; Wilby, 2022). This inconsistency suggests that there may be additional mediating mechanisms between self-efficacy and learning achievement (Wang & Sun, 2020; Yabukoshi, 2021).

**The Mediating Role of Metacognitive Strategies**

To explain the inconsistency in the relationship between self-efficacy and learning achievement, recent studies have increasingly emphasized the mediating role of metacognitive strategies. According to the self-regulated learning theory, self-efficacy, as a motivational leading factor, influences the strategic behaviours of learners. Zimmerman (2013) emphasized self-efficacy precedes performance processes such as metacognitive monitoring and regulation, providing theoretical support for the path of using metacognitive strategies due to self-efficacy.

Empirical studies have shown that learners with higher self-efficacy tend to engage in planning, monitoring, and self-assessment, which in turn enhances learning performance (Lin et al., 2017; Alshahrani, 2025). Although previous research has acknowledged the possibility of a bidirectional relationship between self-efficacy and metacognitive strategies (Gentner & Seufert, 2020; Kyo, 2022), the mainstream empirical model supports the path by which self-efficacy predicts the use of strategies(Shehzad et al., 2020). In online and blended learning environments, due to the reduction of teaching support, learners need to rely more on self-regulation. This relationship is particularly prominent. Metacognitive strategies have been proven to facilitate reflection, problem identification, and adaptive learning (Cai & Zhao, 2023; Teng et al., 2023), although their effectiveness may vary depending on individual factors such as self-efficacy (Lehmann et al., 2014).

**Research Gaps and the Present Study**

Although previous studies have reported positive relationships among self-efficacy, metacognitive strategies, and learning achievement, several research gaps remain.

First, most studies have been conducted in general educational or English as a foreign language (EFL) context, with limited attention to Chinese character learning, which involves unique orthographic and semantic demands. Second, although AI-supported blended learning is increasingly adopted in language education, little is known about how self-efficacy and metacognitive strategies jointly influence Chinese character learning achievement in this context.

To address these gaps, this study examines the relationships among self-efficacy, metacognitive strategies, and Chinese character learning achievement, focusing on the mediating role of metacognitive strategies in an AI-supported blended learning environment. The findings extend self-regulated learning research in Chinese as a Foreign Language (CFL) and provide implications for AI-assisted language learning.

## METHOD

### Participants and data collection procedure

This study is a causal relationship investigation, employing a cross-sectional survey methodology. The target population comprises CFL/CSL learners at public universities in Sabah, Malaysia, with a sample size of 201 students, of whom 65.2% were female and 34.8% were male. The duration of the semesters for the participating students varied from the first to the fourth semester, with the percentages as follows: first semester (12.4%), second semester (44.3%), third semester (22.9%), and fourth semester (20.4%).

The questionnaire mandated participants to finish all included scales. All subjects were notified that they could opt out at any stage of the study without suffering any adverse consequences. No personal identifiable information was disclosed before, throughout, or after the implementation of the study. Prior to making their decision to engage in this survey, all participants provided written informed consent by filling out an online informed consent form. The research protocol for this investigation has received formal authorization from the relevant ethics board at the one University.

### Instruments and pilot test

The questionnaire for this study comprises 4 sections: demographic information, metacognitive strategies (MS), self-efficacy (SE) and Chinese Character Recognition Test. Content validity of the instrument was initially established through a rigorous expert panel review, which was conducted with two specialists in educational technology and one expert in foreign language teaching pedagogy. Satisfactory values for both the Item-level Content Validity Index (I-CVI) and Scale-level Content Validity Index (S-CVI) were obtained via this review process. Pilot testing was then conducted with 35 valid participants to refine item clarity, assess the internal consistency of the MS and SE scales (Cronbach's alpha), and evaluate the reliability of the Chinese character learning achievement via the Kuder-Richardson Formula 20 (KR-20).

*Metacognitive Strategy (MS)*

The Chinese Character Learning Strategy Scale (Chen & Zhang, 2024) was used to assess students' metacognitive strategy. The scale includes 5 items rated on a 5-point

Likert scale (1 = strongly disagree to 5 = strongly agree). Sample item includes "I arrange my time reasonably to ensure enough time for Chinese character learning and practice." The Cronbach's α values was 0.867.

*Self-Efficacy (SE)*

Self-efficacy was measured using the Student Self-Efficacy Scale (Rowbotham & Schmitz, 2013), consisting of 10 items rated on a 5-point Likert scale. The original scale demonstrated high reliability (α = 0.966). Minor contextual adaptations were made for this study. A sample item is: "I am convinced that I am able to successfully learn all relevant Chinese Character content even if it is difficult."

*Chinese character learning achievement*

The Chinese character learning achievement was evaluated through an adapted version of the Chinese character recognition test (Zhang et al., 2023). This test was based on the content of university textbooks and was ultimately reduced to 20 Chinese characters. Participants received 1 point for each correct pinyin answer and 1 point for each correct meaning answer, with a total score of 40 points. The test showed acceptable reliability (KR-20 = 0.706).

**Analytical Procedure**

*Preliminary Data Screening and Assumption Checking*

Before proceeding with the main analysis, the dataset underwent thorough screening to ensure data quality and to meet the prerequisites for multivariate analysis. No missing responses were identified. Normality was assessed by examining skewness and kurtosis values for all observed variables. Evaluate normality by analysing the skewness and kurtosis values of all variables. Results indicate skewness values fall between −2 and +2, while kurtosis values remain within the acceptable range of −7 to +7, suggesting that the data met the normality assumption (Byrne & Van de Vijver, 2010). Multivariate outliers were further examined and potential outliers were detected, however, it was retained in the dataset, as suggested by Hair et al. (2021), who argue that outliers may represent valid population variability rather than data errors.

To assess common method variance (CMV), Harman's single-factor test was performed. The analysis revealed that the first factor explained 42.15% of the total variance, falling below the recommended threshold of 50%. This indicates that measurement variability is unlikely to pose a significant threat to the validity of the study results (Podsakoff & Organ, 1986).

*Statistical Power Analysis*

Prior to conducting the main analyses, a prior power analysis was performed using G*Power 3.1 software to determine the minimum sample size required (Faul et al., 2007). The analysis results indicate that for a multiple regression model with predictor variables, a minimum sample size of 107 respondents is adequate to detect a medium-sized effect ($f^2 = 0.15$) at a significance level of 0.05 and a statistical power of 0.95.

Given that the final sample comprised 201 participants, this study provides sufficient statistical power for subsequent analyses.

*Structural equation modelling analysis*

This measurement model is used to assess the validity of constructs including MS, SE, and Chinese character learning achievement. It was evaluated using a reflective modelling approach, in which causal relationships were specified from latent constructs to their observed indicators. Construct validity was examined utilizing confirmatory factor analysis, with particular emphasis on indicator reliability, internal consistency reliability, convergent validity, as well as discriminant validity.

Structural model analyses were performed to ascertain the relationships among the studied variables. PLS-SEM employs multiple regression method to determine the direct and indirect influence of one variable on the other. In the present study, all analyses were grounded in the estimation of path coefficients, the coefficient of determination ($R^2$), effect size ($f^2$) and $Q^2$ (Hair et al., 2021). The bootstrapping method was implemented to assess the magnitude of path coefficients.

## FINDINGS

### Preliminary analysis

Descriptive statistics and Pearson bivariate correlation coefficients for all core variables are presented in Table 1 and Table 2, respectively, based on a valid sample of 201 participants with complete data. The mean scores of Chinese character learning achievement, metacognitive strategy use, and learning self-efficacy were 31.65 (SD = 5.66), 3.61 (SD = 0.62), and 4.08 (SD = 0.54), respectively.

Correlation results showed that all three variables were significantly and positively correlated with each other. Learning self-efficacy was positively associated with both metacognitive strategy use ($r = 0.482$, $p < 0.001$) and Chinese character learning achievement ($r = 0.171$, $p < 0.05$). Metacognitive strategy also had a significant positive correlation with Chinese character learning achievement ($r = 0.254$, $p < 0.001$).

Table 1
Means, standard deviations, and bivariate pearson correlations for core variables

| Variable | M | SD | 1 | 2 | 3 |
|---|---|---|---|---|---|
| 1. Chinese character learning achievement | 31.65 | 5.66 | — | | |
| 2. Metacognitive Strategy | 3.61 | 0.62 | 0.254** | — | |
| 3. Self-Efficacy | 4.08 | 0.54 | 0.171* | 0.482** | — |

*Note.* N = 201. *p < .05, **p < .01 (two-tailed). Dashes indicate the diagonal of the correlation matrix (fixed value = 1).

### Measurement models

The results indicate that all constructs demonstrated satisfactory internal consistency reliability. Cronbach's alpha values ranged from 0.791 to 0.917, exceeding the recommended threshold of 0.70. Similarly, composite reliability values (rho_c) ranged from 0.856 to 0.931, indicating strong reliability.

In terms of convergent validity, the average variance extracted (AVE) values for all constructs exceeded the threshold of 0.50, with values of 0.544 for metacognitive strategies and 0.574 for self-efficacy. These results suggest that the constructs adequately capture the variance of their respective indicators.

Discriminant validity was assessed using the heterotrait–monotrait ratio (HTMT). As shown in Table 2, all HTMT values were below the conservative threshold of 0.85 (Henseler et al., 2015), indicating adequate discriminant validity(Henseler et al., 2015).

Collinearity was examined using variance inflation factor (VIF) values. All indicator-level VIF values range from 1.238 to 2.676, which are well below the recommended threshold of 5.0. This indicates that multicollinearity is not a concern in the model.

Table 2
Reliability, convergent validity, discriminant validity (HTMT).

| Construct | Cronbach's α | rho_a | rho_c | AVE | 1 | 2 | 3 |
|---|---|---|---|---|---|---|---|
| 1. MS | 0.791 | 0.792 | 0.856 | 0.544 | — | | |
| 2. SE | 0.917 | 0.921 | 0.931 | 0.574 | 0.574 | — | |
| 3. CCLA | — | — | — | — | 0.286 | 0.180 | — |

*Note*. MS = Metacognitive Strategy; SE = Self-Efficacy; CCLA = Chinese character learning achievement; Off-diagonal values represent HTMT ratios.

**Structural model**

The structural model was assessed using a bootstrapping procedure with 5,000 resamples (Hair et al., 2021), with results presented in Table 3.

Addressing RQ1: Direct Relationships among the Variables

To answer RQ1 regarding the relationships among self-efficacy (SE), metacognitive strategies (MS), and Chinese character learning achievement (CCLA) in the AI-supported blended learning environment, the direct paths in the structural model were examined. As shown in Table 3, SE showed a significant positive effect on MS ($\beta$ = 0.500, t = 9.921, $p < 0.001$), with a large effect size ($f^2$ = 0.333). MS, in turn, significantly and positively predicted CCLA ($\beta$ = 0.227, t = 3.356, p = 0.001), with a small effect size ($f^2$ = 0.042). In contrast, the direct effect of SE on CCLA was not statistically significant ($\beta$ = 0.063, t = 0.805, p = 0.421; $f^2$ = 0.003).

Addressing RQ2: The Mediating Effect of Metacognitive Strategies

To answer RQ2 regarding whether MS mediates the relationship between SE and CCLA, the indirect effect was evaluated. The bootstrapping results indicated that the indirect effect of self-efficacy on learning achievement via metacognitive strategies was statistically significant ($\beta$ = 0.113, t = 3.113, p = 0.002; 95% CI [0.043, 0.183]), confirming a significant mediating mechanism. Since the direct effect (SE → CCLA) was non-significant while the total effect remained significant ($\beta$ = 0.177, t = 2.631, p = 0.009), the findings support a full mediation model.

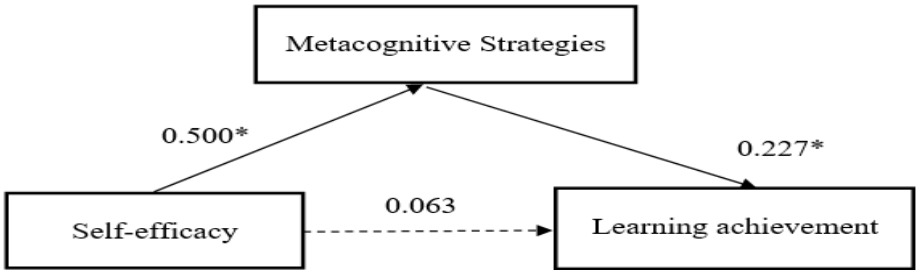
Overall, the model explained 25.0% of the variance in metacognitive strategies ($R^2$ = 0.250) and 7.0% in Chinese character learning achievement ($R^2$ = 0.070), with acceptable predictive relevance ($Q^2 > 0$).

Table 3
Path analysis for direct, indirect, and total effects with mediation (Bootstrap 95% CI).

| Path | β (O) | SD | t-value | p-value | 95% CI | $f^2$ | Result |
|---|---|---|---|---|---|---|---|
| SE → MS | 0.500 | 0.050 | 9.921 | <0.001 | [0.384, 0.584] | 0.333 | Supported |
| MS → CCLA | 0.227 | 0.068 | 3.356 | 0.001 | [0.088, 0.349] | 0.042 | Supported |
| SE → CCLA | 0.063 | 0.079 | 0.805 | 0.421 | [-0.097, 0.209] | 0.003 | Not supported |
| Indirect Effect (SE → MS → CCLA) | 0.113 | 0.036 | 3.113 | 0.002 | [0.043, 0.183] | — | Supported |
| Total Effect (SE → CCLA) | 0.177 | 0.067 | 2.631 | 0.009 | [0.035, 0.295] | — | Supported |

Notes: Variable abbreviations: MS = Metacognitive Strategies; SE = Self-Efficacy; CCLA= Chinese character learning achievement.

Figure 1
Final research model




Note. * = significant at the p < .05 level

## DISCUSSION

This study investigated the relationship among self-efficacy, metacognitive strategies and Chinese language learning achievement in an artificial intelligence-supported blended learning environment. The study yielded two main findings.

### Interpretation of RQ1: Direct Relationships among Core Variables

Regarding RQ1, the study revealed two distinct patterns in the direct relationships among the variables within the AI-supported blended learning environment.

First, the results indicate that self-efficacy can significantly predict metacognitive strategies, which is consistent with previous research findings (Hayat et al., 2020; Lin et al., 2017). In other words, learners with higher self-efficacy are more inclined to plan, monitor, and evaluate their learning processes because confidence can enhance the degree of learning effort, persistence, and strategic participation. This finding strongly

supports social cognitive theory, which posits that self-efficacy contributes to self-regulated learning behaviours (Bandura, 1977).

However, unlike the significant direct influence of self-efficacy on learning achievement reported in some previous studies (Cai & Zhao, 2023; Teng, 2020), this study did not find a significant direct relationship between self-efficacy and CCLA. This discrepancy may be explained by the complexity of the tasks and the specific learning environment. Chinese character learning requires a massive amount of cognitive processing, including visual orthographic analysis and memory-based encoding, which cannot be achieved solely through confidence. In contrast, studies on English learning or general academic achievement typically involve tasks where self-efficacy can more directly influence participation and output. Moreover, the AI-supported blended learning environment may further shift the role of self-efficacy from a direct predictor to an indirect facilitator, as it heavily emphasizes the learner's autonomy and strategic regulation rather than passive exposure.

**Interpretation of RQ2: The Full Mediating Role of Metacognitive Strategies**

Regarding RQ2, the research results confirm that metacognitive strategies completely mediate the relationship between self-efficacy and Chinese character learning performance. This finding aligns with previous scholarship stating that metacognitive strategies are a powerful predictor of learning achievement (Hayat et al., 2020; Teng et al., 2023; Thitipraserth & Manosuthikit, 2025). However, although earlier studies typically reported partial mediating effects involving other variables such as motivation or emotions (Hayat et al., 2020), this study discovered a complete mediating effect, indicating that self-efficacy only affects CCLA through the pathway of metacognitive strategies. This difference may be attributed to the uniqueness of Chinese character learning, where success largely depends on strategic cognitive regulation (such as radical decomposition and stroke order planning) rather than general motivation or emotional states.

Furthermore, in an AI-supported blended learning environment, learners are provided with external scaffolds and instant feedback. However, the effectiveness of these digital tools fundamentally depends on the learner's ability to actively regulate their own learning process. Therefore, metacognitive strategies become the absolute key mechanism for converting psychological beliefs (self-efficacy) into actual, measurable learning achievement.

## IMPLICATIONS

*Theoretical Implications*

This study extends the social cognition theory to the unexplored field of Chinese character learning in the context of artificial intelligence assistance, making contributions to second language acquisition and educational psychology. The research results confirm the complete mediating role of metacognitive strategies between self-efficacy and learning achievement and improve the applicability of these theoretical frameworks in non-alphabet language environments. It is worth noting that self-efficacy

does not directly affect learning achievement. Instead, it functions through the regulation of learners' strategies.

Furthermore, this study elucidated the sequential mechanism of self-efficacy → metacognitive strategies → learning achievement, indicating that metacognitive regulation is crucial for converting beliefs into actual performance. These findings respond to previous calls for research on how strategy application affects the relationship between self-efficacy and Chinese character learning achievement, especially in the context of artificial intelligence-assisted learning environments.

*Practical Implications*

For teachers, merely enhancing self-efficacy is not sufficient. They should prioritize teaching metacognitive strategies (planning, monitoring, and evaluation) in blended learning. For developers of artificial intelligence platforms, integrating metacognitive scaffolds (such as learning planning tools, progress tracking, and error visualization) is crucial for supporting strategic regulation, rather than merely focusing on the functionality itself. For learners, developing metacognitive abilities is the key to transforming confidence into effective autonomous learning behaviours, which ultimately determines the success or failure of Chinese character learning.

*Limitations and Future Research*

This study has some limitations. Firstly, the cross-sectional research design restricts causal inference. Future studies should adopt longitudinal or experimental designs. Secondly, this study did not examine learner characteristics (such as native language background and language proficiency). Future studies can test the generalizability of the model in different subgroups. Thirdly, this study regarded metacognitive strategies as a single structure. Future studies can explore the different roles of planning, monitoring, and evaluation. Finally, this study did not include other variables such as motivation and learning emotions; future studies can construct a more comprehensive regulatory mediating model to better explain the personality learning mechanism of cross-language learning.

## CONCLUSION

This study examined the relationships among self-efficacy, metacognitive strategies, and Chinese character learning achievement in an AI-supported blended learning environment, with particular emphasis on the mediating role of metacognitive strategies. The findings showed that self-efficacy significantly predicted the use of metacognitive strategies but did not directly predict Chinese character learning achievement. Instead, metacognitive strategies fully mediated this relationship, indicating that learners' confidence contributes to learning achievement primarily through effective strategic regulation.

These findings enrich the literature on Chinese as a Foreign Language (CFL) by extending self-regulated learning research to Chinese character acquisition in AI-supported blended learning environments. The study also provides empirical evidence

that metacognitive strategies serve as a key mechanism linking learners' motivational beliefs with learning outcomes in a non-alphabetic language context.

From a practical perspective, CFL teachers should place greater emphasis on developing learners' metacognitive strategies through explicit instruction and guided reflection rather than focusing solely on enhancing self-efficacy. In addition, designers of AI-assisted learning systems should incorporate features that facilitate planning, monitoring, and self-evaluation to better support learners' self-regulated learning and improve Chinese character learning achievement.

## DECLARATIONS

### Funding Information

This research received no financial support.

### Data Availability Statement

The datasets can be obtained from the corresponding author upon reasonable request.

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