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The Impact of AI-Supported Learning on Self-Regulated Learning and Learning Outcomes in Adult Education: Evidence from a Cross-Sectional Study in China

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Abstract
In recent years, the rapid development of artificial intelligence (AI) has reshaped educational practices across K–12 and higher education, yet its role in adult education remains underexplored. Adult education is a crucial domain for lifelong learning and workforce development, where learners face unique challenges such as balancing study with work and family responsibilities. Against this backdrop, this study examines the impact of AI-supported learning on self-regulated learning (SRL) and learning outcomes among adult learners in China. Using a quantitative, cross-sectional survey design, data were collected from 138 participants enrolled in diverse adult education programs. A structured questionnaire assessed AI-supported learning usage, SRL, and self-reported learning outcomes. Correlation analysis revealed significant positive associations among all three variables. Hierarchical regression showed that AI-supported learning usage strongly predicted SRL ($\beta = .52$, $p < .001$) and moderately predicted learning outcomes ($\beta = .33$, $p < .001$) after controlling for demographics. Mediation analysis using the PROCESS macro indicated that SRL partially mediated the relationship between AI-supported learning usage and learning outcomes, accounting for 39% of the total effect. Findings highlight the value of integrating AI tools that enhance SRL skills to improve learning performance in adult education, offering practical guidance for educators and policymakers. Future research should adopt longitudinal or experimental designs to establish causal effects and explore how AI interacts with learner diversity across cultural and institutional contexts.
Keywords: AI-supported learning; self-regulated learning; learning outcomes; adult education.
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1.Introduction

Adult education plays a pivotal role in promoting lifelong learning and social reintegration, with contexts ranging from community programs to correctional institutions (Conway, 2022). The inherently diverse learner population in adult education requires instructional approaches that acknowledge linguistic, cultural, and social dimensions (Auerbach, 2021). Persistence in adult learning is often shaped by learners' ability to maintain engagement and overcome personal, social, and institutional barriers (Comings, 2023). Within this domain, constructivist and social learning theories provide foundational guidance, emphasizing active knowledge construction and collaborative meaning-making (Chuang, 2021). Self-awareness, as a core element of adult development, underpins learners' capacity for reflective decision-making and adaptive learning strategies (Carden et al., 2022).

The rapid expansion of online and blended adult education programs has amplified the importance of understanding learners' characteristics and preferences in digital environments (Gardner et al., 2022). Socio-emotional and cognitive skills have been shown to exert long-term effects on adult life outcomes, influencing not only academic success but also social integration (Schoon et al., 2021). Nevertheless, barriers to participation, such as limited access to resources, inflexible program structures, and systemic inequities, continue to limit the reach of adult literacy and skills training (Pickard, 2021). In parallel, technological advancements, particularly artificial intelligence (AI), are increasingly positioned as transformative tools to personalize and optimize adult learning experiences. Recent findings from secondary education provide supporting evidence: Ng, Tan, and Leung (2024) demonstrated that a ChatGPT-enhanced chatbot (SRLbot) significantly improved students' knowledge acquisition, engagement, and self-regulated learning compared to a rule-based system, highlighting the potential of generative AI to foster more adaptive and sustainable learning practices.Despite the growing interest in AI applications for education, much of the existing work has concentrated on higher education or K–12 contexts, with limited attention to adult education specifically (Lan & Zhou, 2025). Furthermore, empirical research on AI-assisted metacognitive strategies has primarily focused on adolescent learners, leaving a gap in understanding their efficacy among adult learners (Mehmood et al., 2025). In language learning contexts, conceptual frameworks for AI-supported flipped classrooms have highlighted the potential to enhance self-regulated learning (SRL), yet these frameworks are rarely tested in adult education settings (Yin & Chew, 2025). Consequently, the intersection of AI-supported learning, SRL, and adult education remains underexplored in rigorous, context-specific studies.

While adult education research has examined persistence, learner diversity, and instructional approaches, few

studies have systematically integrated these dimensions with emerging AI-supported learning models. Existing AI-SRL research in higher education often overlooks the unique challenges adult learners face, such as balancing study with work, caregiving responsibilities, and prior educational experiences (Lan & Zhou, 2025). Moreover, measurement tools for SRL, though validated in younger populations, have not been extensively adapted to adult learning environments that demand high autonomy and contextual flexibility (Mehmood et al., 2025).

In response to these gaps, this study addresses the following research questions: (1) To what extent does AI-supported learning influence self-regulated learning among adult education participants? (2) How does AI-supported learning impact measurable learning outcomes in adult education contexts? (3) Does self-regulated learning mediate the relationship between AI-supported learning and learning outcomes for adult learners?

The purpose of this study is to quantitatively examine the impact of AI-supported learning on both SRL and learning outcomes in adult education, using validated SRL measures and performance indicators. By focusing on adult learners in diverse educational contexts, the study contributes to closing a critical research gap while providing practical insights for curriculum design, instructional strategies, and technology integration. This research aims to inform educators, policymakers, and technology developers about effective ways to leverage AI tools in fostering learner autonomy, metacognitive skills, and academic success in adult education programs.

2. Methods

2.1 Research Design

This study adopted a quantitative, cross-sectional survey design to investigate the impact of AI-supported learning on self-regulated learning (SRL) and learning outcomes among adult learners in China. A structured questionnaire comprising three sections, AI-supported learning usage, SRL, and self-reported learning outcomes, was distributed online via established survey platforms between March and April 2025, enabling broad geographic coverage and minimizing logistical constraints.

2.2 Participants and Sampling

Participants were adult learners (aged ≥18) enrolled in formal or non-formal adult education programs across China, including open universities, evening schools, adult colleges, vocational training institutions, and community education centers. Inclusion criteria required recent use of AI-supported learning tools and the ability to complete the questionnaire independently, while exclusion criteria included inability to comprehend the questionnaire and invalid response patterns. Using G*Power 3.1, the minimum required sample size was calculated as N = 118 for a medium effect size ($f^2 = 0.15$), $\alpha = 0.05$, power = 0.80, and six predictors; accounting for a 20% non-response rate, 150–180 questionnaires were distributed, yielding 138 valid responses (valid response rate = 83.1%).

2.3 Instruments

The AI-Supported Learning Usage Scale (Cronbach's $\alpha = 0.88$) measured usage frequency, types of AI features employed, and average session duration on a 5-point Likert scale. The Self-Regulated Learning Scale, adapted from the OSLQ and MSLQ-SRL with translation–back-translation procedures, assessed six dimensions (goal setting, environment structuring, task strategies, time management, help seeking, and self-evaluation) on a 5-point Likert scale, with Cronbach's $\alpha = 0.91$ (subscales 0.82–0.88). The Self-Reported Learning Outcomes Scale measured perceived learning achievement, task completion quality, skill improvement, and learning satisfaction (Cronbach's $\alpha = 0.87$).

2.4 Data Collection Procedure

Survey distribution was facilitated through institutional LMS announcements and class communication channels, with data collection spanning three weeks and a reminder issued in the second week. Average completion time was 10–15 minutes. Data screening involved removing cases with >10% missing responses, imputing means for items with <5% missingness, and detecting outliers using standardized z-scores ($|z| > 3.29$) and Mahalanobis distance, ensuring the dataset's suitability for analysis.

2.5 Data Analysis

Analyses were conducted using IBM SPSS Statistics 26.0. Descriptive statistics summarized sample characteristics, and Cronbach's α assessed reliability (≥0.70 as acceptable). Pearson's correlations examined associations among variables. Hierarchical multiple regression tested the direct effects of AI-supported learning on SRL and learning outcomes, controlling demographics. Mediation analysis was performed using the PROCESS macro (Model 4) with 5,000 bootstrap resamples to evaluate SRL's mediating role, reporting standardized coefficients and setting significance at $p < .05$ (two-tailed).

3. Findings

3.1 Descriptive Analysis

The descriptive statistics indicated that participants reported moderate-to-high engagement with AI-supported learning (M = 3.62, SD = 0.74) and self-regulated learning (M = 3.85, SD = 0.68), while self-reported learning outcomes were also relatively high (M = 3.92, SD = 0.71). Pearson's correlation analysis revealed significant positive relationships between AI-supported learning usage and SRL ($r = .54$, $p < .001$), AI-supported learning usage and learning outcomes ($r = .47$, $p < .001$), and SRL and learning outcomes ($r = .59$, $p < .001$), suggesting that higher AI engagement was associated with both improved SRL and better learning outcomes.

Table 1 Descriptive Statistics and Correlations of Main Variables (N = 138)

Variable	M	SD	1	2	3
1. AI-Supported Learning Usage	3.62	0.74	—		
2. Self-Regulated Learning (SRL)	3.85	0.68	.54***	—	
3. Learning Outcomes	3.92	0.71	.47***	.59***	—

Note. M = Mean; SD = Standard Deviation. ***p < .001.

Table 1 showed that AI-supported learning usage significantly predicted SRL after controlling for demographic variables ($\beta = .52$, $p < .001$), and significantly predicted learning outcomes ($\beta = .33$, $p < .001$). Mediation analysis indicated that SRL partially mediated the relationship between AI-supported learning usage and learning outcomes (indirect effect = 0.21, 95% CI [0.12, 0.32], $p < .001$), accounting for approximately 39% of the total effect. This suggests that while AI-supported learning has a direct impact on learning outcomes, its effect is also channelled through the enhancement of self-regulated learning.

3.2 Hierarchical Regression Analysis

A hierarchical multiple regression analysis was conducted to examine the predictive effects of AI-supported learning usage on SRL and learning outcomes, controlling demographic variables (age, gender, and educational attainment). In Model 1, demographic covariates were entered and explained 6% of the variance in SRL ($R^2 = .06$, $F(3, 134) = 2.86$, $p = .039$). In Model 2, the addition of AI-supported learning usage significantly increased the explained variance to 33% ($\Delta R^2 = .27$, $p < .001$), with AI usage emerging as a significant positive predictor of SRL ($\beta = .52$, $p < .001$). A similar pattern was observed for learning outcomes, where AI-supported learning usage explained an additional 15% of the variance beyond demographics, with a significant positive effect ($\beta = .33$, $p < .001$).

Table 2 Hierarchical Regression Analysis Predicting SRL and Learning Outcomes (N = 138)

Predictor Variables	SRL β	t	p	Learning Outcomes β	t	p
Model 1						
Age	0.08	0.92	.359	0.05	0.61	.542
Gender (Male = 1)	0.11	1.29	.199	0.09	1.02	.310
Educational Attainment	0.14	1.64	.104	0.12	1.43	.156
Model 2						
Age	0.05	0.71	.479	0.04	0.52	.605
Gender (Male = 1)	0.09	1.17	.244	0.08	0.96	.339
Educational Attainment	0.12	1.57	.119	0.10	1.26	.210
AI-Supported Learning Usage	0.52	7.20	<.001	0.33	4.48	<.001
R^2	0.33			0.21		
ΔR^2	0.27			0.15		

Note. SRL = Self-Regulated Learning. Standardized β coefficients are reported.

The regression results confirmed that AI-supported learning usage was a robust predictor of both SRL and learning outcomes, even after accounting for demographic factors. The large, standardized coefficient for SRL ($\beta = .52$) suggests that AI engagement is strongly related to learners' self-regulatory behaviors, while the effect on learning outcomes ($\beta = .33$) indicates a moderate but meaningful contribution. These findings provide empirical support for hypothesized direct relationships and lay the foundation for subsequent mediation analysis.

3.3 Mediation Analysis

A mediation analysis was conducted using the PROCESS macro (Model 4) with 5,000 bootstrap resamples to examine whether SRL mediated the relationship between AI-supported learning usage and learning outcomes. The results indicated that AI-supported learning usage was positively associated with SRL ($a = 0.51$, $SE = 0.07$, $p < .001$), and SRL was positively associated with learning outcomes ($b = 0.41$, $SE = 0.06$, $p < .001$) when controlling AI usage. The direct effect of AI-supported learning usage on learning outcomes remained significant ($c' = 0.29$, $SE = 0.07$, $p < .001$), suggesting partial mediation. The indirect effect was statistically significant ($ab = 0.21$, 95% CI [0.12, 0.32]), accounting for approximately 39% of the total effect.

Table 3 Mediation Analysis of SRL Between AI-Supported Learning Usage and Learning Outcomes (N = 138)

Path	Coefficient	SE	t	p	95% CI (LL, UL)
AI → SRL (a)	0.51	0.07	7.29	<.001	[0.37, 0.65]
SRL → Learning Outcomes (b)	0.41	0.06	6.83	<.001	[0.29, 0.53]
AI → Learning Outcomes (total effect, c)	0.50	0.07	7.14	<.001	[0.36, 0.64]
AI → Learning Outcomes (direct, c')	0.29	0.07	4.14	<.001	[0.15, 0.43]
Indirect Effect (ab)	0.21	—	—	—	[0.12, 0.32]

Note. Standardized coefficients are reported; SE = Standard Error; LL = Lower Limit; UL = Upper Limit; CI = Confidence Interval; Bootstrap resamples = 5,000.

The mediation analysis confirmed that SRL partially explained the relationship between AI-supported learning usage and learning outcomes. The significant indirect effect indicates that AI engagement contributes to improved learning outcomes not only through direct pathways but also by enhancing learners' self-regulatory capacities. This finding underscores the importance of integrating AI tools that actively foster SRL skills in adult education settings.

4. Discussion

4.1 AI-Supported Learning and SRL

The finding that AI-supported learning usage significantly predicts SRL aligns with Hill's (2023) argument that structured assessment and feedback mechanisms enhance learners' self-regulation by providing clear performance indicators. This study extends previous insights by confirming that AI features such as personalized feedback and adaptive learning paths can replicate and amplify the formative assessment process in adult education contexts. Moreover, the results resonate with Holloway and Qaisi's (2022) perspective that multimodal and multiliteracy-based learning environments stimulate active meaning-making, which is an essential component of SRL. By leveraging diverse content formats and interaction channels, AI tools appear to facilitate more autonomous goal setting and metacognitive monitoring among adult learners.

4.2 Direct Effects on Learning Outcomes

The direct positive effect of AI-supported learning on learning outcomes corroborates Smith and Gillespie's (2023) findings that sustained professional development and pedagogical innovation improve performance in adult education. The present study demonstrates that AI functions, such as intelligent evaluation and real-time feedback, can serve a similar role by providing timely, individualized learning support. Furthermore, this result echoes Hoggan-Kloubert and Hoggan's (2023) view that fostering autonomy and rational decision-making is critical for effective learning, as AI-driven systems encourage learners to take ownership of their progress. Such autonomy-enhancing features are particularly valuable in adult education, where learners often juggle multiple roles and require flexible yet rigorous support structures.

4.3 Mediating Role of SRL

The partial mediation effect of SRL between AI-supported learning and learning outcomes reinforces Qiu's (2023) assertion that deeply ingrained cultural and personal values shape the way learners approach academic tasks. In contexts where self-regulation is culturally emphasized, AI tools that scaffold SRL processes may have a more pronounced impact on achievement. The current findings also align with Ng et al.'s (2022) meta-analysis, which highlights that pre-learning interventions, when tailored to learners' needs, can significantly improve performance outcomes. By integrating AI functionalities that strengthen SRL, educational programs may achieve more sustainable improvements in adult learning effectiveness.

4.4 Implications and Future Directions

This study's results support Omoyajowo and Bambi's (2025) qualitative evidence that AI integration in higher education enhances learner autonomy, particularly in SRL-intensive tasks. Additionally, the findings complement Samsonovich et al.'s (2024) conceptualization of AI-SRL interaction, where cognitive architectures are designed to augment metacognitive control. The positive associations observed here also align with Wang et al.'s (2025) findings on ChatGPT-integrated feedback promoting higher-order thinking skills. Taken together, these results suggest that future AI implementations in adult education should prioritize tools that directly foster SRL, embed adaptive feedback, and align with learners' personal and cultural contexts.

5. Conclusion

This study investigated the impact of AI-supported learning on self-regulated learning (SRL) and learning outcomes among 138 adult learners in China using a cross-sectional survey. Results showed that AI-supported learning significantly predicted SRL and learning outcomes, with SRL partially mediating this relationship. The evidence suggests that AI tools, such as personalized feedback, adaptive learning paths, and automated assessment,

can strengthen self-regulation and improve academic performance in adult education. Practically, adult education providers should integrate AI systems that foster SRL skills, including goal setting, time management, and metacognitive reflection, while ensuring cultural adaptability. Future research should employ longitudinal or experimental designs to confirm causal effects and explore how AI interacts with learner characteristics across diverse cultural and institutional contexts. In addition, comparative studies across countries and program types could provide a broader understanding of how contextual factors shape the effectiveness of AI in adult learning. Further exploration of ethical considerations, learner privacy, and the balance between human instruction and AI support would also be valuable directions for advancing both theory and practice.

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