

Enhancing Language Learning Autonomy and Proficiency through AI-Driven Metacognitive Strategies

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DOI: <https://doi.org/10.47772/IJRISS.2026.102100142>

Received: 07 September 2026; Accepted: 16 September 2026; Published: 02 October 2026

ABSTRACT

The emergence of artificial intelligence (AI) has significantly changed the landscape of language learning today. Integrating artificial intelligence (AI) into language learning offers new avenues for fostering metacognitive strategies implemented throughout the learning process. This study examined the relationship between AI usage and metacognitive strategy adoption among undergraduates within tertiary educational institutions. A quantitative survey was administered to 120 respondents from several academic programs at selected university in Malaysia, and the data were analysed using Structural Equation Modelling (SEM). Results demonstrated that AI use was positively associated with metacognitive strategy adoption, which in turn mediated positive effects on both learner autonomy and language proficiency. These results underscore the pivotal role of AI as a cognitive scaffold, offering theoretical contributions to metacognitive strategy research and practical insights for policymakers and language instructors implementing AI-driven language curricula.

Keywords: Artificial Intelligence, Language Learning, Metacognitive Strategies

INTRODUCTION

In recent years, educational paradigms have undergone a profound transformation driven by rapid technological integration. The adoption of technology allows a flexible mode of learning and provides easy access to language learning (Ismail et al., 2023). The use of a technology-assisted approach in education is regarded as an effective way to enhance students' understanding of the course content in line with Education 4.0 and Industry 4.0 (Abdullah et al., 2023). The integration of artificial intelligence (AI) in language learning has rapidly shifted the landscape from traditional rule-based systems to large language models (LLMs) over the past decade. Artificial intelligence was first coined around 1950 in order to define machines that could perform functions that were more complex than routine tasks (UNESCO World Commission on the Ethics of Scientific Knowledge and Technology, 2019: 3). Today, the term is used to describe the intelligent systems or machines capable to simulate real conversations. AI is designed based on algorithms that enable task automation traditionally performed by humans (Chaudhry & Kazim, 2022) tasks to emulate human intelligence, such as language comprehension, problem-solving or decision-making (Muñoz-Basols, Gutiérrez, & Balkwill, 2025). This provides a platform for students to enhance their language learning with

immediate feedback, tailored instructional content that is crucial for enhancing language proficiency (He et al., 2025).

The emergence of AI has significantly enhanced the language learning process, where learners are able to use the tools for instant feedback in any language-related task (Albedah, 2025). Due to the global demand, mastery of English serves not only as a social and communicative function in a community but also as a main component for communication in various disciplines at international levels, particularly for university students upon graduation (Yusop, 2024; Baeh & Baun, 2022). This is consistent with Malaysia's aspirations in empowering English language proficiency among students must be a national priority for the nation to be competitive in higher education institutions and workplace settings.

Despite several educational reforms in the last forty years of English language education in Malaysia, English proficiency is still a challenge in the context of Malaysian teaching and learning (Rahman, Abdul Karim & Singh, 2022). Most students struggled in producing a good quality of essays in terms of vocabulary, grammar, and mechanics (Sabarun et al., 2024). The Ministry of Education launched its blueprint to strengthen the English language with the local language as an integrated solution. The blueprint, English Language Education Reform in Malaysia: The Roadmap 2015-2025, offers a new insight to English language education in Malaysia. The roadmap addresses the need to produce graduates with communicative competence in English so that they can take part in the global economy as a part of the national agenda.

AI applications including generative models, automated writing assistants, and intelligent tutoring systems such as ChatGPT, Quillbot, Grammarly and Copilot, enhance target language acquisition. These tools not only provide real-time scaffolding and adaptive learning experiences but also foster deeper linguistic immersion (Li et al., 2025). ChatGPT, for example, offers a wide range of context-specific writing assistance, such as idea generation, outlining, content improvement, organization, editing, proofreading, and post-writing reflection (Barrot, 2023). Nonetheless, there is a concern about students' learning loss due to their over-reliance on the tools.

LITERATURE REVIEW

The incorporation of AI into educational frameworks has reshaped pedagogical paradigms, particularly within language acquisition. Drawing from historical timeline, early AI-based tools primarily focused on automated feedback and error correction (Li et al., 2025). With the advancement of natural language processing (NLP) and machine learning, more advanced AI technologies, such as speech recognition, machine translation, and chatbots, have been used to support personalized language learning (Radzuan & Arif, 2025). The use of generative AI technologies such as GPT-based models have gained significant popularity for their easy access and ability to produce sophisticated human-like text and multimodal content (Liu et al., 2023).

The integration of AI and metacognitive strategies enhances the process of language learning. The Strategy Inventory for Language Learning (SILL) by Oxford (1990) provides validated measures of metacognitive strategies and remains a leading theoretical and measurement framework in second language acquisition research. The inventory is a validated framework used to measure learners' language learning strategies with 6 different strategies; memory, metacognitive, cognitive, affective, compensation and social (Oxford, 1990; Ranjan, Philominraj & Saavedro, 2021). Metacognitive strategy includes planning, monitoring, and evaluating which has been recognised as essential for self-regulated language learning (Oxford, 1990). These strategies help learners set goals, select appropriate tasks, observe performance, and revise strategies, and have been strongly associated with learner autonomy and improved language proficiency. The use of AI tools such as automative writing evaluation and intelligent tutoring systems can reinforce metacognitive engagement by prompting as learners learn to reflect, revise and adapt strategies based on the output (Ranalli, 2018; Xu & Wang, 2025).

To date, a growing number of studies investigate how AI tools mediate metacognitive engagement. Past research related to the use of automatic writing evaluation reported that instant, task-specific feedback can prompt learners to notice errors and reflect on revisions. Several recent experimental and quasi-experimental

studies indicate that the integration of metacognitive prompts or scaffolds within AI environments improve self-regulation and performance tasks (Xu & Wang, 2025). As technology has brought significant transformations in second language acquisition all over the globe, this not only changed the language learning setting but also promoted autonomy for language learners (Lin, Narayanan & Noor, 2024). Autonomy has been a goal of language learning as it allows learners to take charge of their own learning process (Little, 1991; Benson, 2013). Additionally, AI tools can support autonomy by providing learners with on-demand scaffolding and diagnostic information that reduces dependence on teacher direction. Recent systematic reviews on AI and autonomy reported promising links between AI affordances (i.e. adaptive tasks, progress dashboards) and indicators of autonomous behavior such as self-paced study, goal setting.

Notably, artificial intelligence (AI) substantially enhances target language communication skills through varied applications extending beyond spoken interaction. Sharples and Pérez (2022) demonstrate that conversational agents facilitate collaborative creative writing tasks while fostering high-order cognitive skills, including critical reading and analytical reasoning. As noted by Soler Montes and Juan-Lázaro (2025), AI-driven autonomous learning frameworks enable digital linguistic immersion that promote prompt query resolution, and individualized feedback. These technological affordances accommodate personalized learning experiences that allows learners to enhance their language learning process systematically (Radzuan & Arif, 2025). This is particularly relevant in language learning where AI tools can provide feedback for grammar and vocabulary corrections which indirectly improves their language mechanics in the target language (He, Abbasi & He, 2025).

Past research revealed that AI-driven tools may enhance the students' language proficiency as their use can lead to the acquisition of basic skills in the target language (Dokukina & Gumanova, 2020). However, studies on the use AI-mediated metacognitive strategies on language learning particularly for Malaysian students remains underexplored. Further empirical studies are also needed to confirm the hypothesis as the use of AI tools for language learning may heavily relies on the sophistication of the tools' design (Muñoz-Basols et al., 2025). Therefore, this study seeks to identify the extent AI can support learners' metacognitive strategies, autonomy and proficiency in language learning. Additionally, the present study also addresses these gaps by testing a conceptual model in which AI use is associated with metacognitive strategy adoption, which in turn is associated with learner autonomy and ultimately is related to higher language proficiency.

RQ1: What is the relationship between the use of artificial intelligence (AI) tools and metacognitive strategies among learners at the undergraduate level?

RQ2: What is the relationship between metacognitive strategy use and learner autonomy in AI- mediated language learning contexts?

RQ3: Does AI use have an indirect association with language proficiency through metacognitive strategy use and learner autonomy?

Following the research questions, this study formulated a hypothesis linking AI use, metacognitive strategy adoption, autonomy, and language proficiency.

H1: AI use is positively associated with metacognitive strategy use.

H2: Metacognitive strategy use is positively associated with learner autonomy.

H3: Learner autonomy is positively associated with language proficiency.

H4: Metacognitive strategy use mediates the association between AI use and learner autonomy.

H5: AI use is indirectly associated with language proficiency through the serial pathway of metacognitive strategy use and learner autonomy

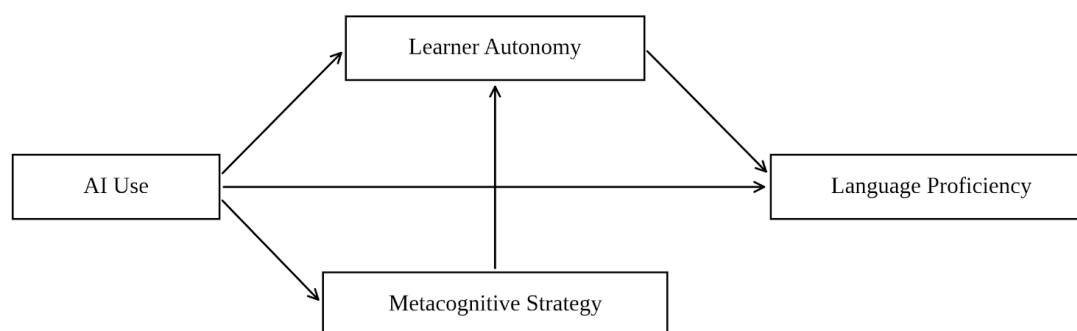


Figure 1: Proposed Theoretical Framework

METHODOLOGY

This quantitative study employed an online questionnaire and convenience sampling. The participants comprised 120 undergraduate students enrolled in English-language courses at selected local higher education institution in Malaysia. The students enrolled as a full-time undergraduate or diploma student at the institution and they voluntarily completed the online informed consent form prior to survey administration. Participants represented academic program from sciences and social sciences and reported English proficiency levels ranging from CEFR B1 to B2.

The questionnaire used for this study adapted from past research to meet the research objectives. AI use was measured from a survey adapted from Chai et al. (2021). Metacognitive strategy use was adapted from the metacognitive component of Oxford's (1990) Strategy Inventory for Language Learning. For learner autonomy, items were adapted from Little (1991) and Benson (2013)'s Learner Autonomy Scale. Language proficiency was measured using self-assessment grid from Common European Framework of Reference for Languages (CEFR) to help learners to self-assess their level of proficiency. According to the Common European Framework of Reference for Languages (CEFR; Council of Europe, 2020), this framework provides a standardized guidelines to describe and measure language proficiency, ranging from A1 to C2 levels. All constructs were assessed using a five-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). For data collection, data were collected through a secure online survey platform. Before completing the questionnaire, participants received information about the study and provided informed consent. Participation was voluntary, and responses were collected anonymously.

Data were analysed using PLS-SEM in SmartPLS version 3.0. The measurement model was assessed using indicator loadings, Cronbach's alpha, composite reliability, average variance extracted and Fornell-Larcker discriminant validity. Collinearity was examined using variance inflation factors. The structural model was evaluated using path coefficients, coefficient of determination, effect size, and predictive relevance.

RESULTS AND DISCUSSION

Demographic Profile of the Respondents

Table 1 presents the demographic profile of the respondents involved in this study. Of the 120 respondents, 93 (77.5%) were female and 27 (22.5%) were male. Most respondents were enrolled in science-related programmes ($n = 96$, 80.0%), while 24 (20.0%) were enrolled in social science programmes. For the language skills, writing was the language skill most frequently practised using AI tools ($n = 77$, 64.2%), followed by reading ($n = 22$, 18.3%), speaking ($n = 19$, 15.8%), and listening ($n = 2$, 1.7%).

Table 1: Demographic Profile of the Respondents

Variable	Category	Frequency (n)	Percentage (%)
Gender	Female	93	77.5
	Male	27	22.5
Field of study	Sciences	96	80.0
	Social Sciences	24	20.0
Language skill frequently practiced using AI	Writing	77	64.2
	Reading	22	18.3
	Speaking	19	15.8
	Listening	2	1.70
	Total	120	100.0

Measurement Model

The measurement model was thoroughly examined to ensure the reliability and validity of the constructs employed in this research. All indicator loadings surpassed the recommended benchmark of 0.70, confirming strong individual item reliability for each construct (Hair et al., 2019). Internal consistency reliability was assessed using Cronbach's Alpha (CA) and Composite Reliability (CR), with both values for all constructs exceeding the accepted threshold of 0.70. This finding demonstrates that the items consistently represent their corresponding latent variables. Additionally, convergent validity was verified through the Average Variance Extracted (AVE), as all constructs achieved AVE scores above 0.50. This result suggests that each construct accounts for more than half of the variance in its respective indicators, thereby supporting a satisfactory level of convergent validity.

Table 2: Reliability and Validity Test

Construct	Item	Loadings	CA	CR	AVE
AI Use	USE1	0.901	0.949	0.961	0.832
	USE2	0.922			
	USE3	0.896			
	USE4	0.913			
	USE5	0.927			
Metacognitive Strategies	MC1	0.843	0.870	0.905	0.657
	MC2	0.834			
	MC3	0.775			

	MC4	0.821			
	MC5	0.843			
Learner Autonomy	LA1	0.820	0.897	0.924	0.708
	LA2	0.811			
	LA3	0.736			
	LA4	0.842			
	LA5	0.839			
Language Proficiency	LP1	0.807	0.882	0.914	0.679
	LP2	0.837			
	LP3	0.822			
	LP4	0.886			
	LP5	0.853			

To assess discriminant validity, the study applied the Fornell-Larcker criterion, which posits that the square root of each construct's AVE must exceed its correlations with other constructs in the model. As presented in Table 3, this condition was satisfied for all constructs, confirming that each construct is empirically distinct and that the measurement model demonstrates adequate discriminant validity.

Table 3: Discriminant Validity (Fornell-Larcker)

Latent construct	LA	LP	MS	USE
LA	0.810			
LP	0.807	0.841		
MS	0.691	0.752	0.824	
USE	0.704	0.724	0.701	0.912

Structural Model

The structural model was assessed to evaluate the hypothesized relationships among all latent variables in the proposed framework. Using the Partial Least Squares (PLS) bootstrapping procedure with 5,000 resamples, the study estimated the significance and strength of each structural path. This analysis enabled the evaluation of direct, indirect, and mediating effects among constructs, as well as the overall explanatory power of the model. The resulting path coefficients (β values), along with their corresponding t-statistics and p-values, are presented in Table 4. This provides empirical evidence for testing the proposed hypotheses and determining the magnitude of the relationships among the study variables.

Table 4: Hypothesis Testing

Hypothesis	β	t-value	p-value	Decision
H1: AI USE>MS	0.701	12.411	0.001	Supported
H2: MS>LA	0.388	4.034	0.001	Supported
H3: LA>LP	0.590	8.531	0.001	Supported

The path from AI Use to Metacognitive Strategies was found to be strong and highly significant ($\beta = 0.701$, $t = 12.411$, $p < 0.001$), indicating that learners who frequently engage with AI-based tools tend to develop more robust metacognitive regulation skills. This finding suggests that the integration of AI technologies in learning encourages students to plan, monitor, and evaluate their learning processes more effectively, fostering greater self-awareness and strategic control over their cognitive activities. Hence, Hypothesis 1 is supported.

Furthermore, Metacognitive Strategies exert a significant positive influence on Learner Autonomy ($\beta = 0.388$, $t = 4.034$, $p < 0.001$). This result confirms that learners who actively employ metacognitive strategies such as goal setting, self-monitoring, and reflective evaluation are more likely to exhibit autonomous learning behaviours. These learners take greater responsibility for their progress and demonstrate increased independence in managing their educational activities. Thus, Hypothesis 2 is supported.

Lastly, the association of Learner Autonomy on Language Proficiency was also strong and significant ($\beta = 0.590$, $t = 8.531$, $p < 0.001$). This implies that autonomous learners achieve higher levels of language proficiency because of their ability to take initiative, set learning goals, and persistently manage their learning outcomes. In other words, learner autonomy serves as an important correlate of linguistic competence and sustained improvement in second language acquisition. Therefore, Hypothesis 3 is supported.

Table 5: Mediation Analysis

Mediation path	β	t-value	p-value	Decision
H4: AI USE-MS-LA	0.272	4.629	0.000	Supported
H5: AI USE-MS-LA-LP	0.160	3.301	0.000	Supported

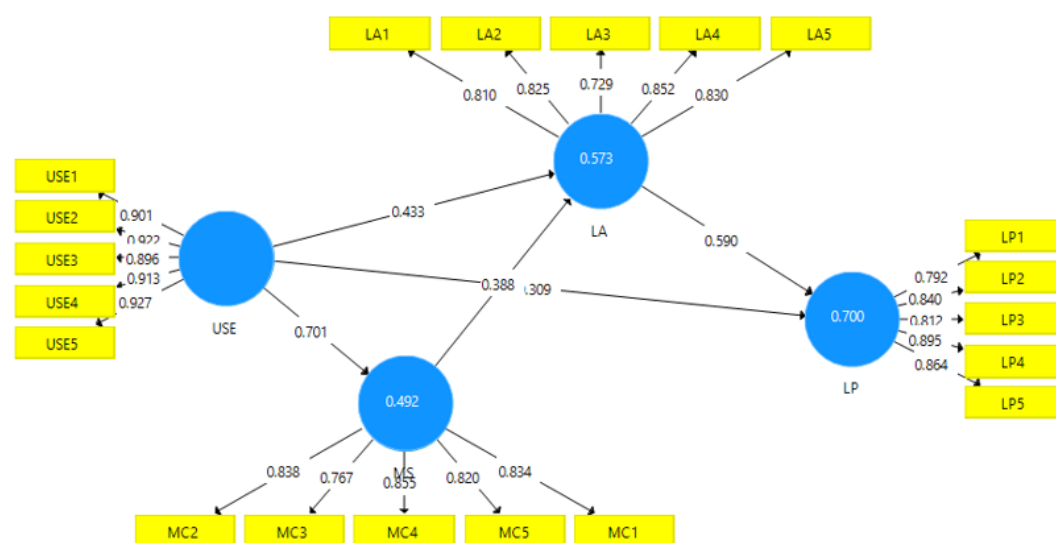


Figure 2: Path Relationship

The specific indirect association between AI use and learner autonomy through metacognitive strategy use was positive and statistically significant ($\beta = 0.255$, $t = 4.629$, $p < 0.001$). Therefore, H4 was supported. The serial indirect association between AI use and language proficiency through metacognitive strategy use and learner autonomy was also statistically significant ($\beta = 0.160$, $t = 3.301$, $p < 0.001$, supporting H5). These findings indicate statistically significant indirect associations within this sample. In comparison with previous studies, our finding is consistent with the results of Yeh and Siah (2025)'s study as the use of large language models had a positive correlation with the students' metacognitive strategies. Additionally, Wang et al. (2026) reported that AI use had an indirect effect through the indirect-only mediating role of metacognitive ability which supports the potential use of AI in promoting language learner autonomy and language proficiency.

CONCLUSION

This study examined the associations among AI use, metacognitive strategy use, learner autonomy, and language proficiency in a convenience sample of 120 Malaysian undergraduates. AI use was positively associated with metacognitive strategy use, which was associated with greater learner autonomy. Learner autonomy was, in turn, positively associated with language proficiency. The serial indirect pathway from AI use to language proficiency through metacognitive strategy use and learner autonomy was statistically significant.

These findings apply to the participants and context examined and should not be interpreted as evidence of causal relationships. The convenience sampling and the relatively small sample restrict generalizability of the entire population. The reliance on self-reported measures may also introduce common-method and response biases. To build upon the findings of this study, future research should adopt a mixed-methods research design to achieve a more comprehensive analysis. This mixed-methods approach will not only validate quantitative trends across broader and more diverse demographic samples but also contextualize *why* and *how* these patterns emerge within real-world environments. Research should employ longitudinal or experimental designs to examine the directional relationships among AI dependency, metacognitive ability and self-efficacy across diverse learning contexts and proficiency levels.

From a pedagogical perspective, the findings suggest that AI-supported language activities may be more valuable when they explicitly encourage learners to plan, monitor, and evaluate their learning. However, the broader effectiveness of such practices should be verified through intervention-based research before firm instructional recommendations are made. Through these strategic alignments, institutions can leverage digital environments not merely as technological platforms, but as catalysts to foster learner autonomy and sustain lifelong linguistic growth.

ACKNOWLEDGEMENTS

The authors express their sincere gratitude to all participants for generously contributing their time and valuable insights into this study.

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