



Beyond Whiteboard EFL Classrooms: Uncurtaining the Links between AI Self-efficacy, AI Cognitive-emotion Regulation, AI-assisted L2 Learning Attitude, and AI Psychological Flow in Higher Education

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ABSTRACT

The incorporation of artificial intelligence (AI) in English as a Foreign Language (EFL) instruction has led to a closer look at how it affects the experiences and outcomes of learners in this field. This study looks at how psychological flow, AI cognitive-emotion regulation, AI-assisted second language (L2) learning attitudes, and AI self-efficacy are related among 318 university students. By applying Structural Equation Modeling (SEM) via AMOS, the study explains how these variables cooperate in order to make the language learning experiences better. The results suggest that a more favorable attitude toward AI-assisted L2 learning is cultivated as a result of the positive impact of higher levels of AI self-efficacy on cognitive-emotion regulation. Additionally, a robust correlation was observed between these attitudes and the experience of psychological flow, indicating that the integration of AI can substantially improve student engagement and overall learning outcomes. The findings also emphasize the importance of cognitive-emotional processes in influencing students' perspectives on AI tools, demonstrating that emotional modulation strategies can alleviate feelings of apprehension and uncertainty, thereby fostering a more optimistic learning environment. Furthermore, the implications of these discoveries for curriculum development and teaching practices are addressed, offering educators valuable insights on how to effectively utilize AI technology.

KEYWORDS: AI self-efficacy; AI cognitive-emotion regulation; AI-assisted L2 learning attitude; AI psychological flow; Higher education

1. Introduction

The swift development of AI in educational settings has revolutionized conventional language learning frameworks, especially in the instruction of EFL. AI technologies, including language learning apps, have arisen as potent instruments that may complement the educational experience by offering individualized feedback, adaptive learning trajectories, and real-time conversational practice (Zhao, 2024). AI technologies, such as language learning applications, have emerged as powerful tools that may enhance the educational experience by providing personalized feedback, adaptive learning paths, and real-time conversational practice (Chen, 2024). As these technologies become more incorporated into language instruction, understanding the psychological elements that affect students' engagement and efficacy in these settings is essential. This research examines several interrelated constructs: AI self-efficacy, AI cognitive-emotional control, AI-assisted second language learning attitude, and AI psychological flow. Each of these dimensions is crucial in molding learners' experiences and results in AI-enhanced language learning environments, eventually affecting their language ability and desire to study.

AI self-efficacy denotes an individual's confidence in their capability to effectively interact with AI technologies and use them for language acquisition. Bong (2013) highlighted that self-efficacy profoundly influences motivation, perseverance, and performance, making it an essential element in educational contexts. Individuals with elevated self-efficacy are more inclined to confront problems, establish loftier objectives, and dedicate more effort to attain them. In the realm of language learning, elevated self-efficacy correlates with enhanced perseverance and resilience, resulting in superior language learning results (Wang & Chuang, 2023). Moreover, self-efficacy affects learners' engagement with technology; individuals who possess confidence in their capacity to use AI technologies proficiently are more inclined to interact with them, thereby improving their entire learning experience (Huang, 2024).

AI cognitive-emotion regulation encompasses the techniques used by learners to govern their thoughts and emotions in reaction to AI-facilitated learning experiences. This concept is crucial since it affects how students manage problems, such as frustration or fear, that may occur throughout the learning process. Liu (2024) asserts that proficient emotion control enhances academic achievement and general well-being, underscoring its significance in language development. Students who adeptly manage their emotions are more capable of sustaining attention, alleviating anxiety, and maintaining motivation, all of which are essential for language learning. Comprehending the mechanics of cognitive-emotional regulation in AI environments may provide educators with insights to assist students in managing their emotional reactions to technology-enhanced learning (Garnefski, 2020).

The attitude towards AI-assisted L2 learning includes learners' attitudes and emotions toward the use of AI technology in their language studies. Favorable perceptions of AI may augment motivation and engagement, resulting in more efficacious learning experiences. According to Zhai (2024) indicates that learners' attitudes regarding technology substantially affect their readiness to embrace new tools. Students who perceive AI as a beneficial resource for improving their language abilities are more inclined to use these tools consistently, hence promoting superior language learning results. Conversely, adverse sentiments may lead to opposition to using AI, so limiting the potential advantages these technologies provide.

This research additionally examines AI psychological flow, which is described as students' deep absorption and engagement while using AI technology (Norsworthy, 2023). In language teaching, flow may be fostered by assigning students appropriately demanding tasks that are linked with their competency levels and interests. Individuals who experience flow may lose sense of time and become completely absorbed in the learning process, resulting in improved language retention and mastery (Liu, 2024). Therefore, an examination of the factors that promote fluidity in AI-assisted environments is critical for improving learning outcomes and ensuring that students completely benefit from new technologies.

Notwithstanding the expanding literature on AI in education, a substantial study vacuum persists regarding the interaction among these dimensions in EFL situations. Although research has investigated AI self-efficacy and its influence on learning outcomes (e.g., Heydarnejad et al., 2024; Yang, 2023; Zhai, 2024), empirical data about the interaction between cognitive-emotion regulation, learning attitudes, self-efficacy, and psychological flow remains few. This gap underscores the need for thorough research that synthesizes these components to provide a more refined understanding of AI's function in language acquisition. Furthermore, current research often emphasizes discrete notions instead of exploring their interrelations, perhaps resulting in insufficient understanding of the learning process. Therefore, this research seeks to enhance the current literature and provide significant insights for educators and policymakers in EFL environments by examining the relationships among these dimensions using SEM. Comprehending the interplay of these psychological components helps guide the development of AI-enhanced learning environments that facilitate language acquisition and foster delighted learner experiences. To meet these purposes the following research questions were explored:

RQ1: Does AI self-efficacy contribute to AI-assisted L2 learning attitude and AI psychological flow in Iranian EFL landscape?

RQ2: Does AI cognitive-emotion regulation contribute to AI-assisted L2 learning attitude and AI psychological flow in Iranian EFL landscape?

2. Literature review

2.1. Theoretical framework

2.1.1. AI self-efficacy

AI self-efficacy, grounded on Bandura's Social Cognitive Theory (2012), has demonstrated an impact on students' motivation, perseverance, and overall learning results, especially in digital and technology-enhanced educational environments. It pertains to a learner's self-assurance in their ability to effectively utilize AI-driven technology to improve their language skills (Wang & Chuang, 2024). According to Bandura (1997), self-efficacy is impacted by social and personal circumstances, especially in collectivist settings. The opinions of their peers, teachers, and the educational environment at large may have a significant impact on students' assessments of their AI skills in Iran, which is a collectivist country. Iranian EFL learners are more inclined to cultivate elevated AI self-efficacy when AI technologies are approved or exemplified by esteemed authority figures or peers, rather than only through self-directed inquiry. Consequently, fostering AI self-efficacy in Iran may necessitate culturally attuned tactics that prioritize collective affirmation and institutional support. The Technology Acceptance Model (Davis, 1989) serves as a relevant paradigm for comprehending AI self-efficacy. The model indicates that perceived ease of use and perceived utility

are essential determinants of technology adoption. In Iran, where access to AI technology is restricted and digital literacy varies, the perceived usability may be diminished, especially among students from under-resourced digital areas. The cultivation of AI self-efficacy among Iranian learners involves not just personal conviction but also systemic support, accessibility, and culturally relevant training.

2.1.2. Cognitive-emotion regulation

The utilization of cognitive strategies to regulate emotional responses in stressful or difficult circumstances is referred to as cognitive-emotion regulation (Garnefski & Kraaij, 2007). Using AI-powered tools to assist learners in managing their cognitive and emotional states is referred to as AI cognitive-emotion regulation. This may involve adaptive learning pathways, motivational prompts, or personalized feedback that promote resilience and alleviate frustration. According to Keegan and Holas (2009), Cognitive-Behavioral Theory (CBT) serves as a theoretical foundation for these interventions by emphasizing the interplay between thoughts, emotions, and behaviors. In contexts where learners may dread failure or lack confidence with new technologies, cognitive reappraisal and other CBT-based strategies enable learners to reframe challenges as opportunities for growth. AI tools that foster emotional autonomy and encourage positive reframing can be transformative in Iran, where learners may be acclimated to correction-focused feedback and one-way instruction. Gross's (2002) Emotion Regulation Theory provides additional evidence in favor of the utilization of AI for emotional support. In formal classroom settings, emotional expression is frequently suppressed. AI-driven platforms can provide learners with a private and judgment-free environment in which to manage frustration, receive encouragement, and develop emotional resilience. Iran is particularly in need of this support, as the affective engagement with new technologies may be impeded by rigorous pedagogical norms and limited learner autonomy.

2.1.3. L2 learning attitudes

L2 learning attitude includes cognitive and emotional reactions to language learning, including motivation, self-assurance, and total involvement (Dörnyei, 2005). In AI-mediated learning settings, instruments such as chatbots, virtual tutors, and adaptive platforms may influence these attitudes via real-time feedback and interactive experiences. In the Iranian educational setting, student perceptions regarding AI are significantly influenced by conventional pedagogical standards. Traditionally, instruction has been characterized by grammar-translation approaches and teacher-centered practices, prioritizing precision and rote memorization above interaction or learner autonomy. Consequently, learners may first exhibit skepticism towards AI tools that prioritize communicative learning, such as conversational agents, while demonstrating more receptiveness to tools that correspond with their previous experiences, such as grammar checkers and translation programs. Gardner's Socio-Educational Model (1985) offers a valuable framework for understanding the formation of these attitudes. This approach posits that integrative motivation (interest in the culture of the target language) and instrumental motivation (practical advantages of language ability) both affect language learning results. AI technology may enhance both motivating aspects, such as providing culturally appropriate information or emphasizing the employment advantages of language proficiency. To successfully augment motivation among Iranian EFL learners, these technologies need to align with or progressively broaden the expectations established by conventional educational experiences.

2.1.4. Psychological flow

Psychological flow, as defined by Csikszentmihalyi (1990), is a state of profound engagement and genuine pleasure in an activity, marked by concentrated attention, explicit objectives, and an equilibrium between difficulty and skill. In language acquisition, attaining flow correlates with enhanced motivation and superior results. AI-driven platforms, especially adaptive systems, effectively facilitate flow by aligning task complexity with learner ability (Heydarnejad, 2024). In the Iranian setting, attaining and maintaining flow poses distinct obstacles. A significant obstacle is limited and inconsistent internet connectivity, which may disrupt learning sessions and hinder the sustained engagement necessary for flow. Technological disturbances may induce frustration, impair focus, and diminish learners' feeling of control—essential circumstances for achieving a flow state. Furthermore, some Iranian learners may lack familiarity with self-directed, immersive learning experiences owing to their educational backgrounds. Consequently, even optimally built AI systems may have difficulties in promoting flow unless they are accompanied by reliable infrastructure, user training, and culturally attuned design elements. Therefore, while Csikszentmihalyi's (1990) theory offers a significant perspective on optimum learning experiences, it needs adaptation to address the infrastructural and pedagogical challenges encountered by Iranian learners. Developing AI products for this demographic necessitates adaptive functionalities, stability, accessibility, and support systems that alleviate environmental disturbances and foster sustained concentration.

2.1.5. Experimental studies

In learning a language, if learners see AI technologies as user-friendly and beneficial for attaining linguistic objectives, they are more inclined to cultivate greater self-efficacy in using these instruments. As Chen (2024) concluded, AI-driven language learning systems considered as user-friendly enhance learners' self-efficacy, hence augmenting engagement and overall learning efficacy. Huang (2024) investigated the link between AI self-efficacy and student engagement in a digital language learning environment. They discovered that students with greater AI self-efficacy were more inclined to use language learning applications and actively participate in language activities. Furthermore, Xu and Wang (2024) investigated effectiveness of

artificial intelligence on English language learning achievement. They discovered that emotional experiences when interacting with AI tools might either increase or decrease AI self-efficacy. AI aids in cognitive control by assisting learners in managing the cognitive load related to language acquisition. Garnefski (2020) examined the efficacy of AI language learning platforms in alleviating cognitive load by deconstructing complex language problems into smaller, manageable components and offering contextual cues as necessary. These platforms used machine learning algorithms to modify the difficulty level according to the learner's progress, so mitigating cognitive overload and enhancing learning results. This method enables learners to concentrate on the learning process without succumbing to frustration, which may adversely affect their emotional control. Xiao (2024) demonstrated that in AI integrated language learning the state of self-esteem and cognitive-emotion regulation are closely related to their academic enjoyment and language success.

In this regard, Karataş et al. (2024) investigated the manner in which AI-driven language learning applications customize information according to learners' competence and individual preferences, resulting in a notable enhancement of learners' attitudes towards the language learning process. Yang (2023) examined the function of AI in delivering tailored learning experiences and enhancing intrinsic motivation. The research indicated that students using AI-assisted platforms, which adjusted to their advancement by presenting more challenging assignments at suitable intervals, encountered reduced frustration and heightened delight. These results highlight AI's capacity to improve learners' emotional reactions, transforming their attitudes from negative to positive by reducing stress and anxiety. Furthermore, Zhai (2024) investigated the influence of AI-driven individualized learning systems on the psychological flow of second language learners. Their study indicated that learners using AI-driven platforms tailored to their ability level and learning speed were more inclined to achieve a state of flow. This research concluded that these AI systems facilitated the attainment of flow by delivering consistent, timely feedback and enabling learners to advance through more challenging tasks.

AI technologies, which provide dynamic and individualized teaching methods, have been progressively integrated into higher education language-learning environments in recent years. One important application is Intelligent Tutoring Systems (ITS), which offer adaptive learning experiences by tailoring instructional content and feedback to learners' individual needs. For example, platforms such as Duolingo employ AI algorithms to adjust lesson difficulty based on learners' ongoing performance, ensuring that practice activities target specific strengths and weaknesses. Another widely adopted technology is AI-driven chatbots and virtual assistants, which simulate conversational interactions and facilitate language practice in low-anxiety environments. Applications such as Replika provide real-time interaction, immediate corrective feedback, and opportunities for immersive language use, thereby supporting the development of communicative competence and fluency (Yaseen, 2025). In addition, speech-recognition technologies enhance speaking proficiency by offering instant feedback on pronunciation, accuracy, and fluency. Tools such as Google Speech-to-Text and AI-powered pronunciation applications enable learners to practice oral skills independently, reinforcing classroom instruction while increasing learner confidence.

Furthermore, AI technologies support language learning through affective and motivational mechanisms. Sentiment analysis tools can interpret learners' emotional responses to instructional materials, enabling educators to adapt teaching strategies and provide more responsive support. AI-assisted writing platforms such as Grammarly contribute to the development of written communication by offering grammatical, stylistic, and tone-related feedback, helping learners refine both accuracy and effectiveness in their writing (Faisal & Carabella, 2023). Similarly, AI-enhanced gamified learning systems such as Kahoot! and Quizlet personalize activities and assessments based on user performance and engagement. This adaptive gamification not only increases learner motivation and participation but also makes the learning process more enjoyable and meaningful (Waluyo & Balazon, 2024). Collectively, these applications illustrate the transformative potential of artificial intelligence in foreign language education by promoting learner autonomy, personalized instruction, emotional engagement, and more effective learning experiences than many traditional approaches.

3. Methodology

3.1. Participants

The research included 316 individuals, consisting of 187 females and 129 males, all enrolled in undergraduate and graduate programs at different universities in the provinces of Gilan, Khorasan Razavi, Shiraz, and Tehran. Participants were pursuing degrees in Teaching English as a Foreign Language (TEFL), English Literature, and Translation Studies. Participants included diverse academic standings, including sophomores, juniors, seniors, and master's students, therefore assuring a comprehensive academic spectrum. Furthermore, learners indicated varying degrees of English competence, spanning from intermediate to advanced, as determined by self-assessment and institutional placement examinations. The sample's academic and geographic variety offers a robust basis for analyzing the psychological and attitudinal aspects of AI-assisted EFL learning in various educational and cultural settings.

3.2. Instruments

The Artificial Intelligence Self-Efficacy Scale (AISES) for measuring an individual's perceived self-efficacy in regard to the use of AI technologies/products. This scale was designed by Wang and Chuang (2023) and entails 22 questions in four subscales as following: Assistance (6 items), Anthropomorphic Interaction (5 items), Comfort with AI (5 items), and Technological Skills (6 items). The AISES's reliability as determined by Cronbach's alpha was satisfactory for the present inquiry, with values ranging from 0.782 to 0.841).

The AI Cognitive-emotion Regulation (AICERQ), was utilized to assess the particular cognitive emotion regulation strategies that participants employed when confronted with menacing or distressing life events. To this end, CERQ by Garnefski and Kraaij (2007) with 36 items was revised and the AI environments was added to the items: self-blame, other-blame, rumination, catastrophizing, positive refocusing, positive reappraisal, acceptance, and planning on a five-point Likert scale. In this study, the internal consistencies of each subscale fall within the acceptable range of 0.812 to 0.866.

The AI-assisted second language (L2) learning attitude scale (AL2AS) by Suh and Ahn (2022) was utilized to gauge the attitudes and experiences of students while using AI in learning. AL2AS included 26 items on a five Likert scale in following subcomponents: Cognitive, Affective, and Behavioral. Based on analysis, the internal consistency of this scale was satisfactory (ranged between 0.789 to 0.855).

The AI Psychological Flow Scale (AIPFS) was applied to gauge the thoughts and feelings the students may have experienced while applying AI. In so doing, the Psychological Flow Scale by Norsworthy (2023) was modified. This scale included 9 items in seven-point Likert scale in the following subscales: Absorption (e.g., All my attention was on the task/activity), Effort-less Control (e.g., I felt like I could easily control what I was doing), and Intrinsic Reward (e.g., The experience felt satisfying). The Cronbach’s alpha value for AIPFS yielded an acceptable result (ranging from 0.801 to 0.844)

3.3. Data collection procedure and analysis

Data collection used structured questionnaires to evaluate the four primary constructs: AI self-efficacy, AI cognitive-emotion regulation, AI-assisted L2 learning attitude, and AI psychological flow. Each dimension was assessed using established scales tailored to the context of AI in language learning. To improve accessibility and convenience for respondents, the surveys were administered online. To evaluate the validity and reliability of the instruments, a pilot study was carried out with a smaller group of students before they were distributed. Throughout the whole study procedure, ethical issues were given top priority. All respondents gave their informed permission, and participation was entirely voluntary. To address data privacy, responses were anonymized and stored on secure, encrypted servers to prevent unauthorized access. Furthermore, the questionnaire's design prevented gathering personally identifying information. In terms of algorithmic bias, attention was made to employ validated and impartial assessment tools to limit the potential of biased results, especially for demographic factors like as gender, proficiency level, and cultural background.

Following the data collection, analysis was performed using SEM and CFA with AMOS software. SEM enables the examination of variable correlations while considering measurement error, providing a thorough framework for clarifying the complex relationships in this study. CFA was used to evaluate the factor structure of the measurement model and determine the accurate representation of the constructs. The data was subjected to a series of analyses. Initially, descriptive statistics were first computed to summarize the demographic data and key variables. Consequently, CFA was used to validate the measurement model. Following confirmation, SEM analysis was performed to assess the suggested relationships among the constructs. Fit indicators, such as the Comparative Fit Index (CFI), Root Mean Square Error of Approximation (RMSEA), and Chi-Square/df ratio, were used to assess model fit.

4. Result

This section analyzes and delineates the interrelationships among AI Self-efficacy, AI Cognitive-emotion Regulation, AI-assisted L2 Learning Attitude, and AI Psychological Flow within the context of EFL in AI-integrated language learning.

Table 1.
Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. deviation
Assistance	316	1	7	4.32	1.49
Anthropomorphic Interaction	316	1	7	4.87	1.69
Comfort with AI	316	1	7	5.13	1.62
Technological Skills	316	1	7	5.90	1.57
Self-blame	316	1	5	4.42	0.87
Other-blame	316	1	5	4.79	0.61
Rumination	316	1	5	4.47	0.72
Catastrophizing	316	1	5	3.74	1.00
Putting into Perspective	316	1	5	4.23	0.79
Positive Refocusing	316	1	5	4.11	0.80
Positive Reappraisal	316	1	5	3.96	0.78
Acceptance	316	1	5	4.29	0.68
Planning	316	1	5	4.17	0.71
Cognitive	316	1	5	4.71	0.52
Affective	316	1	5	4.64	0.58

Behavioral	316	1	5	4.43	0.68
Absorption	316	1	7	4.39	1.80
Effort-less Control	316	1	7	4.40	1.67
Intrinsic Reward	316	1	7	4.45	1.65

According to Table 1, the assistance variable yielded a mean score of 4.32 (SD = 1.49), indicating a moderate perception of support among the participants, although responses showed considerable variability. Humanistic interaction recorded a higher mean score of 4.87 (SD = 1.69), suggesting relatively positive perceptions of interactions with AI systems. Similarly, comfort with AI demonstrated a mean score of 5.13 (SD = 1.62), indicating that participants generally felt comfortable engaging with artificial intelligence technologies. Technology abilities received the highest mean score (M = 5.90, SD = 1.57), reflecting participants' strong confidence in their technological competence. Regarding coping strategies, self-blame showed a mean score of 4.42 (SD = 0.87), whereas other-blame was slightly higher (M = 4.79, SD = 0.61). The mean scores for rumination (M = 4.47, SD = 0.72) and catastrophizing (M = 3.74, SD = 1.00) suggest the presence of some maladaptive cognitive patterns, although catastrophizing appeared to be less prevalent among the participants. Positive coping strategies, including perspective-taking (M = 4.23, SD = 0.79) and positive reappraisal (M = 3.96, SD = 0.78), received moderate ratings, indicating occasional use of these adaptive strategies. Likewise, acceptance (M = 4.29, SD = 0.68) and planning (M = 4.17, SD = 0.71) demonstrated comparable levels of engagement, reflecting a balanced utilization of adaptive coping mechanisms.

Further analysis of participants' emotional and behavioral responses revealed mean scores of 4.71 (SD = 0.52) for cognitive responses, 4.64 (SD = 0.58) for affective responses, and 4.43 (SD = 0.68) for behavioral responses. These findings suggest that participants exhibited a diverse range of cognitive, emotional, and behavioral reactions, highlighting the complexity of their experiences when interacting with technology. In addition, task-engagement dimensions demonstrated moderate levels of involvement, including absorption (M = 4.39, SD = 1.80), effortless control (M = 4.40, SD = 1.67), and intrinsic reward (M = 4.45, SD = 1.65). Collectively, these findings provide a comprehensive overview of participants' perceptions of technology, their coping strategies, and their engagement experiences, revealing a combination of adaptive and maladaptive responses across the measured constructs.

Table 2.

The Analysis of Skewness and Kurtosis

	skewness		kurtosis	
	statistic	std. error	statistic	std. error
Assistance	.926	.137	-.288	.273
Anthropomorphic Interaction	.243	.137	-1.395	.273
Comfort with AI	.189	.137	-1.732	.273
Technological Skills	-.832	.137	-.971	.273
Self-Blame	-1.752	.137	3.335	.273
Other-Blame	-1.920	.137	7.875	.273
Rumination	-1.510	.137	3.020	.273
Catastrophizing	-.701	.137	.218	.273
Putting into Perspective	-.873	.137	.592	.273
Positive Refocusing	-.735	.137	.660	.273
Positive Reappraisal	-.661	.137	.817	.273
Acceptance	-.626	.137	.052	.273
Planning	-.468	.137	-.165	.273
Cognitive	-1.743	.137	2.993	.273
Affective	-1.757	.137	4.744	.273
Behavioral	-1.163	.137	1.802	.273
Absorption	.435	.137	-1.123	.273
Effort-Less Control	.600	.137	-.903	.273
Intrinsic Reward	.494	.137	-.797	.273

The examination of skewness and kurtosis for the variables in Table 2 elucidates the distribution features of the data. Skewness denotes the extent of asymmetry in the distribution, while kurtosis signifies the degree of peakedness or flatness in comparison to a normal distribution.

Table 3.

Correlations Overview

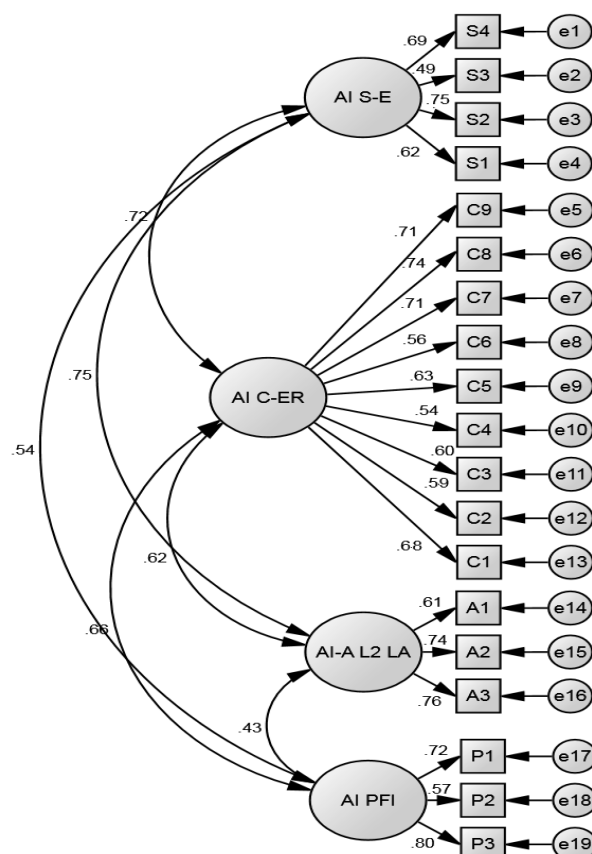
	AI Self- efficacy	AI Cognitive-emotion Regulation	AI-assisted L2 Learning Attitude	AI Psychological Flow
AI Self-efficacy	1.000			
AI Cognitive-emotion Regulation	0.446 **	1.000		
AI-assisted L2 Learning Attitude	0.433 **	0.516 **	1.000	
AI Psychological Flow	0.291 **	0.514 **	0.321 **	1.000

** Correlation is significant at the 0.01 level (2 tailed).

Table 3 presents the correlations among four key constructs: AI Self-efficacy, AI Cognitive-Emotion Regulation, AI-Assisted L2 Learning Attitude, and AI Psychological Flow. These constructs collectively contribute to understanding how learners interact with artificial intelligence in language-learning contexts. The results indicate that AI Self-efficacy was positively and significantly associated with AI Cognitive-Emotion Regulation ($r = 0.446$, $p < 0.01$), suggesting that learners who are more confident in their ability to use AI technologies effectively are more likely to employ adaptive cognitive and emotional regulation strategies during AI-mediated learning activities. Likewise, AI Self-efficacy showed a significant positive correlation with AI-Assisted L2 Learning Attitude ($r = 0.433$, $p < 0.01$), indicating that greater confidence in using AI is associated with more favorable perceptions of AI-assisted language learning. Furthermore, AI Cognitive-Emotion Regulation was positively correlated with AI-Assisted L2 Learning Attitude ($r = 0.516$, $p < 0.01$). This finding suggests that learners who effectively manage their thoughts and emotions while interacting with AI technologies tend to demonstrate more positive attitudes toward the integration of AI in second-language learning.

The findings also reveal meaningful relationships involving AI Psychological Flow. AI Self-efficacy was positively associated with AI Psychological Flow ($r = 0.291$, $p < 0.01$), indicating that learners with higher levels of confidence in using AI are more likely to experience a state of flow characterized by deep concentration, engagement, and immersion during AI-supported learning activities. Similarly, AI Cognitive-Emotion Regulation demonstrated a strong positive correlation with AI Psychological Flow ($r = 0.514$, $p < 0.01$), highlighting the important role of cognitive and emotional regulation in facilitating optimal learning experiences. Learners who can effectively regulate their emotions and cognitive processes appear more likely to achieve a flow state while interacting with AI technologies. Finally, AI-Assisted L2 Learning Attitude was positively correlated with AI Psychological Flow ($r = 0.321$, $p < 0.01$), suggesting that favorable attitudes toward AI-assisted language learning contribute to greater engagement and immersion in learning tasks. Collectively, these findings indicate that self-efficacy, cognitive-emotional regulation, and positive attitudes toward AI are closely interconnected and play important roles in enhancing learners' psychological engagement and experiences in AI-supported language-learning environments.

The following figure displays the outcomes of a structural equation modeling analysis, emphasizing the interrelations among several latent constructs: AI Self-efficacy (AI S-E), AI Cognitive-emotion Regulation (AI C-ER), AI-assisted L2 Learning Attitude (AI-A L2 LA), and AI Psychological Flow (AI PF).

Figure 1.*The Results of the CFA*

Based on Figure 1, the indicators of AI Self-efficacy (S1, S2, S3, and S4) demonstrate strong positive associations with the latent construct. The estimates for S1 (0.624) and S2 (0.751) were statistically significant at the 0.01 level, with critical ratios of 2.617 and 2.550, respectively, indicating that both indicators contribute meaningfully to the measurement of AI Self-efficacy. Among these indicators, S3 exhibited a substantial standardized estimate (0.495) and an exceptionally high critical ratio ($CR = 6.734$, $p < 0.001$), highlighting its particularly strong contribution to the construct. Although S4 did not report a standard error or significance value because it served as a reference indicator in the measurement model, its inclusion remains essential for defining the latent variable. Similarly, the indicators of AI Cognitive-Emotion Regulation (C1–C9) demonstrated consistently strong factor loadings and statistically significant relationships with the construct. The estimates ranged from 0.540 to 0.742, and all corresponding critical ratios indicated highly significant contributions ($p < 0.001$). Notably, C7 yielded the highest critical ratio ($CR = 11.225$), suggesting that it was one of the strongest indicators of cognitive-emotional regulation. Overall, these results underscore the central role of cognitive-emotional regulation processes in learners' interactions with AI technologies.

The indicators associated with AI-Assisted L2 Learning Attitude also demonstrated strong relationships with the underlying construct. Specifically, A2 (0.740) and A3 (0.759) showed statistically significant factor loadings ($p < 0.001$), with critical ratios of 9.333 and 9.428, respectively, indicating that these items substantially contributed to learners' attitudes toward AI-assisted language learning. Although A1 (0.613) did not include a reported standard error or significance value due to its role as a reference indicator, its loading nevertheless suggests a meaningful contribution to the construct. Likewise, the indicators of AI Psychological Flow (P1, P2, and P3) exhibited strong associations with the latent variable. P1 demonstrated a substantial loading of 0.720, while P2 and P3 showed estimates of 0.570 and 0.796, respectively, accompanied by high critical ratios ($CR = 8.888$ and $CR = 10.661$, $p < 0.001$). These findings indicate that all four latent constructs were adequately represented by their respective indicators. In particular, the strong contributions of AI Cognitive-Emotion Regulation and AI Self-efficacy suggest that these factors play a pivotal role in fostering positive attitudes toward AI-assisted language learning and enhancing learners' psychological flow. Collectively, the results provide robust support for the importance of these constructs in facilitating the effective integration of artificial intelligence into language-learning environments.

Table 4.
Model Fit Summery

CMIN	DF	CMIN/DF	TLI	CFI	RMSEA	GFI	AGFI	PGFI	GFI
384.19	146	2.631	.940	.978	.098	.909	.951	.922	.909
CMIN/DF ≤ 3, RMSEA≤ 0.09, TLI, CFI, GFI, AGFI, PGFI, GFI ≥ 0.9									

Table 4 offers an evaluation of the structural equation model's performance through various fit indices. Each index provides an evaluation of the alignment between the proposed model and the observed data. The CMIN (Chi-Square) value is 384.19, with 146 degrees of freedom (DF), yielding a CMIN/DF ratio of 2.631. This ratio is below the recommended threshold of 3, indicating an acceptable fit between the model and the data. A lower CMIN/DF ratio suggests that the model adequately accounts for the variance in the data. The Tucker-Lewis Index (TLI) and CFI exhibit robust values of 0.940 and 0.978, respectively. The indices span from 0 to 1, with elevated values signifying a superior fit. Both indices surpass the benchmark of 0.90, thereby confirming the model's effectiveness in elucidating the relationships among the constructs. RMSEA is reported at 0.098, marginally exceeding the optimal threshold of 0.09. This indicates a moderate level of fit, suggesting potential for model improvement. A lower RMSEA value is preferred, indicating a superior fit of the model to the data. Furthermore, the Goodness of Fit Index (GFI) and Adjusted Goodness of Fit Index (AGFI) are recorded at 0.909 and 0.951, respectively. Both values exceed the 0.90 threshold, indicating a favorable fit. The Parsimony Goodness of Fit Index (PGFI) is significant at 0.922, suggesting that the model maintains goodness of fit while considering model complexity.

Figure 2.
SEM Model

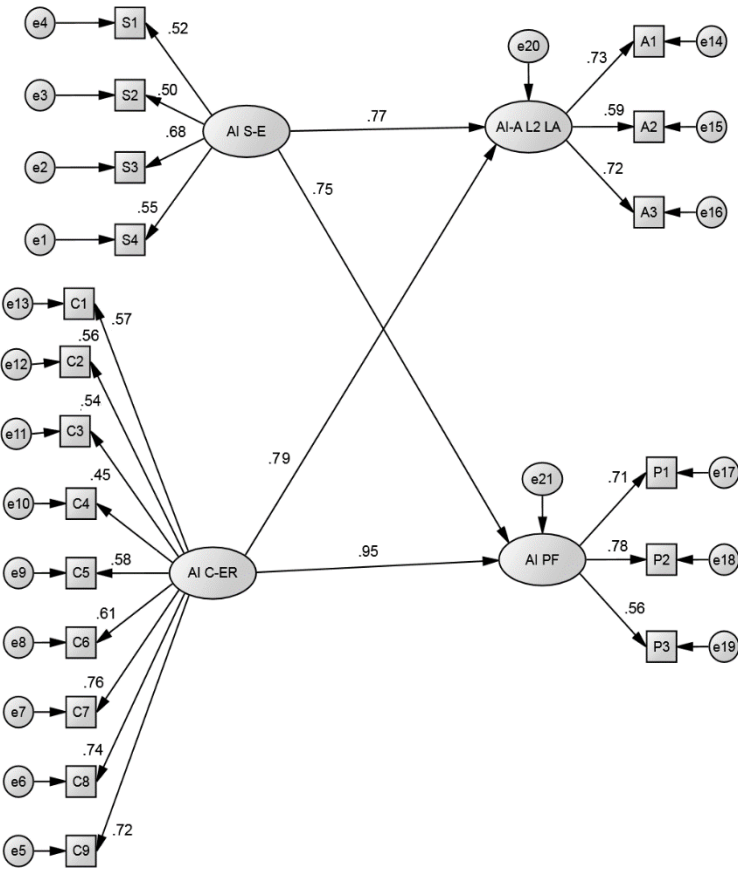


Table 5.
The Results of Path Analysis Between the Main Variables

			Estimate	S.E.	C.R.	P	RESULT
AI S-E	--->	AI-A L2 LA	.77	.076	4.612	***	Accept
AI C-ER	--->	AI-A L2 LA	.79	.043	5.800	***	Accept
AI S-E	--->	AI PF	.75	.114	2.129	***	Accept
AI C-ER	--->	AI PF	.95	.107	7.378	***	Accept

Figure 2 and Table 5 present the results of the path analysis examining the relationships among AI Self-efficacy (AI S-E), AI Cognitive-Emotion Regulation (AI C-ER), AI-Assisted L2 Learning Attitude (AI-A L2 LA), and AI Psychological Flow (AI PF). The analysis includes standardized path estimates, standard errors (S.E.), critical ratios (C.R.), significance levels (p values), and the outcomes of hypothesis testing. The results indicate that AI Self-efficacy had a significant positive effect on AI-Assisted L2 Learning Attitude ($\beta = 0.77$, S.E. = 0.076, C.R. = 4.612, $p < 0.001$). This finding suggests that learners who possess greater confidence in their ability to use AI technologies tend to exhibit more favorable attitudes toward AI-assisted language learning. Therefore, the corresponding hypothesis was supported. Similarly, AI Cognitive-Emotion Regulation exerted a significant positive influence on AI-Assisted L2 Learning Attitude ($\beta = 0.79$, S.E. = 0.043, C.R. = 5.800, $p < 0.001$). This result indicates that learners who effectively regulate their cognitive and emotional responses during AI-mediated learning experiences are more likely to develop positive attitudes toward AI-assisted language learning. Accordingly, this hypothesis was also supported.

The results further demonstrate significant relationships between the predictor variables and AI Psychological Flow. AI Self-efficacy showed a positive and statistically significant effect on AI Psychological Flow ($\beta = 0.75$, S.E. = 0.114, C.R. = 2.129, $p < 0.001$), suggesting that learners with higher levels of AI-related confidence are more likely to experience a state of psychological flow characterized by deep concentration, engagement, and immersion during AI-supported learning activities. In addition, AI Cognitive-Emotion Regulation emerged as a particularly strong predictor of AI Psychological Flow ($\beta = 0.95$, S.E. = 0.107, C.R. = 7.378, $p < 0.001$). This finding highlights the critical role of effectively managing cognitive and emotional processes in facilitating optimal learning experiences and sustained engagement with AI technologies. Collectively, these results provide strong empirical support for all proposed hypotheses and underscore the importance of self-efficacy and cognitive-emotional regulation in shaping learners' attitudes toward AI-assisted language learning and their psychological engagement in AI-mediated educational environments.

Table 6.

The Results of Path Analysis Between the Subscales

			Estimate	S.E.	C.R.	P	RESULT
AI S-E	--->	S1	.52	.161	4.922	***	Accept
AI S-E	--->	S2	.50	.117	2.060	.039	Accept
AI S-E	--->	S3	.68	.105	2.638	.008	Accept
AI S-E	--->	S4	.55				Accept
AI C-ER	--->	C1	.57	.100	7.447	***	Accept
AI C-ER	--->	C2	.56	.079	12.571	***	Accept
AI C-ER	--->	C3	.54	.091	11.954	***	Accept
AI C-ER	--->	C4	.45	.092	9.550	0.031	Accept
AI C-ER	--->	C5	.58	.091	10.101	***	Accept
AI C-ER	--->	C6	.61	.116	8.952	***	Accept
AI C-ER	--->	C7	.76	.084	9.508	***	Accept
AI C-ER	--->	C8	.74	.071	6.087	***	Accept
AI C-ER	--->	C9	.72				Accept
AI-A L2 LA	--->	A1	.73	.101	7.552	***	Accept
AI-A L2 LA	--->	A2	.59	.160	8.421	***	Accept
AI-A L2 LA	--->	A3	.72				Accept
AI PF	--->	P1	.71	.191	8.435	***	Accept
AI PF	--->	P2	.78	.083	8.543	***	Accept
AI PF	--->	P3	.56				Accept

Table 6 provides an in-depth examination of the interrelations among main AI constructs—AI S-E, AI C-ER, AI-A L2 LA, and AI PF—alongside their corresponding subscales. The results demonstrate substantial positive correlations across all examined variables, indicating that these dimensions are interrelated and crucial in affecting diverse educational outcomes. For example, AI S-E demonstrates a robust correlation with S3 (estimate of 0.68, C.R. of 2.638, $p = 0.008$), as well as significant associations with S1 (0.52, $p < 0.001$) and S2 (0.50, $p = 0.039$), underscoring the critical role of self-efficacy in improving performance. AI C-ER has strong associations, especially with C7 (0.76, $p < 0.001$) and C8 (0.74, $p < 0.001$), indicating that proficient cognitive-emotional regulation substantially enhances favorable emotional and cognitive results. The AI-A L2 LA construct has significant correlations, particularly with A1 (0.73, $p < 0.001$) and A2 (0.59, $p < 0.001$), suggesting that a positive disposition towards AI in language acquisition is essential for achievement. Finally, AI PF demonstrates substantial correlations with P1 (0.71, $p < 0.001$) and P2 (0.78, $p < 0.001$), underscoring the importance of psychological flow in augmenting engagement and performance. These results indicate that promoting self-efficacy, cognitive-emotional control, favorable attitudes towards AI, and psychological flow may substantially improve educational experiences and outcomes.

5. Discussion

This study underlines the crucial roles of AI self-efficacy and AI cognitive-emotion regulation in improving AI-assisted L2 learning attitudes and psychological flow in the Iranian EFL environment. The major objective was to investigate AI cognitive-emotion regulation as a significant determinant affecting learners' views about AI-assisted language learning. Cognitive-emotion regulation pertains to learners' capacity to control and adjust their emotional reactions to AI tools—a crucial skill for sustaining motivation and cultivating good attitudes in the face of adversity. In technology-enhanced learning environments, learners frequently encounter challenges such as acclimating to new AI systems or contending with the inherent limits of these tools. Thus, learners' emotional control profoundly influences their perception of AI technology as either advantageous or disheartening and disengaging. The results indicate that students with enhanced emotional control abilities are more inclined to maintain positive views regarding AI-assisted learning. This aligns with Gross's Emotion Regulation Theory (2002), which asserts that learners use adaptive ways to manage their emotions during stress or failure sustain more motivation and engagement. Hoang (2025) underscores the influence of emotional regulation on learners' views of AI, promoting AI functionalities that assist in mitigating frustration and adverse emotions. Xiao (2024) also affirm that learners who experience more control over their emotional responses are inclined to embrace and evaluate instructional technology favorably. These observations highlight the essential function of cognitive-emotional control in influencing learners' perceptions of AI-assisted language learning, especially in environments characterized by anxiety or fear of failure.

Moreover, the collectivist cultural norms characteristic of Iranian society uniquely influences AI self-efficacy and emotional regulation. In collectivist settings, learners often prioritize social harmony and approval, which can affect their confidence in independently using AI tools. Iranian EFL learners may rely more heavily on peer or instructor validation when engaging with AI, which in turn influences their self-efficacy beliefs differently than learners from individualistic cultures. This cultural orientation may also affect emotional regulation strategies, as learners might suppress overt expressions of frustration to maintain social cohesion, thereby shaping their engagement with AI-mediated learning in culturally specific ways.

The research illustrates a robust correlation between AI cognitive-emotional management and psychological flow. Csikszentmihalyi's Flow Theory (1990) posits that flow is attained when learners encounter an ideal equilibrium between challenge and competence, promoting profound attention and intrinsic satisfaction. Individuals proficient in emotional regulation are more capable of navigating the hurdles presented by AI-driven language activities without succumbing to stress or adverse emotions. This emotional modulation enhances the persistent concentration necessary for flow, promoting ongoing engagement and motivation despite obstacles (Namaziandost, 2023). These findings correspond with Çelik and Aşık (2023), who discovered that adept emotional management enhances the probability of attaining flow in language acquisition. Likewise, Heydarnejad (2024) and Halkiopoulos and Gkintoni (2024) present more evidence that AI-assisted emotional regulation improves student focus and fosters good educational experiences.

However, it is important to consider that restricted internet access—common in many Iranian educational contexts—may pose a significant barrier to attaining psychological flow. Unstable or limited connectivity can disrupt the seamless interaction necessary for flow, leading to frustration and attention lapses. This highlights the necessity of designing AI tools that accommodate such infrastructural limitations, for example through offline functionality or adaptive data use, to support uninterrupted learner engagement. Additionally, traditional Iranian pedagogical practices, which tend to be teacher-centered and grounded in grammar-translation methods, may shape learners' initial attitudes toward AI-assisted learning. Iranian students accustomed to authoritative and structured instruction might exhibit skepticism toward AI conversational tools, perceiving them as less credible or effective than human teachers. Conversely, AI applications that complement established practices, such as grammar-checkers, may be more readily accepted. These pedagogical factors are likely to influence learners' self-efficacy and attitudes toward different AI tools, emphasizing the importance of culturally responsive AI designs.

The outcomes of this study illuminate the ways in which AI cognitive-emotion regulation and AI self-efficacy can improve attitudes toward AI tools and facilitate psychological flow, thereby contributing to a more engaging and effective language learning experience, within the specific context of Iranian EFL learners. In traditional classrooms, Iranian EFL learners frequently encounter a variety of challenges, such as inadequate exposure to native speakers, overcrowded classes, and inadequate individual attention (Namaziandost, 2025). In this context, AI tools offer a chance to confront these obstacles by providing personalized learning experiences that can enhance motivation and promote learner autonomy. Additionally, AI tools may aid in the maintenance of positive attitudes and a state of fluidity by assisting learners in regulating their emotions. This emphasizes the significance of AI tools that are culturally pertinent and that consider the unique emotional and pedagogical requirements of Iranian EFL learners.

6. Conclusion

The current research investigated the links between AI self-efficacy, AI cognitive-emotion regulation, AI-assisted L2 learning attitude, and AI psychological flow in the setting of Iranian EFL students. The results demonstrated that AI cognitive-emotion regulation had an important role in changing learners' attitudes toward AI tools and supporting the achievement of psychological flow, which is defined as deep engagement and immersion in the learning process. It indicates that cognitive and emotional aspects play important roles in shaping learners' interactions with AI systems in language learning. EFL teachers may build more effective and interesting learning environments by developing better levels of self-efficacy and boosting emotion management, allowing students to not only improve their language proficiency but also enjoy the learning process. The findings contribute to

the literature on AI in language learning by illustrating the intricate relationships between self-efficacy, cognitive-emotion regulation, attitudes, and flow. Although earlier research has addressed these characteristics individually, this study takes a more holistic approach, stressing how these psychological dimensions impact the entire learning experience in AI-enhanced language learning environments. The findings contribute to a more profound comprehension of the ways in which AI can influence the motivation, engagement, and ultimately, the language learning outcomes of learners by demonstrating the significance of these psychological factors.

To enhance self-efficacy in learners, instructors must provide opportunities for students to develop their confidence in using AI-based learning technology. Practical approaches may include providing guided tutorials, encouraging experiential learning, and ensuring early exposure to AI technology in the language development process. Teachers may increase students' self-efficacy and, therefore, their motivation and engagement with AI applications by organizing the learning process and allowing them to experiment with them in a stress-free environment. Moreover, the results underscore the significance of AI cognitive-emotion control in enhancing learners' interactions with AI tools. Consequently, it is important for instructors to assist students in navigating the spectrum of emotions they may encounter when using AI technologies, particularly adverse emotions like irritation or worry. Teachers may integrate emotion regulation tools, including cognitive reappraisal, mindfulness, and stress management techniques, into the curriculum to provide EFL learners with the necessary abilities to handle difficult emotions. These strategies will assist learners in surmounting possible obstacles and sustaining motivation, resulting in more efficient use of AI technologies and improved educational results. The research underscores the importance of fostering favorable views towards AI-assisted language learning. To cultivate favorable attitudes, instructors have to emphasize the advantages of AI technologies, demonstrating their capacity to personalize learning and provide customized feedback that caters to learners' specific requirements.

Motivating learners to see AI as a beneficial educational ally may foster ongoing engagement with these technologies. Conversely, adverse sentiments about AI tools may lead to hesitance in using these resources, impeding learning advancement. Consequently, it is essential for educators to provide explicit elucidations of how AI technologies facilitate language acquisition and to present tangible instances of their efficacy. Ultimately, psychological flow has surfaced as a vital element in engaging learners in AI-assisted language acquisition. Flow, defined as complete absorption and delight in a learning activity, has been shown to significantly enhance both motivation and effective learning. Teachers should create AI-enhanced learning activities that correspond with students' interests and skill levels. Tasks that are suitably hard, but attainable, cultivate a feeling of achievement and flow. By providing learners with a mix of challenge and competence, educators may guarantee that students stay thoroughly engaged with the educational content, hence improving their learning results.

The study's results indicate many viable approaches for the implementation of AI-enhanced language learning that include both cognitive and emotional aspects. Initially, instructors may implement confidence-enhancing activities by providing systematic advice and practical encounters using AI technologies. Such instruction should be structured to facilitate learners' progressive acclimatization to the technologies, therefore alleviating feelings of uneasiness or uncertainty. Furthermore, offering students early chances for success helps reinforce their confidence in using AI technologies proficiently. Teachers may include targeted tactics into the curriculum to enhance emotional control. Instructing students on managing irritation and stress while encountering obstacles using AI technologies helps alleviate anxiety. Cognitive reappraisal, which involves reframing negative beliefs, and mindfulness techniques, which emphasize present-moment awareness, may be especially beneficial. These methods facilitate learner concentration and reduce the probability of discouragement, hence sustaining positive involvement with the educational process.

A further pragmatic approach is the incremental integration of AI technologies. Teachers should start with fundamental resources rather than inundating students with intricate technology, gradually integrating more advanced AI systems as students gain proficiency. This systematic method guarantees that trainees remain unencumbered and may concentrate on acquiring fundamental abilities prior to advancing to more complex functionalities. Moreover, instructors have to provide tailored learning experiences that address the specific requirements of individual learners. AI technologies that adjust to learners' capabilities and preferences might provide more immersive experiences that promote psychological flow. Customized feedback, individualized activities, and adaptive learning functionalities may empower learners to take charge of their advancement, hence enhancing their motivation and involvement in the process. Ultimately, ongoing feedback mechanisms are crucial for sustaining learner engagement and enhancing self-efficacy. AI-driven educational systems must provide instantaneous feedback, enabling learners to monitor their progress and implement necessary modifications. This continuous feedback assists learners in remaining focused and assures them that their efforts are acknowledged, therefore bolstering their confidence and motivation.

This research offers significant insights into the interplay of AI self-efficacy, AI cognitive-emotional regulation, AI-assisted L2 learning attitudes, and AI psychological flow; nevertheless, some limitations need to be recognized. These constraints may guide future research directions to enhance our understanding of the variables affecting AI-assisted language development. The primary limitation of this research is the sample size. To mitigate this constraint, further research may include cross-cultural studies by enlisting participants from many nations and educational backgrounds. This would assist in ascertaining if psychological factors affecting AI-enhanced language development are universal or whether cultural characteristics influence learners' interactions with AI tools. A further weakness of this research is its cross-sectional design. This approach measures the connections between variables at a particular moment in time, capturing correlations between constructs without demonstrating causation or studying the evolution of these interactions across time. Future study might use a longitudinal approach to examine changes in AI self-efficacy, emotional control, attitudes, and psychological flow over an extended duration.

Moreover, the reliance on self-reported data may have introduced certain biases, including social desirability effects, which could have led participants to overreport favorable behaviors or attitudes toward AI technologies. Future studies should incorporate strategies to detect and minimize such biases, including the use of validated control measures or the triangulation of self-reported responses with alternative data sources. In addition, this study was conducted within the unique socio-political context of Iran, where restrictions on internet access and variations in digital infrastructure may influence learners' access to, use of, and perceptions of AI technologies. These contextual factors may affect both the adoption and effectiveness of AI-supported learning tools. Consequently, future research should examine the influence of these contextual constraints more explicitly and conduct cross-cultural comparisons to evaluate the generalizability of the present findings across different educational and technological environments.

Furthermore, the study primarily relied on questionnaire-based measures to assess constructs such as AI self-efficacy, cognitive-emotional regulation, and attitudes toward AI-assisted learning. Future research could adopt mixed-methods designs to provide a more comprehensive understanding of learners' interactions with AI technologies. Qualitative interviews, classroom observations, think-aloud protocols, and analyses of usage logs generated by AI-based platforms may offer deeper insights into learners' actual experiences, behaviors, and psychological states during AI-enhanced language learning. Additionally, the present study did not account for several potentially influential contextual variables, including access to technology, socioeconomic status, digital literacy, and disparities in educational infrastructure. These factors may significantly shape the relationship between psychological characteristics and AI-assisted learning outcomes. Future investigations should therefore explore the roles of resource availability, technological competence, and broader socioeconomic conditions in influencing learners' engagement with AI technologies. A better understanding of these contextual dimensions is essential for identifying barriers to equitable AI adoption and for informing policies and practices that promote inclusive, accessible, and effective technology-enhanced learning opportunities for diverse learner populations.

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