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Enhancing students' self-directed learning through emotion recognition systems and intelligent collaboration platforms: Evidence from AI-enabled primary schools in Chengdu, China

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ABSTRACT

The relationships among students' perceived Emotion Recognition Systems (ERS), Intelligent Collaboration Platforms (ICP) and Self-Directed Learning Ability (SLA) were explored in six private primary schools in Chengdu, China. A questionnaire survey was carried out, and 402 Grade 4 - 6 students were surveyed cross-sectionally. Descriptive statistics, reliability analysis, Pearson correlations, regression analyses and bootstrapped mediation analysis were performed. ERS and ICP were positively associated with SLA ((**β** = .754) and (**β** = .812), respectively, (p < .001)). ICP was also positively associated with ERS (**β** = .680, p < .001). In the joint regression model, ERS (**β** = .375, p < .001) and ICP (**β** = .557, p < .001) remained positively associated with SLA, explaining 73.5% of its variance (R^2 = .735). The bootstrapped indirect association of ICP with SLA through ERS was significant (ab = .144, Boot SE = .026, 95% CI [.095, .196]). The results indicate that the positive attitudes of students toward CLD are correlated with their SLL. The results must be considered as associations and not as causal effects due to the cross-sectional design of the study. Longitudinal and experimental studies are needed in the future that will look at the temporal relationship, quality of implementation, and data and privacy protection for children.

Keywords: AI in education, emotion recognition systems, intelligent collaboration platforms, primary education, self-directed learning, self-regulated learning.

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INTRODUCTION

Artificial Intelligence (AI) is transforming the educational landscape with adaptive learning, personalisation, and data-driven approaches. It can be used for intelligent tutoring systems, learning analytics, adaptive assessment, emotion recognition systems, and intelligent collaboration platforms. These technologies can be used to complement effective pedagogy and promote not only academic performance and participation but also more complex skills such as reflection, relationships, creativity and pupils' self-directed learning. Evidence from primary schools in China has shown that there is a correlation between self-regulated learning and interactive learning in the development of primary school students' digital literacy (Rattanapun et al., 2026). But the educational potential of AI is not just about technology adoption. It involves how cognitive, affective and social support is provided using AI tools during the learning process (Broadbent and Lodge, 2021; Howard et al., 2021).

The criteria chosen as the dependent measure in this study is Self-Directed Learning Ability (SLA). SLA is the ability of students to be responsible for their own learning process in identifying learning needs, formulating learning objectives, finding and utilising appropriate tools, resources and strategies, monitoring learning progress, seeking assistance when needed, and appraising learning results. Self-regulated learning (SRL), independent learning and learner autonomy are related to SLA but are conceptually different. Self-directed learning is about a person's greater ability to plan, initiate, manage, and evaluate his or her learning, including the choices of learning goals and learning resources. In contrast, SRL is the cyclical cognitive, motivational, behavioral and affective processes that learners engage in when planning, monitoring, controlling and reflecting on their learning in a specific task and context (Panadero, 2017; Zimmerman, 2000). Independent learning and learner autonomy are more general concepts and are not considered to be distinct from each other in the present investigation.

The SRL theory is not an alternative to SLA but is adopted as a process-oriented explanation to the development of SLA. These can be stated as follows: In this view, the overall ability of learning is what this study is trying to explain, and the processes through which students develop that ability is what SRL explains. This involves goal setting, strategy use, self-monitoring, emotional control, help seeking, and reflection. This distinction becomes even more relevant in primary education, where the cognitive, emotional, and social skills that allow students to manage their learning in a more independent and autonomous manner are still evolving, which makes it vital to incorporate AI into these learning processes.

One type of affective support in the form of artificial intelligence is Emotion Recognition Systems (ERS). Based on the concept of affective computing, ERS can detect signs of learners' emotions through facial expressions, voice tone, interaction, behavior or other means. With proper use and careful reading, these systems can inform teachers and learners with timely information about potential frustration, disengagement, confusion and interest. This information can be used for emotional awareness and for allowing appropriate instructional or self-regulatory responses. In terms of SRL, ERS can help learners monitor their affective states that affect their attention, persistence, motivation and strategy selection. However, the general impression of automatic improvement of SLA through ERS is incorrect, as the value required for education lies in the accuracy of the system, pedagogical responses that are appropriate to the system, and taking into account the ethical safeguards of student data and privacy.

Intelligent Collaboration Platforms (ICP) are an alternative AI-backed learning tool which combines shared workspaces, digital communication, learning resources, peer feedback and real-time interaction. They can facilitate enquiry togetherness, co-construction of knowledge, help-seeking, and reflection. An SRL perspective might support individual planning and monitoring of SRL activities by ICP. Also, socially, from a social-regulation perspective, ICP can enable co-regulation and socially shared regulation in which teacher and peers collaborate in planning, monitoring, and evaluating learning. These social processes are particularly important for pupils in Primary school during the early stages of their development of self-direction, which is often structured by teacher and peer interactions, but not by independent learning in most cases.

While there is much research in the field of AI in education, theoretical and empirical questions are still not answered. Recent studies focused on self-regulated learning and interactive learning in primary education in China have shown that these two factors are related to the development of digital literacy, but they have not explored AI-mediated collaboration, emotion recognition systems or SLA as an outcome (Rattanapun et al., 2026). First, previous studies have focused on ERS and ICP either individually or independently, leaving insufficient knowledge about the interaction of affective and collaborative AI supports for SLA. Secondly, previous studies have focused more on immediate outcomes (such as academic achievement, engagement, technology acceptance, and collaborative performance) than on SLA as a more comprehensive learner ability. Third, the connection between collaborative AI environments, emotion-aware support and SLA is not sufficiently explained. However, little research has focused on how ICP might provide social and collaborative environments conducive to meaningful AMR of ERS and as a mediator of SLA-ICP ties, respectively.

The present study contributes to the literature in three ways. It first identifies SLA as a developmental outcome and SRL as a process-based perspective that theoretically explains the development of SLA. Second, by combining ICP with ERS, it views these technologies as complementary tools and not as mutually exclusive ones. Third, it looks at this integrated model in private primary schools, in which students are learning the basic skills of self-directed learning. The study does not measure students' emotional regulation or socially shared regulation as separate variables. Instead, it investigates the relationship between ICP and ERS with SLA as well as the possible statistical mediation between ICP and ERS.

In China, educational digitalisation has been identified as a national strategic priority, and private primary schools in Chengdu are seeing a growing number of smart classrooms and intelligent collaboration platforms together with emotion-related AI technologies to facilitate innovative teaching and learning. These schools offer a meaningful context in which to explore AI-assisted learning in a real primary-school setting. They are also relatively flexible in using new educational technologies, which gives an opportunity to study how to use AI to assist the development of SLA in young people. However, this study's contribution is not limited to a geographical/population gap, as it focuses on the less well-studied relationship among AI-supported collaboration, emotion-aware support, and SLA.

Based on this, the mediation model of Intelligent Collaboration Platforms, Emotion Recognition Systems, and students' Self-Directed Learning Ability in private primary schools of Chengdu, China, is developed and tested in this study. It investigates the direct relationships between ICP and SLA as well as ERS and ICP and SLA.

The study builds on SRL theory, with the incorporation of Self-Determination Theory, Social Cognitive Theory, and the Community of Inquiry (COI) framework, to describe the potential impact of AI-enabled social interaction, affective feedback, perceived competence, learner monitoring, and reflection on SLA. The results will help advance research on responsible use of AI in learning and support the design of effective, ethical, and developmentally appropriate learning spaces by educators, school leaders, technology developers and policymakers.

Research objectives

1. To examine the effect of the Emotion Recognition System (ERS) on students' self-directed learning ability (SLA) in private primary schools in Chengdu, China.
2. To investigate the effect of the Intelligent Collaboration Platform (ICP) on students' self-directed learning ability in private primary schools in Chengdu, China.
3. To examine the association between intelligent collaboration platforms and emotion recognition systems.
4. To examine the mediating role of the Emotion Recognition System in the relationship between the Intelligent Collaboration Platform and students' self-directed learning ability.

LITERATURE REVIEW

AI has revolutionized the educational landscape by providing adaptable teaching, intelligent feedback and tailored learning experiences. But the educational benefits of AI are not solely dependent on the technological capacity; they also rely on how AI-supported learning environments are conducive to the learners' cognitive, emotional and social development. Therefore, this study is based on the three theories of Self-Determination Theory (SDT), Social Cognitive Theory (SCT) and the Community of Inquiry (CoI) framework to reveal how Emotion Recognition Systems (ERS) and Intelligent Collaboration Platforms (ICP) can positively impact students' Self-Directed Learning Ability (SLA). AI-integrated learning spaces foster autonomy, competence, and relatedness, enhancing intrinsic motivation and self-directed learning, as SDT proposes. SCT also underscores that through continuous emotional feedback, learners' awareness, self-efficacy and self-regulation are improved; the CoI Framework also clarifies the ways in which collaborative digital environments can support meaningful learning that occurs through cognitive, social, and teaching presence. This study suggests that ICP can directly foster students' self-directed learning, and that the effectiveness of ERS can also be enhanced, thereby promoting the ability of the learners to regulate their emotions and learn independently. The hypotheses and theoretical model for this study are developed within this integrated theoretical framework.

Emotion recognition system and self-directed learning ability

Emotion Recognition Systems (ERS) are systems that use artificial intelligence (AI) to recognize the emotional state of the learner, based on the analysis of multimodal information such as facial expressions, speech, eye movements, physiological information, and learning behavior. In recent years, technological developments in the field of affective computing have allowed such systems to deliver real-time emotional feedback, facilitating adaptive teaching, personalized learning, and pedagogical interventions at the appropriate time (Vistorte et al., 2024). ERS isn't just about identifying emotions; it's about establishing emotionally responsive learning environments that empower learners to manage their emotions, stay motivated, and remain engaged in the learning process. While identifying emotions is important, ERS is more about creating environments where learners can manage their emotions, stay motivated, and remain engaged in the learning process (Salloum et al., 2025).

Self-Determination Theory (SDT) states that if the emotional feedback from learning activities is personalized to improve learners' perception of autonomy and competence, then their intrinsic motivation and self-directed learning will be strengthened (Ryan and Deci, 2020). Similarly, Social Cognitive Theory (SCT) suggests that the feedback process would increase the self-efficacy, self-monitoring, and self-regulation of the learners, which would aid them in recognizing their emotional challenges, modifying their learning approach and regulating their learning activities more effectively (Bandura, 1986, 1997). More recent works in the field of multimodal learning analytics also show that the evidence of emotional and behavioural data can be used to better understand SRL processes and to develop adaptive learning contexts (Azevedo and Gašević, 2019; Järvelä et al., 2021).

Research shows that AI tools for emotion recognition can enhance learner engagement, motivation, adaptive learning, and instructional responsiveness in the context of technology-enhanced learning environments (TELs) (Salloum et al., 2025; Vistorte et al., 2024). Nevertheless, the emotion detection accuracy, learner engagement or short-term academic achievement have been the main areas of the previous studies, and less attention has been paid to how emotion recognition contributes to the self-directed learning ability of students in the long term, especially in primary education environments (Broadbent and Lodge, 2021; Howard et al., 2021).

From this theoretical and empirical view, it is expected that Emotion Recognition Systems will increase the emotional awareness, adaptive regulation and self-monitoring of students while learning activities are carried out, so that it can facilitate students' self-directed learning ability.

H1. ERS will be positively associated with SLA.

Intelligent collaboration platform and students' self-directed learning ability

Intelligent Collaboration Platforms (ICP) combine AI and digital communication, collaborative workspaces, real-time interaction, and adaptive learning support to enable collaborative construction of knowledge and engagement of learners. Unlike traditional learning management systems, ICP encourage inquiry learning, interaction between students, and ongoing feedback, allowing students to engage in planning, monitoring and evaluation of learning processes (Janssen et al., 2021; Stahl et al., 2014). Additionally, recent research indicates that collaborative learning with AI support positively influences self-regulation, metacognition, and independent learning processes for students, as AI systems provide customised recommendations and intelligent feedback (Crompton and Burke, 2023; Zawacki-Richter et al., 2019). Based on empirical evidence, it can be concluded that collaborative digital learning environment (CDLE) supports SRL and learner autonomy through active interaction, collaborative inquiry and reflective learning (Janssen et al., 2021; Rattanapun et al., 2026).

Intelligent collaboration platforms can help students learn on their own by meeting their psychological needs of autonomy, competence, and relatedness, which is the foundation of SDT (Ryan and Deci, 2020). The other explanation in social cognitive theory (SCT) of collaborative learning, is that collaborative learning environments increase self-efficacy and self-regulation by observation, peer modelling, feedback and reflection learning (Bandura, 1986, 1997). Similarly, the Community of Inquiry (CoI) Model suggests that the three components of cognitive presence, social presence, and teaching presence are necessary to foster meaningful learning, which can be supported by AI-based collaborative learning environments (Garrison et al., 2000; Garrison et al., 2001).

Research is overwhelmingly positive about the impact of intelligent collaboration platforms in enhancing collaborative problem-solving, student engagement, knowledge sharing, and higher-order thinking skills (Janssen et al., 2021; Crompton and Burke, 2023). Research on SLA, however, has largely been conducted in the context of academic performance, team performance or technology adoption, and fewer studies have been conducted in the context of primary education with AI support systems. Thus, more empirical studies are required to investigate the role of the intelligent collaboration platforms in the development of autodidactic learning of primary school students.

Such theoretical and empirical support should lead to an enhanced learning planning, monitoring, regulating and evaluation capability for students as a result of Intelligent Collaboration Platforms.

H2. ICP will be positively associated with SLA.

Intelligent collaboration platforms and emotion recognition systems

The use of Emotion Recognition Systems (ERS) in the context of Intelligent Collaboration Platforms (ICP) is becoming more common as it becomes increasingly important to make learning environments adaptive and learner-centred using Artificial Intelligence. AI-powered collaboration platforms capture multimodal learning data such as communication patterns, collaborative behaviours, facial expressions, and engagement indicators, unlike traditional learning management systems, making it possible to provide rich contextual information for emotion recognition and adaptive instruction (Vistorte et al., 2024). These interaction data provide a foundation for more precise identification of the emotional state of the learners and for more targeted and effective feedback in a timely manner through emotion recognition systems.

Meaningful learning comes from the synergy of three types of presence in the learning process, namely cognitive presence, social presence, and teaching presence, as described by the Community of Inquiry (CoI) Framework (Garrison et al., 2000, 2001). ICP facilitates continuous behavioural and social interaction data, which helps improve the ability of emotion recognition systems to identify the engagement, confusion, motivation and regulation of learners. Likewise, Social Cognitive Theory (SCT) proposes that learning is a dynamic process between the learner, the behaviours and the learning environment (Bandura, 1986). Creatively rich interactions can thus be seen as a useful behavioural indicator for AI systems to improve emotion-aware feedback and adaptive support for instruction.

Several recent studies have demonstrated that the use of AI in collaborative learning settings enhances the capabilities of learning analytics, behavioural monitoring, and personalized feedback, thus boosting the performance of emotion-aware educational systems (Crompton and Burke, 2023; Vistorte et al., 2024). Yet, empirical studies on the direct link between intelligent collaboration platforms and emotion recognition systems are still limited, especially in the field of AI-supported primary education. Therefore, this research investigates emotion-aware learning and suggests that intelligent collaboration platforms can help implement and make emotion recognition systems meaningful in the context of collaborative interaction data for emotion learning.

H3. ICP will be positively associated with ERS.

The mediating role of emotion recognition systems

Intelligent Collaboration Platforms (ICP) encourage students to learn together, but they not only directly affect their Self-Directed Learning Ability (SLA); they also indirectly affect it through the students' emotional experiences. In Collaborative Learning, students often have emotions that impact motivation, engagement, and self-regulation, including feelings of confusion, frustration, and satisfaction. Emotion Recognition Systems (ERS) are able to detect these emotions in real time and to give adaptive feedback, helping learners to control their emotions and maintain their learning effectiveness (Vistorte et al., 2024).

The mediating mechanism is supported by two theories: Self-Determination Theory (SDT) and Social Cognitive Theory (SCT). Based on SDT, an emotionally responsive learning environment can increase learners' autonomy, competence, and relatedness, which can improve learners' intrinsic motivation and self-directed learning (Ryan and Deci, 2020). In the meantime, SCT proposes that continuous emotional feedback can facilitate self-awareness, self-efficacy and self-regulation, which in turn can allow learners to modify their learning strategies and continue their efforts in the event of learning problems (Bandura, 1986, 1997). The Community of Inquiry (CoI) Framework also explains that the essence of collaborative learning environments is to create meaningful emotional information through cognitive and social interactions for ERS to offer more precise and individualized instructional assistance (Garrison et al., 2000).

AI-based emotion recognition contributes to improved learner engagement, adaptive learning, and teaching effectiveness, and intelligent collaboration tools foster collaborative exploration and independent learning (Crompton and Burke, 2023; Salloum et al., 2025). To date, however, there is little empirical study that focuses on the role of emotion recognition in the relationship between collaborative AI environments and students' self-directed learning, as applied to primary education. Based on this, the following hypotheses of this study are put forward: Emotion Recognition Systems partially mediate between Intelligent Collaboration Platforms and students' Self-Directed Learning Ability.

H4. ERS will statistically mediate the association between ICP and SLA

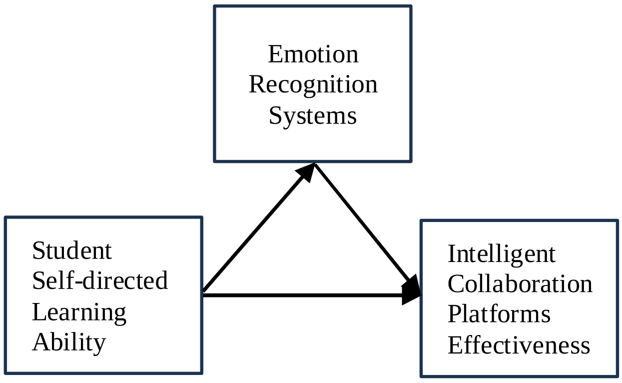

Figure 1. Conceptual framework.

METHODOLOGY

This study employed a quantitative and cross sectional survey design to investigate the relationship between Emotion Recognition Systems (ERS) and Intelligent Collaboration Platforms (ICP) to Students' Self-Directed Learning Ability (SLA) in private primary schools in Chengdu, China. The dependent construct was SLA, and the learning processes involved in the development of SLA was explained by SRL theory including planning, monitoring, emotional regulation and reflection. The study was guided by the theories of Self-Determination Theory (Ryan and Deci, 2020), Social Cognitive Theory (Bandura, 1986), CoI (Garrison et al., 2000), and SRL theory (Zimmerman, 2000).

The subjects included 14,297 grade 4-6 students from six private schools that joined Artificial Intelligence in Education Pilot Program in Chengdu during 2025 school year. With a sampling error of 5% and applying the Yamane (1967) formula, the sample size that was required was 390 students. 402 responses were received and were valid. The 18 school–grade strata (six schools × three grade levels) were used for proportionate stratified random sampling. The absolute minimum number of students to be selected in each stratum were determined based on the proportion of the total population in each stratum. For each stratum students who were eligible and did not provide parental/guardian consent and student assent were replaced as per a random reserve list within the same stratum. A total of 450 questionnaires were sent out and

402 complete questionnaires were kept for analysis.

A 20 item Chinese-language questionnaire, including ERS (6 items), ICP (6 items) and SLA (8 items), was employed to gather data. The items were adapted from existing literature and validated instruments that have been developed to measure affective computing and emotion-aware learning [insert ERS source], computer-supported collaborative learning [insert ICP source] and self-directed and self-regulated learning [insert SLA source]. Sample items were: “The system reminds me when I feel frustrated or lose concentration in learning” (ERS); “I can discuss the learning task and solving the problem with others in the class” (ICP); and “I set the learning goals and see if I achieve them.” (SLA). The answers were scored on a Likert scale of 1 (strongly disagree) to 5 (strongly agree). To guarantee the semantic equivalence (Brislin, 1970), the questionnaire was translated into Chinese and then back-translated into English.

The questionnaire items were researcher-developed and informed by the literature on affect-aware learning technologies, collaborative learning, and self-directed learning. The ERS items were informed by research on affective states and emotion-aware learning technologies (Calvo and D’Mello, 2011; D’Mello and Graesser, 2012; Salloum et al., 2025). The ICP items were informed by research on asynchronous collaboration (Lu et al., 2024). The SLA items were informed by the self-directed learning literature and the SELF-ReDiAL framework (Arianpoor et al., 2025). Because the questionnaire was adapted for upper-primary students in China, its content validity and internal consistency were assessed in the present study.

Three experts assessed the content validity through the Item–Objective Congruence method and the values ranged from .67 to 1.00. A preliminary test using 75 students evaluated the clarity of the items and preliminary test–retest reliability. The overall Cronbach's alpha was .851 and all item-total corrected correlation values were > .30.

Data was collected using the Wenjuanxing platform. Students volunteered for the course and there was no penalty for their withdrawal. There were no names, identification numbers, pictures of faces, recordings of voice or any other material collected that could be used to identify the student. Data were stored securely, and given only to the research team, and reported in an aggregate form.

SPSS Statistics Version 27 and the PROCESS version 4 were used for data analysis. Descriptive statistics, Cronbach's alpha and Pearson correlations were computed. The direct relationships between ICP, ERS and SLA were tested using multiple regression analysis. To test mediation, PROCESS Model 4 was used with 5,000 bootstrap resamples with ICP as the independent variable, ERS as the mediator variable, and SLA as the dependent variable (Hayes, 2022). An indirect effect was deemed significant if the 95% bootstrap confidence interval on the effect did not contain zero. Residual diagnostics, Durbin-Watson statistic and variance inflation factors were used to check the regression assumptions such as linearity, normality of residuals, homoscedasticity, independence of errors and multicollinearity.

RESULTS

Table 1 shows the demographics of the 402 questionnaire respondents. 51.5% of pupils were 207 female students and 48.5% were 195 male students. Grade 6 students made up 48.8% of the respondents, followed by Grade 5 students at 26.6% and Grade 4 students at 24.6%. Out of 6 private elementary schools that use AI, 26.3% were represented at Xinchuan Foreign Language School (106) to provide a diverse sample.

Table 1. Demographic characteristics of respondents (n = 402).

	Category	Frequency	Percent (%)
Gender	Male	195	48.50
	Female	207	51.50
Grade	Grade4	99	24.62
	Grade 5	107	26.61
	Grade6	196	48.75
School name	Chengdu Jiaxiang Foreign Language School (Jinjiang District)	32	7.97
	Chengdu Jiaxiang Foreign Language School (Wenjiang District)	88	21.89
	Chengdu Tianli School (Pidu District)	78	19.40
	Chengdu Xichuanhui Jindu School (Longquanyi District)	63	15.67
	Primary School Affiliated to Tianfu Middle School	35	8.70
	Chengdu Xinchuan Foreign Language School (Xindu District	106	26.3

Variable characteristics table

Table 2 presents the descriptive statistics and reliability coefficients for the study variables. The mean scores for Emotion Recognition Systems (ERS), Intelligent Collaboration Platforms (ICP), and Students' Self-Directed Learning Ability (SLA) were (M = 4.271, SD =0.699), (M =4.458, SD =0.642), and (M = 4.474, SD =0.655), respectively.

Table 2. Descriptive statistics of the study variables (n = 402).

Variables	Mean	Standard deviation	Interpreted
Emotion Recognition System (ERS)	4.271	0.699	Very High
Intelligent Collaboration Platform (ICP)	4.458	0.642	Very High
Self-directed Learning Ability (SLA)	4.474	0.655	Very High
Total	**4.401**	**0.665**	Very High

Table 3. Reliability analysis of the measurement instrument (n = 402).

Questions	CITC	Item deleted α coefficient
ERS-Emotion Recognition Systems, Cronbach's Alpha = 0.842		
ERS1 The emotion recognition system accurately detects my emotions while learning.	0.682	0.842
ERS2. The system's emotional input matches my learning feelings.	0.691	0.841
ERS3. The system reacts quickly to emotional changes during learning.	0.673	0.843
ERS4. The system provides feedback at optimal learning times.	0.664	0.844
ERS5. The system adapts to my learning style and emotions.	0.702	0.840
ERS6. The system supports learning with varied emotions.	0.685	0.842
ICP-Intelligent Collaboration Platforms, Cronbach's Alpha = 0.845		
ICP7. The collaboration tool lets me collaborate with classmates throughout learning.	0.712	0.845
ICP8. The platform helps students collaborate on learning projects.	0.721	0.844
ICP9. Peer feedback and learning support are available on the platform.	0.703	0.846
ICP10 lets me share ideas and learning with other students.	0.714	0.845
ICP11. The platform lets me pick when and how to collaborate.	0.722	0.844
ICP12 Flexible engagement in collaborative activities on the platform is possible	0.715	0.845
SLA-Student self-directed Learning Ability Cronbach's Alpha = **0.853**		
SLA13. I manage my learning time well with digital tools.	0.762	0.850
SLA14. I can schedule enough time for learning.	0.753	0.851
SLA15. I identify learning goals before starting.	0.771	0.849
SLA16. I track my learning goals.	0.764	0.851
SLA17. I evaluate my learning to improve.	0.725	0.852
SLA18. I assess my learning techniques following learning tasks.	0.743	0.853
SLA19. I actively seek learning resources outside teacher-provided.	0.734	0.853
SLA20. I take initiative in exploring new learning opportunities independently.	0.731	0.853
Standardized Cronbach's alpha coefficient=0.862		

The Cronbach's alpha coefficients were 0.842 for ERS, 0.845 for ICP, and 0.853 for SLA, indicating acceptable internal consistency.

Correlation analysis

Pearson correlation analysis was conducted to examine the associations among ERS, ICP, and SLA. As shown in Table 4, ERS was positively associated with SLA, r = [0.754], p <0.001. ICP was also positively associated with

SLA, *r* = [0.812], *p* < .001. In addition, ERS and ICP were positively associated, *r* = [0.680], *p* <0.001. These results indicate that students reporting more positive experiences of ERS and ICP also tended to report higher SLA. Because the study used a cross-sectional design, these associations should not be interpreted as causal effects.

Table 4. Pearson Correlation Analysis of Emotion Recognition System (ERS), Intelligent Collaboration Platform (ICP), and Students' Self-Directed Learning Ability (SDLA) (n = 402)

Variable	Correlation	ERS	ICP	SLA
ERS	Pearson correlation	1.000	0.680**	0.754**
	Sig.(2-tailed)		0.000	0.000
ICP	Pearson correlation	0.680**	1.000	0.812**
	Sig.(2-tailed)	0.000		0.000
SLA	Pearson correlation	0.754**	0.812**	1.000
	Sig.(2-tailed)	0.000	0.000	

** p < 0.01 (2-tailed).

Regression and mediation analyses

Regression and bootstrapped mediation analyses were conducted to examine the hypothesised associations among Intelligent Collaboration Platforms (ICP), Emotion Recognition Systems (ERS), and Students' Self-Directed Learning Ability (SLA). The results are summarised in Table 5.

Table 5. Regression and Mediation Analyses (*N* = 402).

Hypothesis	Path	B	SE	β	t	p	R^2	Decision
H1	ERS → SLA	0.520	0.040	.754	22.98	< .001	.569	Supported
H2	ICP → SLA	0.550	0.034	.812	27.83	< .001	.659	Supported
H3	ICP → ERS	0.450	0.043	.680	18.52	< .001	.462	Supported
Joint model	ERS → SLA (controlling ICP)	-	0.042	.375	10.61	< .001	.735	-
Joint model	ICP → SLA (controlling ERS)	-	0.045	.557	15.75	< .001	.735	-
H4	ICP → ERS → SLA	ab=0.144	Boot "SE"=0.026 [0.095, 0.196]	-	-	< .001	-	Supported (Indirect Association)

Note. The joint model reports F (2,399) = 553.33, p < .001, R^2 = .735, and R2 = .734, and adjusted R^2 = .734. The 95% bootstrap confidence interval for the indirect association was [0.095, 0.196]. For H1 and H2, the reported R^2 equals the squared zero-order correlation from Table 4 (R^2 = .569 and R^2 = .659, respectively).

As shown in Table 5, ERS was positively associated with SLA, *B* = 0.520, *SE = 0.040*, *β* = .754, *t* = 22.980, p < .001, accounting for 56.9% of the variance in SLA (R^2 = .569). ICP was also positively associated with SLA, *B* = 0.550, *SE* = 0.034, *β* = .812, *t* = 27.830, p < .001, accounting for 65.9% of the variance in SLA (R^2 = .659). In addition, ICP was positively associated with ERS, *B* = 0.450, *SE* = 0.043, *β* = .680, *t* = 18.520, p < .001, R^2 = .462.

When ERS and ICP were entered simultaneously, the regression model was statistically significant, F(2,399) = 553.33, p < .001, explaining 73.5% of the variance in SLA (R^2 = .735, adjusted R^2 = .734). After mutual adjustment, ERS remained positively associated with SLA (*β* = .375, *t* = 10.610, p < .001), and ICP remained positively associated with SLA (β = .557, t = 15.750, p < .001). This model indicates the joint predictive contribution of ERS and ICP to SLA. It does not demonstrate a synergistic effect because an ERS × ICP interaction was not tested.

Bootstrapped mediation analysis using 5,000 resamples examined the indirect association between ICP and SLA through ERS. The indirect association was significant, ab = 0.144, Boot *SE* = 0.026, 95% CI [0.095, 0.196]. Because the confidence interval did not include zero, H4 was supported. The direct association between ICP and SLA after accounting for ERS remained significant (*β* = .557, *t* = 15.750, p < .001). Given the cross-sectional design, the mediation finding should be interpreted as a statistical indirect association and not as evidence of a causal mechanism.

Overall, the findings indicate associations among ICP, ERS and SLA. These results should be interpreted within the context of the study's framework.

DISCUSSION

The present study examined the effects of Emotion Recognition Systems (ERS) and Intelligent Collaboration Platforms (ICP) on students' Self-Directed Learning Ability (SDLA) in private primary schools in Chengdu, China, using an AI-enhanced education context. This study aimed to explore the impact of Emotion Recognition Systems (ERS) and Intelligent Collaboration Platforms (ICP) on the Self-Directed Learning Ability (SDLA) of students in an AI-enhanced private primary school in Chengdu, China. The results confirm the proposed conceptual model, which shows that both the AI technologies have a positive impact on students' self-directed learning. Most crucially, the results indicate that the relationship between ICP and SDLA is partially explained by ERS, and offer novel insights into the emotional processes that enable collaborative AI tools to support independent learning. All these findings together broaden the understanding of AI-supported learning, bringing together the cognitive, emotional, and collaborative perspectives in a single theory.

Emotion recognition systems and self-directed learning ability

The results suggest that Emotion Recognition Systems have a significant effect on the Self-Directed Learning Ability of students, which supports H1. This finding points out that the emotional feedback provided by AI plays an important role in fostering both the emotional health of students as well as their learning independence. Emotion recognition systems continuously identify learners' emotions and give adaptive feedback in time, so that students can recognize their own emotional issues, control negative emotions, and keep them active in learning activities. Emotional awareness is a key element of self-directed learning that enhances learners' ability to monitor, evaluate and modify their own learning processes.

The results may be illuminated by the application of Self-Determination Theory and Social Cognitive Theory. According to the Self-Determination Theory, adaptive emotional support helps students to feel competent and self-determining by lowering barriers of emotions interfering with the process of autonomous learning. At the same time, Social Cognitive Theory indicates that feedback that increases emotional awareness increases students' self-efficacy and self-regulatory behaviour, which in turn helps them to successfully manage learning challenges. Emotion recognition systems are not just pieces of affective support; they can be a continuous reflective tool, a tool for managing one's emotions, and a tool for adapting learning behaviours, and thus become part of Self-regulated learning.

These findings align with recent research showing that using AI to recognize emotions improves learning engagement, motivation, and adaptive learning behaviours. However, this study takes the evidence to the primary level of education and shows that emotion-aware technologies can also make a big difference in developing self-directed learning for younger students. The article extends the possible scope of the application of affective computing in compulsory education and underscores the significance of the incorporation of emotional intelligence in classroom settings accompanied by the use of AI.

Intelligent collaboration platforms and self-directed learning ability

In addition, the results show that Intelligent Collaboration Platforms have a significant effect on enhancing students' Self-Directed Learning Ability, which is consistent with supporting H2. This result suggests that the collaborative AI learning environment can foster autonomy in learning as it helps learners communicate, interact, solve problems together and construct knowledge together. Collaborative learning platforms offer a framework for learning and provide students with opportunities to take more responsibility for planning, monitoring and evaluating their own learning, while gaining support from peers.

This discovery is consistent with the concept of the Community of Inquiry Framework, in which meaningful learning results from the interaction of the three components: cognitive presence, social presence, and teaching presence. The three dimensions are reinforced through intelligent collaboration platforms, which provide spaces for collaborative work to inspire active engagement, reflection, and construction of knowledge. Meanwhile, collaborative learning settings can meet learners' psychological needs of relatedness and competence, which further improves their intrinsic motivation and self-directed learning.

The more positive standardized regression weight coefficient for ICP than for ERS further indicates that collaborative learning environments are the association factor in the classroom for promoting self-directed learning when using AI. The results of this study align with recent studies in educational technology that have demonstrated how structured digital collaboration can foster higher-order learning and self-regulated learning as well as metacognitive reflection, when compared with technology that is employed for content delivery alone. Intelligent collaboration platforms should therefore be considered not only communication spaces, but as learning ecosystems that foster autonomous learning by co-engaging.

Smart collaboration platforms more intelligent emotion recognition systems

The results also prove that Intelligent Collaboration Platforms highly predict the effectiveness of Emotion Recognition Systems, thereby supporting H3. This discovery indicates that co-constructed digital learning environments are an important source of behavioral, communicative and interactional data important for emotion recognition systems. Multimodal learning data are created through rich peer interaction, continuous communication and collaborative learning activities, which help AI systems to better identify the emotions learners are experiencing and to deliver adaptive emotional feedback.

The social cognitive theory (SCT) regards collaborative learning situations as reciprocating interactions between learners, behaviors and learning contexts so that emotions can be made visible and are responsive to instruction. Similarly, in the case of collaborative platforms, higher levels of social and cognitive presence in the platform can promote better emotional engagement, and consequently improve the effectiveness of emotion-aware technologies, according to the Community of Inquiry Framework. These results suggest that intelligent collaboration platforms can foster learning directly, but can also help establish the conditions that allow emotion-recognising systems to provide personal emotional support.

In contrast to earlier research that has focused on either collaborative technologies or affective computing separately, the findings of this research study provide a strong structural relationship between the two technologies, thus making the understanding of an AI-supported learning environment more integral.

Emotion recognition systems as a mediator

From this research, the most significant result is that Emotion Recognition Systems partially mediate the relationship between the Intelligent Collaboration Platform and the Students' Self-Directed Learning Ability, which is used to support H4. The result shows that collaborative technologies have a positive effect on self-directed learning, not just by being used collaboratively, but also by enhancing the emotions of the learners in learning activities. The large indirect effect provides evidence that the emotional process is an important indirect pathway between collaborative AI technologies and autonomous learning.

The theoretical basis of the mediation finding is strong in terms of integrating Self-Determination Theory, Social Cognitive Theory and the Community of Inquiry Framework. Intelligent collaboration platforms create a collaborative learning environment to encourage interaction and knowledge building, while emotion recognition systems improve the competence, emotional regulation and self-efficacy of the learners and thus facilitate the transformation of collaborative experiences into effective self-directed learning behaviours. Results showed that the direct effect remained after the indirect effect was significant, which means that this effect was partially mediated and that emotional regulation was complementary to collaborative learning processes.

This mediation mechanism is the main theoretical finding of the study. The analysis of the emotion recognition systems and collaborative learning platforms conducted in previous studies centred on one or the other technology without considering their interaction with each other in a single learning context, while in the present study, the two technologies are able to work together in a common learning framework. Hence, the findings contribute to the literature by revealing emotion recognition as one of the psychological mechanisms of collaborative AI-supported learning environments that lead to SRL in primary school students.

The overall findings indicate that collaborative learning technologies and emotion-aware systems are best combined, not used in isolation, for the most effective learning environment supported by AI. Intelligent collaboration platforms offer the collaborative learning environment, and emotion recognition systems enhance learners' emotion regulation and self-awareness, which helps to make collaborative learning into self-directed learning behaviors. This integrated mechanism broadens the existing discussion on AI-supported learning by providing a framework to understand that the most effective educational technologies should tackle learners' cognitive, social, and emotional dimensions all at once. In practical terms, the essential use of integrated collaborative AI platforms and emotion-aware technologies, along with teacher training, professional development, and ethical AI governance, should be emphasised in schools to ensure that the students' learning processes are self-directed and that there are maximum benefits for long-term learning.

CONTRIBUTIONS

This research work will be helpful in the field of Artificial Intelligence (AI) in education by designing and experimenting with an integrated system that elucidates how Emotion Recognition Systems (ERS) and Intelligent Collaboration Platforms (ICP) work together to boost the Self-Directed Learning Ability (SLA) of students. The study addresses the mediating role of ERS, goes beyond the direct relationship between technology–learning and shows the relationship between ERS and collaborative learning in supporting autonomous learning. Moreover, Self-Determination Theory, Social Cognitive Theory and the Community of Inquiry Framework are integrated to offer an extensive theoretical account of AI-supported learning in primary school, and to add empirical support from the under-explored context of Chinese K–12 schools.

This study's practical implications indicate that the integration of ERS and ICP in the school environment should be as complementary technologies to provide a learner-centred, emotionally responsive, and collaborative learning environment. The results also emphasize the need for teacher professional development, ethical governance of AI, and equitable access to AI technologies for successful implementation. The results are relevant to Sustainable Development Goal 4 (Quality Education) as they illustrate the capacity of AI to foster personalized learning, build up self-directed learning skills, and contribute to inclusive, high-quality education.

CONCLUSION

The study explored the effects of Emotion Recognition Systems (ERS) and Intelligent Collaboration Platforms (ICP) on students' Self-Directed Learning Ability (SLA) in private primary schools of Chengdu, China. The results indicate that ERS and ICP both positively impact students' SLA, and ERS partially mediated the link between ICP and SLA. These findings suggest that the use of AI tools in collaborative learning settings has an indirect effect on autonomous learning via emotional awareness and regulation, as well as a direct effect.

This research adds to the existing body of knowledge by combining the three models (SST, SOC, and CoI) within a single framework that explains the learning process with the support of AI. The study is a contribution to the literature because it is an integration of three models (Self-Determination Theory, Social Cognitive Theory, and Community of Inquiry) into one model that explains the learning process with AI support. It also builds on previous findings by providing evidence of the combined effect of emotion-aware and collaborative AI technologies on promoting SLL in primary school students in China.

In practice, it is important to consider ERS and ICP as two complementary technologies that should be implemented in classrooms that are already learner-centred. The implementation of successful outcomes will need to address teacher professional learning, ethical AI governance, and equitable access to AI-supported learning environments. The results offer insights on how teachers, school administrators and policymakers can support teaching and learning in responsible ways and for developing lifelong learning skills.

LIMITATIONS AND FUTURE RESEARCH

There are a number of limitations in this study. First, because of the cross-sectional design, causal inferences are not possible among the variables of interest in this study. Second, the results are limited to six private primary schools in Chengdu, which may not be representative. Third, self-reported data were used in the study, which can be subject to common method bias and social desirability. In addition, teacher AI competency, students' digital literacy, and parental support were not considered in the proposed model.

Longitudinal or experimental studies are recommended for future research to determine causal relationships between AI-supported learning technologies and SDLs. It is also recommended that this proposed model be tested at various levels of education, in public schools and across diverse cultures. Lastly, future research can expand the model with more mediating and/or moderating variables, such as AI competency, learning motivation, digital literacy, and parental support, and incorporate learning analytics and qualitative data to gain a deeper understanding of the learning processes when using AI.

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REFERENCES

Arianpoor, A., Taylor, S. C. R., Lucas, C., Webster, C. S., Henning, M. A., Sofija, E., Boyd, M. J., Charrois, T. L., Kellar, J., Perepelkin, J., Smith, L., Mani, R., Mantzourani, E., Marley, C., Shulruf, B., & Huang, P.-H. (2025). Development and validation of a tool for evaluating self-regulated and self-directed aptitudes of learning (SELF-ReDiAL). *Medical Science Educator, 35*, 2429–2439. https://doi.org/10.1007/s40670-025-02454-0

Azevedo, R., & Gašević, D. (2019). Analyzing multimodal multichannel data about self-regulated learning with advanced learning technologies: Issues and challenges. *Computers in Human Behavior, 96*, 207–210. https://doi.org/10.1016/j.chb.2019.03.025

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Prentice-Hall.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. W. H. Freeman.

Brislin, R. W. (1970). Back-translation for cross-cultural research. *Journal of Cross-Cultural Psychology, 1*(3), 185–216. https://doi.org/10.1177/135910457000100301

Broadbent, J., & Lodge, J. M. (2021). Self-regulated learning: Current and future directions for learning and teaching in higher education. *Higher Education Research & Development, 40*(3), 631–645. https://doi.org/10.1080/07294360.2020.1865542

Calvo, R. A., & D'Mello, S. K. (Eds.). (2011). *New perspectives on affect and learning technologies*. Springer. https://doi.org/10.1007/978-1-4419-9625-1

Crompton, H., & Burke, D. (2023). Artificial intelligence in higher education: The state of the field. *International Journal of Educational Technology in Higher Education, 20*, Article 22. https://doi.org/10.1186/s41239-023-00392-8

D'Mello, S. K., & Graesser, A. C. (2012). Dynamics of affective states during complex learning. *Learning and Instruction, 22*(2), 145–157. https://doi.org/10.1016/j.learninstruc.2011.10.001

Garrison, D. R., Anderson, T., & Archer, W. (2000). Critical inquiry in a text-based environment: Computer conferencing in higher education. *The Internet and Higher Education, 2*(2–3), 87–105.

https://doi.org/10.1016/S1096-7516(00)00016-6
Garrison, D. R., Anderson, T., & Archer, W. (2001). Critical thinking, cognitive presence, and computer conferencing in distance education. *American Journal of Distance Education, 15*(1), 7–23. https://doi.org/10.1080/08923640109527071
Hayes, A. F. (2022). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach* (3rd ed.). Guilford Press.
Howard, S. K., Tondeur, J., Siddiq, F., & Scherer, R. (2021). Ready, set, go! Profiling teachers' readiness for online teaching in secondary education. *Technology, Pedagogy and Education, 30*(1), 141–158. https://doi.org/10.1080/1475939X.2020.1839543
Janssen, J., Bodemer, D., & Kirschner, P. A. (2021). Scripted computer-supported collaborative learning: A review of research and future directions. *Educational Research Review, 33*, Article 100411. https://doi.org/10.1016/j.edurev.2021.100411
Järvelä, S., Malmberg, J., Haataja, E., Sobocinski, M., & Kirschner, P. A. (2021). What multimodal data can tell us about the regulation of learning. *Learning and Instruction, 72*, Article 101203. https://doi.org/10.1016/j.learninstruc.2019.04.004
Lu, Y., Ma, N., & Yan, W.-Y. (2024). Social comparison feedback in online teacher training and its impact on asynchronous collaboration. *International Journal of Educational Technology in Higher Education, 21*, Article 55. https://doi.org/10.1186/s41239-024-00486-x
Panadero, E. (2017). A review of self-regulated learning: Six models and four directions for research. *Frontiers in Psychology, 8*, Article 422. https://doi.org/10.3389/fpsyg.2017.00422
Rattanapun, S., Wu, X., White, A., & Darodjat, T. (2026). The impact of interactive learning and self-regulated learning on digital literacies development in primary school students. *Contemporary Educational Technology, 18*(1), Article ep625. https://doi.org/10.30935/cedtech/17865
Ryan, R. M., & Deci, E. L. (2020). Intrinsic and extrinsic motivation from a self-determination theory perspective: Definitions, theory, practices, and future directions. *Contemporary Educational Psychology, 61*, Article 101860. https://doi.org/10.1016/j.cedpsych.2020.101860
Salloum, S. A., Alomari, K. M., Alfaisal, A. M., Aljanada, R. A., & Basiouni, A. (2025). Emotion recognition for enhanced learning: Using AI to detect students' emotions and adjust teaching methods. *Smart Learning Environments, 12*, Article 21. https://doi.org/10.1186/s40561-025-00374-5
Stahl, G., Koschmann, T., & Suthers, D. (2014). Computer-supported collaborative learning. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (2nd ed., pp. 479–500). Cambridge University Press. https://doi.org/10.1017/CBO9781139519526.029
Vistorte, A. O. R., Deroncele-Acosta, A., Martín Ayala, J. L., Barrasa, A., López-Granero, C., & Martí-González, M. M. (2024). Integrating artificial intelligence to assess emotions in learning environments: A systematic literature review. *Frontiers in Psychology, 15*, Article 1387089. https://doi.org/10.3389/fpsyg.2024.1387089
Yamane, T. (1967). *Statistics: An introductory analysis* (2nd ed.). Harper & Row.
Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education - Where are the educators? *International Journal of Educational Technology in Higher Education, 16*, Article 39. https://doi.org/10.1186/s41239-019-0171-0
Zimmerman, B. J. (2000). Attaining self-regulation: A social cognitive perspective. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 13–39). Academic Press.

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