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Resilience and online learning emotional engagement among college students in the digital age: a perspective based on selfregulated learning theory



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Abstract

Background Self-efficacy perception and strategy use are two key processes for achieving self-regulated learning. Based on the perspective of self-regulated learning theory, this study explores the mediating mechanism of selfregulated learning efficacy, and strategy use (self-control and emotion regulation strategies) between resilience and online learning emotional engagement.

Methods The study was conducted on 2182 college students from China using questionnaires, and a structural equation model was established to test the mediating effects.

Results The results showed that: firstly, resilience, self-regulated learning efficacy, self-control, cognitive reappraisal, and online learning emotional engagement were all significantly positively correlated with each other, while expressive suppression was significantly negatively correlated with resilience and self-control. Secondly, resilience can individually mediate online learning emotional engagement through self-regulated learning efficacy, self-control, and cognitive reappraisal. Additionally, it can indirectly predict emotional engagement in online learning by way of the chain mediating effect of self-regulated learning efficacy, self-control, and cognitive reappraisal, but the direct effect of resilience on online learning emotional engagement is not significant. Lastly, there are differences in the mediating effects between urban and rural areas.

Conclusion The results of this study provide new intervention perspectives and procedural learning support suggestions for enhancing learners' emotional engagement and optimizing their online learning experience.

Keywords Online learning, Resilience, Emotional engagement, Self-control, Emotion regulation strategies, Self-regulated learning efficacy

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Introduction

"Internet + Education" is a pivotal strategy for advancing the digital transformation of education, and research on online learning has emerged as a critical area in promoting this transformation. The impact of the COVID-19 pandemic has further accelerated the adoption of online learning, making it the "new normal" for students worldwide [1]. Compared to traditional teaching, online learning has undergone significant changes, not only in terms of learning locations, presentation methods, and assessment methods but also in terms of teacher-student interaction, group collaboration, and knowledge absorption and dissemination. Online learning features characteristics such as temporal and spatial flexibility, openness, and personalization, playing a key role in achieving the goal of "learning for all, anytime, anywhere" [2, 3], leading to transformative and innovative changes in student learning. However, due to the temporal and spatial separation between teaching and learning, lack of interaction, and direct emotional communication between teachers and students, online learning also faces challenges such as high dropout rates, passive experiences, negative perceptions, and low efficiency [4-6]. These challenges highlight a critical issue: the overemphasis on cognitive skill development and technological utilization in online learning, often at the expense of students' emotional experiences. This has resulted in a learning paradigm that prioritizes "knowledge over emotion" and "separation of emotion and knowledge."

In recent years, there has been a growing consensus among researchers that emotions and cognition are equally important in the learning process [7, 8]. They emphasize that fostering active emotional engagement and cultivating positive emotional experiences should be central objectives in the design and implementation of online learning environments. "Focusing on the emotional existence of learners, inspiring learners' emotional engagement, and optimizing learners' online learning experience" has become an important field and inevitable trend in online learning and its research. Despite this recognition [7, 8], research specifically addressing emotional engagement in online learning remains limited, particularly in terms of understanding the dynamic processes involved. Accurately identifying and analyzing students' online learning processes is crucial for improving online learning outcomes and enhancing learning experiences. However, there is limited empirical research that applies self-regulated learning models to investigate the mechanisms of emotional engagement in online learning.

To address this gap, this study examines the impact of learners' resilience—a key personal characteristic—on emotional engagement in online learning, with a specific focus on the regulatory processes (cognitive, emotional, volitional, and behavioral) that mediate this relationship. Resilience, defined as the ability to adapt and thrive in the face of adversity, is posited to play a crucial role in shaping students' emotional engagement by influencing their capacity to self-regulate their learning. Self-regulated learning, serves as a bridge between resilience and emotional engagement, enabling learners to manage challenges and maintain motivation in online environments. Furthermore, while existing research has extensively explored factors influencing online learning, there is limited understanding of the synergistic effects and interrelationships among these factors. By adopting a holistic perspective grounded in self-regulated learning theory, this study aims to provide a comprehensive understanding of how resilience affects emotional engagement through self-regulated learning processes. The findings are expected to offer practical insights for online teaching practices and contribute to the cultivation of talents in the digital age.

Relationship between resilience and online learning emotional engagement

Emotional engagement is considered as the learner's emotional response and emotional state towards learning tasks [2]. Emotions play an important role in the learning process, motivation, and learning decisions. Research has proved that emotional engagement can effectively promote learners' cognitive engagement and behavioral engagement [6, 9]. Only when learners emotionally accept and identify with online learning will they be willing to commit and work hard to learn. Emotional engagement is a key factor in learning efficiency and a direct influence on academic performance [6, 7]. Learners will face greater challenges in online learning, and understanding emotional engagement is particularly important to improve the sustainability and effectiveness of online learning [6, 7, 9]. In recent years, numerous studies have supported the direct impact of positive noncognitive characteristics on the development of learning behavior, among which resilience is a key factor [10, 11]. As an adaptive strategy, resilience refers to the dynamic process in which individuals can still be competent and adapt positively to adversity [12, 13]. It not only focuses on how individuals cope with or handle challenges when faced with difficulties but also on their ability to adapt to environmental changes [11]. Everyone has resilience, but there are individual differences in resilience. Learners with higher resilience have more psychological resources, develop better ability to cope with difficult situations, and produce more positive adaptive states, which in turn promote academic performance [11]. The dynamic model of resilience also suggests that the formation and development of individual resilience undergoes a complex process, which affects their performance in facing academic tasks [14]. Recently it has been proposed that the mechanism of action behind resilience is the self-regulation of flexibility and that individuals with high resilience produce higher levels of positive emotional stability, and greater cognitive flexibility [15].

Therefore, it is hypothesized that H1: resilience positively predicts online learning emotional engagement.

Self-regulated learning theory

Online learners are transformed from the object of traditional educational knowledge instillation to the main body of information processing and the active constructor of knowledge meaning, and the learner's subjective role is maximized in online teaching and learning. Effective self-regulation is an important feature of online learning and a "prerequisite for successful online learning" [5, 9]. Self-regulated learning (SRL) refers to a type of learning that requires goal setting, strategy use, selfmonitoring, and self-adjustment [16]. Zimmerman(2000) defines three phases of self-regulated learning: forethought, performance, and self-reflection [17]. In the first phase, learners assess their ability to successfully perform a task and establish goals and plans for completing it. This includes task analysis and self-motivation beliefs. In the second phase, learners employ various strategies to facilitate their learning and task completion, such as self-control and self-observation. The third phase involves reflective evaluation of the learning process, academic performance, and outcomes, encompassing self-judgment and self-reaction. The self-regulated learning theory provides a comprehensive framework for understanding how students manage their cognition, motivation/emotion, behavior, and environment [18]. From the perspective of goal motivation in the self-regulation process, the process of self-regulation is a process in which individuals continuously adjust their behavior (such as resisting temptation) and emotions (such as changing moods) based on their own or others' goals, ultimately developing towards the goal [19]. The most significant feature of self-regulated learning is the learner's actual control over their own learning, achieved by guiding cognitive and motivational processes toward learning goals [20]. Self-efficacy perception and strategy use are two key processes for achieving self-regulated learning. As the initial stage of the self-regulated learning process, self-efficacy perception is an important factor in determining whether learners will actively participate in learning [21], while strategy use is the process by which individuals actively use strategies to regulate and maintain their motivation level. Therefore, regarding the internal mechanism of online learning emotional engagement, self-regulated learning efficacy, self-control, and emotion regulation strategies are worthy of consideration as mediating variables. Self-regulated learning efficacy belongs to self-efficacy perception, while self-control and emotion regulation strategies belong to strategy use. According to the self-regulated cognitive theory, students with stronger self-efficacy perception are more likely to actively use various strategies to regulate and monitor effectively. It is therefore inferred that self-regulated learning efficacy, self-control, and emotion regulation strategies play separate and sequential mediating roles between resilience and emotional engagement. However, most of the previous research on the self-regulation learning process has been separate and isolated, and there is a lack of empirical evidence on how students regulate motivation, emotion, and behavior during the self-regulation process [18, 22].

The mediating role of self-regulated learning efficacy

Self-efficacy, as a student's intrinsic motivation [10], affects the online experience, learning status, interest in learning, and student satisfaction, and is the most central resource in the self-regulation process [9]. Self-regulated learning is the process in which learners continuously stimulate learning motivation, improve learning initiative, and use appropriate and effective strategies to learn [23]. The extent of a person's willingness to engage in and maintain self-regulation is particularly dependent on self-regulation efficacy [17]. Self-efficacy for self-regulated learning refers to students' perceived ability to use a variety of self-regulated learning strategies such as selfmonitoring, self-evaluation, goal setting and planning, self-consequences, and environmental restructuring [17, 24]. Self-regulated learning efficacy may have a significant impact on emotional engagement. On the one hand, selfregulated learning efficacy affects students' self-regulated learning strategy selection [10-14]. Students with high self-efficacy perception will adopt more effective self-regulated strategies such as effective monitoring of learning time, and persistent effort in academic challenges [29]. For students who lack confidence in using self-regulation skills, self-regulated strategies may be difficult to implement. On the other hand, self-regulated learning efficacy also helps to enhance students' motivational beliefs, selfesteem efficacy, and academic achievement efficacy [9, 17, 30]. Studies have also found that self-regulated learning efficacy can improve intrinsic interest and pleasure in academic performance and is negatively correlated with academic anxiety [31, 32].

Therefore, it is hypothesized that H2: self-regulated learning efficacy mediates the relationship between resilience and emotional engagement.

The mediating role of self-control

Self-control is the ability of individuals to restrain their original thoughts, emotions, and impulses, and to adjust their behavior to meet social norms and long-term goals [33, 34]. The theory of limited self-control

resources suggests that self-control is a finite resource, and the strength of self-control depends on self-control resources, and self-control resources are universal and can be used for different tasks [36-38]. According to this theory, adequate cognitive resources are necessary for the successful implementation of self-control, and the more depletable resources there are, the higher the level of self-control [38]. As a positive resource, resilience can provide depletable mental energy for self-control. Individuals with high resilience have abundant mental resources, which can increase the total amount of depletable resources for self-control and promote the improvement of self-control ability. Enhanced self-control may be an important manifestation of resilience mobilizing internal resources [12]. Therefore, it can be inferred that resilience can positively predict self-control. Secondly, self-control may promote emotional engagement. Lack of sufficient self-control resources may induce various problems, while individuals with higher self-control ability can better suppress and change emotions to achieve their ultimate goals [36–38]. Self-control has a positive predictive effect on positive behaviors such as academic achievement and social responsibility. Previous studies have shown that self-control is beneficial for academic performance and better academic results [34, 39], therefore, self-control may promote emotional engagement. Based on the theory of limited self-control resources and previous research results, resilience, as a positive resource, may affect individuals' development (emotional engagement) through an important ability (self-control).

Therefore, this study hypothesizes that H3: self-control may mediate the relationship between resilience and emotional engagement.

The mediating role of emotion regulation strategies

How learners regulate their emotions plays an important role in the learning process, and researchers have emphasized the importance of emotions and emotion regulation in self-regulated learning theory [8], but the specific impact of emotion regulation on emotional engagement in online learning is unclear [6]. Gross' model of emotion regulation is often used to investigate emotion regulation strategies used during student learning [8]. Gross defines emotion regulation as the process through which individuals influence the frequency, intensity, duration, and expression of their emotions [40]. It involves various strategies and techniques that individuals use to modify their emotional experiences and responses in order to adapt to different situations and achieve their goals. Cognitive reappraisal and expressive suppression are the most commonly used and effective emotion regulation strategies. Gross's emotion regulation process model suggests that cognitive reappraisal is an antecedent-focused strategy that mainly reduces emotional responses by changing the understanding, cognition, and meaning of emotional events [40, 41]. Expressive suppression, on the other hand, is a response-focused strategy that mainly involves inhibiting the expression of emotions that are about to occur or are occurring. However, expressive suppression can only inhibit behavior and cannot reduce the experience and feelings of negative emotions. Cognitive reappraisal is considered highly adaptive, such as favoring life satisfaction and increased positive emotional experiences. In contrast, expression suppression is considered maladaptive, such as increased negative emotional experiences and decreased levels of positive functioning [42]. Previous research has shown that the two emotion regulation strategies have vastly different psychological and cognitive effects on individuals, and both have different effects on learning engagement. There is evidence that the use of cognitive reappraisal positively promotes cognitive engagement, emotional engagement, and behavioral engagement in the learning process [43]. Whereas research has shown that resilience is closely related to emotion regulation, resilience is negatively correlated with emotion regulation difficulties [44] and significantly positively correlated with cognitive reappraisal [45, 46] and that increased individual resilience allows for flexible implementation of emotion regulation strategies [15]. Individuals with high resilience are more inclined to use positive emotion regulation strategies to reduce negative emotional responses. According to the Broadenand-build theory of positive emotions, positive emotions expand an individual's momentary thinking, widen the scope of attention, and enhance cognitive flexibility, which in turn enhances emotional engagement [47].

Based on this, this study proposes hypothesis H4: emotion regulation strategies mediate the relationship between resilience and emotional engagement.

In addition, according to the theory of limited selfcontrol resources, self-control is a limited resource, and various self-control behaviors make use of this limited resource [34, 48]. Regulating emotions is a common experience that depletes the internal resources needed for self-control. In self-control research, the most commonly used strategy is inhibition, such as inhibiting thoughts, emotions, or behavioral tendencies, and avoiding taking action [34, 48]. However, recent research on self-control has found that high self-control does not always adopt inhibition strategies [48]. Therefore, selfcontrol may affect individuals' use of emotion regulation strategies.

Chain mediating effect

Although they belong to the same mediating variables, there is a certain correlation between self-regulated learning efficacy and self-control and emotion regulation strategies. According to the self-regulated social cognitive model, the process of self-regulated learning includes three stages: planning, performance, and reflection [27]. The planning stage is the task analysis before action, which includes self-motivation beliefs such as intrinsic motivation, goal orientation, and self-efficacy (such as self-regulated learning efficacy); the performance or will control stage includes the will control process of focusing attention on learning tasks (such as self-control and emotion regulation); the reflection stage includes selfjudgment and self-response. The three stages represent the general time sequence that learners will experience when performing tasks, so there is a certain sequence between self-regulated learning efficacy and self-control and emotion regulation strategies. Secondly, cognitionemotion-intention-behavior is a progressive mechanism. Self-regulated learning efficacy, as a cognition of self, promotes individuals to gain a sense of control and efficacy, which can enhance self-control intention and effectively regulate self-emotions. Empirical research also confirms that self-regulated learning efficacy can positively predict self-control ability and emotion regulation.

Based on this, this study proposes hypothesis H5:resilience first affects online learning emotional engagement through self-regulated learning efficacy, and then affects it through self-control and emotion regulation strategies.

Most previous studies have found a digital divide between urban and rural students [49]. The differences in urban and rural backgrounds are primarily reflected in living environments, educational resources, and opportunities. Compared to rural students, urban students have access to diverse learning resources, rich learning experiences, and mature network technologies. Also, rural students have been reported to have lower general digital self-efficacy compared to their urban counterparts, reflecting judgments about their ability to perform certain tasks using computers, software, and digital applications [50, 51]. This may impact rural students' online learning experiences [49]. Thus, this study also compares the urban-rural differences in this model relationship.

The present study

In summary, based on the perspective of self-regulated learning theory, this study selects resilience, selfregulated learning efficacy, self-control, and emotion regulation strategies as key variables in the personality traits, planning stage, performance stage, and reflection stage respectively. By constructing a chain mediating model(Fig. 1), this study explores the influencing factors and formation mechanism of online learning emotional engagement, verifies the rationality and applicability of the self-regulated learning theory model, and attempts to integrate the self-regulated learning theory model with related theoretical models to enhance its explanatory power, expand the basis of existing theories, and provide decision-making basis for effectively stimulating learners' motivation and promoting learning emotional engagement.

Method

Participants

A convenience sampling method was used to recruit Chinese college students from Jiangsu, Zhejiang, and Shanghai. These regions, characterized by high - level economic development and rich educational resources, represent diverse urban and rural educational contexts in eastern China. Data was collected via the online platform Survey Star (www.wjx.cn), and questionnaires were distributed through university networks and student associations to ensure wide access. The criteria for participant



Fig. 1 Research analytical model. Note: SRLE: Self-Regulating Learning Efficiency; SC: Self-control; OLEE: Online Learning Emotional Engagement; CR: Cognitive Reappraisal; ES: Expressive Suppression

exclusion were as follows: with completion times shorter than 3 minutes (determined based on pilot testing); regular response patterns (repeated identical scores across all items); failure to pass the embedded lie detection items (e.g., "please select 'strongly disagree' for this item"). A total of 2,182 valid questionnaires were collected, with a validity rate of 90.92%. Among the participants, 1,483 were male and 699 were female; 780 were freshmen, 709 were sophomores, and 693 were juniors; 842 were urban students, 1,340 were rural students; 789 were only children, and 1,393 were non-only children; 789 were student leaders, and 1,393 were non-student leaders. All participants gave informed consent. In subsequent analyses, variables such as gender, academic year, and family structure were statistically controlled to isolate the effects of urban-rural background.

Measures

The brief resilience scale

The scale was developed by Smith and revised by Chen et al. [52, 53]. The scale consists of three positive and three negative items measured on a 5-point Likert scale, such as "It is hard for me to snap back when something bad happens". Higher scores indicate greater resilience. The Cronbach's alpha coefficient in this study was 0.76, indicating good reliability. The confirmatory factor analysis showed that the scale had good validity, with $\chi^2/df = 1.548$, RMSEA = 0.016, CFI = 0.999, TLI = 0.998, NFI = 0.998, and CR = 0.761, AVE = 0.455.

Student engagement in distance education

The scale was revised by Sun et al. [54], the scale consists of 15 items in three dimensions: behavioral engagement, cognitive engagement, and emotional engagement. This study used the emotional engagement scale, which includes 7 items(e.g., 'I feel happy when taking online class') measured on a 5-point Likert scale. Higher scores indicate greater emotional engagement. The internal consistency reliability coefficient of the scale in this study was 0.86, indicating good reliability. The confirmatory factor analysis showed that the scale had good validity, with $\chi^2/df = 5.159$, RMSEA = 0.044, CFI = 0.994, TLI = 0.990, NFI = 0.993, and CR = 0.874, AVE = 0.545.

Self-regulated learning self-efficacy scale

The Chinese version of the scale was revised by Wang et al. [55]. measures an individual's beliefs in their self-regulated learning abilities when facing academic tasks. The scale consists of 11 items (e.g., 'I will choose to study even when I have other things to do that interest me') measured on a 7-point Likert scale. Higher scores indicate greater self-regulated learning self-efficacy. The internal consistency reliability coefficient of the scale in this study was 0.95, indicating good questionnaire reliability. The confirmatory factor analysis showed that the scale had good validity, with RMSEA = 0.072, CFI = 0.978, TLI = 0.967, NFI = 0.976, and CR = 0.946, AVE = 0.617.

Self-control scale

The scale was developed by Tangney and revised by Tan and Guo [34, 56], the scale consists of 19 items (e.g., 'I have trouble concentrating') in five dimensions measured on a 5-point Likert scale, with 15 reverse-scored items. Higher scores indicate greater self-control abilities. The Cronbach's alpha coefficient in this study was 0.86, indicating good reliability. The confirmatory factor analysis showed that the scale had good validity, with RMSEA = 0.084, CFI = 0.915, TLI = 0.883, NFI = 0.910, and CR = 0.933, AVE = 0.503.

Emotion regulation strategy scale

The scale was developed by Gross and revised by Wang et al. [40, 57], the scale consists of 10 items in two factors: cognitive reappraisal (e.g., 'I control my emotions by changing the way I think about the situation I'm in') and expressive suppression(e.g., 'I control my emotions by not expressing them.'). Each item is measured on a 7-point Likert scale, with higher scores indicating a greater tendency toward the strategy. The Cronbach's alpha coefficient in this study was 0.80, with Cronbach's alpha coefficients of 0.90 and 0.87 for the two factors, indicating good reliability. The confirmatory factor analysis showed that the scale had good validity, with $\chi^2/df = 4.050$, RMSEA = 0.037, CFI = 0.995, TLI = 0.991, and NFI = 0.994.

Results

Common method bias

The data in this study were self-reported by the participants, which may result in common method bias. To control for this bias, the study used unified instructions, reverse scoring, and Harman's single-factor test. The results showed that the eigenvalues of the eight factors were greater than 1, with the first factor explaining 28.042% of the variance, which was less than the critical standard of 40%, indicating that there was no serious common method bias. Also, common method bias was further tested by controlling for the effects of non-measurable latent factors. By entering common method bias as a latent variable into the structural equation model, and allowing all identifying variables to load on this method latent variable, the common method bias effect was examined by comparing the degree of fit between the two scenarios containing the common method bias latent variable and the scenario without the method latent variable. The results showed that the model with the inclusion of the common method bias latent variable had better-fit indices: $\chi^2/df = 7.078$, *p* < 0.01, CFI = 0.904,

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Variables	м	SD	Resilience	SRLE	SC	CR	ES	OLEE
Resilience	3.44	0.60	1					
SRLE	5.37	1.10	0.24***	1				
SC	3.29	0.52	0.51***	0.34***	1			
CR	5.29	1.00	0.44***	0.47***	0.33***	1		
ES	4.17	1.35	-0.30***	-0.02	-0.28***	0.01	1	
OLEE	3.33	0.84	0.18***	0.57***	0.23***	0.37***	0.02	1

 Table 1
 Means, standard deviations, and correlation coefficients among variables

Note: *p < 0.05,**p < 0.01,*** p < 0.001



Fig. 2 Chain mediation model of the influence of resilience on emotional engagement in online learning(cognitive reassessment outside parentheses, expressive suppression inside parentheses)

TLI = 0.894, RMSEA = 0.053. However, the model fit indices did not improve significantly compared to the model without the common method bias latent variable (Δ CFI = 0.014, Δ TLI = 0.011, Δ RMSEA = 0.002). This indicates that the fitting data of the added method factor model did not obtain significant improvement and the homologous method variation had a small impact on this study. In addition, the CFA results indicated a poor fit of the one-factor model (χ^2/df = 33.052, p < 0.01, CFI = 0.463, TLI = 0.441, RMSEA = 0.121). Therefore, it can be judged that common method bias was not serious in this study.

Correlation analysis

The correlation analysis showed that resilience was significantly positively correlated with self-regulated learning self-efficacy, self-control, cognitive reappraisal, and emotional engagement, while expressive suppression was significantly negatively correlated with resilience and self-control. See Table 1.

Mediation analysis

As the measures used in this study, including resilience, self-regulated learning self-efficacy, online learning emotional engagement, cognitive reappraisal, and expressive suppression, were all single-dimensional questionnaires, a balanced method in the factor analysis was used to improve the stability of the model estimation, the reliability of data fitting, and reduce data bias [58]. Specifically, resilience and cognitive reappraisal were combined into three indicators, self-regulated learning self-efficacy was combined into four indicators, self-control was observed as its dimension, and expressive suppression was composed of four original items. The observed variables after packaging were replaced by the average score of each item in the package. Based on the hypothesis model and the analysis of the relationships between variables, a structural equation model was established to examine the mediating effects of self-regulated learning self-efficacy, self-control, and emotion regulation strategies on the relationship between resilience and online learning emotional engagement. The model is shown in Fig. 2, with various fit indices: $\chi 2/df = 7.08$, CFI = 0.97, TLI = 0.96, IFI = 0.97, NFI = 0.96, RMSEA = 0.05, indicating a good model fit. However, the path from resilience to emotional engagement was not significant ($\beta = -0.01$, p > 0.05), the path from expressive suppression to emotional engagement was not significant ($\beta = 0.03$, p > 0.05), and the path from self-control to cognitive reappraisal was not significant ($\beta = 0.01$, p > 0.05). Therefore, after deleting these three paths, the initial model was revised, and a new model was established, with various fit indices:

Table 2Mediation effects estimated by bootstrap method and95% confidence intervals

Paths	Effect	95%C	р	
		CI-L	CI-U	-
Resilience →SRLE →OLEE	0.14	0.12	0.19	< 0.001
Resilience →SC→OLEE	0.05	0.02	0.08	< 0.001
Resilience →CR→OLEE	0.04	0.02	0.07	< 0.001
Resilience →SRLE→SC→OLEE	0.01	0.003	0.014	< 0.001
$Resilience \rightarrow SRLE \rightarrow CR \rightarrow OLEE$	0.01	0.006	0.02	< 0.001
Total indirect effect	0.25	0.22	0.31	< 0.001

 χ^2/df = 6.98, CFI = 0.97, TLI = 0.96, IFI = 0.97, NFI = 0.96, RMSEA = 0.05, indicating a good model fit.

As shown in the figure, resilience had a significant positive predictive effect on self-regulated learning self-efficacy, self-control, and cognitive reappraisal ($\beta = 0.26$, p < 0.01; $\beta = 0.52$, p < 0.01; $\beta = 0.38$, p < 0.01), and a significant negative predictive effect on expressive suppression ($\beta = -0.22$, p < 0.01). Self-regulated learning self-efficacy had a significant positive predictive effect on self-control, cognitive reappraisal, expressive suppression, and emotional engagement ($\beta = 0.31$, p < 0.01; $\beta = 0.40$, p < 0.01; $\beta = 0.16$, p < 0.01; $\beta = 0.52$, p < 0.01), while self-control had a negative predictive effect on expressive suppression ($\beta = -0.27$, p > 0.05), and both self-control and cognitive reappraisal had a significant positive predictive effect on emotional engagement ($\beta = 0.09$, p < 0.01; $\beta = 0.10$, p < 0.01).

Furthermore, the bias-corrected percentile Bootstrap method was used to test the mediating effects (with 3000 repetitions). The results showed that the mediating effects consisted of five paths: "Resilience \rightarrow SRLE \rightarrow emotional engagement", with a mediating effect value of $(0.26) \times (0.52) = 0.14$; "Resilience \rightarrow SC \rightarrow OLEE ", with a mediating effect value of $(0.52)\times(0.09) = 0.05$; "Resilience $\rightarrow CR \rightarrow OLEE$ ", with a mediating effect value of $(0.38) \times (0.10) = 0.04$; "Resilience \rightarrow SRLE \rightarrow SC \rightarrow OLEE", with a mediating effect value of $(0.26) \times (0.31) \times (0.11) = 0.01$; and "Resilience" \rightarrow SRLE \rightarrow CR \rightarrow OLEE ", with a mediating effect value of $(0.26)\times(0.40)\times(0.10) = 0.01$. The specific results are shown in Table 2. The study found a multiple mediation model of resilience in emotional engagement. By comparing path coefficients, it was found that the effect of self-regulated learning self-efficacy as a mediator was the strongest, followed by the individual mediations of self-control and cognitive reappraisal, while the chain mediation path effect was weaker.

Analysis of urban-rural differences in chain mediation effects

To further analyze the urban-rural differences in chain mediation effects, the chain mediation effects of the urban and rural samples were separately tested. The results showed that the models for both urban and rural students had good model fit indices and were acceptable for cross-group comparisons. Therefore, a non-restricted model (with the same model structure for urban and rural groups, with freely estimated path coefficients) and a restricted model (with the same model structure for urban and rural groups, with invariant factor loadings and path coefficients for latent variables across groups) were established. The results showed a significant difference between the non-restricted and restricted models $(\Delta \chi 2 = 67.71, \Delta df = 11, p < 0.01)$. The non-restricted model was better than the restricted model, indicating that there were urban-rural differences in the chain mediation effects of self-regulated learning self-efficacy, self-control, and cognitive reappraisal. The specific results are shown in Table 3.

Figure 3 shows the standardized path coefficients of the mediation model for urban students. resilience had a significant positive predictive effect on self-regulated learning self-efficacy, self-control, and cognitive reappraisal, and a significant negative predictive effect on expressive suppression. Self-regulated learning self-efficacy had a significant positive predictive effect on self-control, cognitive reappraisal, expressive suppression, and emotional engagement, while self-control had a negative predictive effect on expressive suppression. Cognitive reappraisal had a significant positive predictive effect on emotional engagement, and the predictive effect of self-control on emotional engagement was not significant. Figure 4 shows the standardized path coefficients of the mediation model for rural students. The results were similar to those for urban students.

Discussion

Based on the self-regulated learning model, this study integrated two key processes for achieving self-regulated learning and constructed a mediation model in which self-regulated learning self-efficacy and strategy use (selfcontrol and emotion regulation strategies) mediated

Table 3 Fit indices of structural equation model

Model	χ2/df	CFI	GFI	NFI	IFI	TLI	RMSEA
M urban	3.56	0.97	0.93	0.96	0.97	0.96	0.06
M rural	4.74	0.97	0.94	0.96	0.97	0.96	0.05
M Unconstrained	4.15	0.97	0.94	0.96	0.97	0.96	0.04
M constrained	4.18	0.97	0.93	0.96	0.97	0.96	0.04



Fig. 3 Chain mediation model of the influence of resilience on emotional engagement in online learning (urban)



Fig. 4 Chain mediation model of the influence of resilience on emotional engagement in online learning (rural)

the relationship between resilience and online learning emotional engagement. This study reveals the relationship between resilience and emotional engagement in online learning as well as the underlying psychological processes. The findings broaden empirical research on self-regulated learning theory and adopt an integrative perspective to examine the influences on emotional engagement.

The relationship between resilience and online learning emotional engagement

This study found that resilience had a significant indirect predictive effect on college students' emotional engagement in online learning, while the direct predictive effect was not significant. Resilience mainly affects emotional engagement in online learning by influencing self-regulated learning processes, rather than having a direct effect on emotional engagement. This result validates that the mechanism behind resilience is flexible self-regulation by the individual, which consists of three sequential steps: firstly, identifying a demanding task; secondly, utilizing multiple regulation strategies; and lastly, responding flexibly and monitoring with feedback [42]. However, the flexibility sequence has been studied mostly in isolation, and the present study verifies that resilience efficacy requires all components to work together. Compared to traditional face-to-face learning environments, online learning requires addressing more challenges, such as environmental interference, technical difficulties, and a lack of emotional support. The online learning environment has a higher demand for self-regulation skills, and learners' proactive, positive, and constructive self-regulation strategies are particularly important [16]. The use of self-regulated learning strategies shows a stronger relationship with successful learning [10, 18]. The internal mechanism of resilience is flexible self-regulation [42], it utilizes self-regulation strategies actively or passively manner and works with them to form a flexible mindset and promote higher emotional engagement.

The mediating role of self-regulated learning efficacy

This study found that self-regulated learning self-efficacy played a mediating role between resilience and emotional engagement. The results showed that resilience can enhance individuals' emotional engagement by increasing their self-regulated learning self-efficacy. This is consistent with the findings of Zimmerman et al. [26–29]. Self-regulation is important in any learning environment, whether it is traditional or online [9, 16, 59]. Students with higher levels of resilience can effectively cope with and adapt to the changing environment when facing difficulties, but to make individuals more actively and effectively engaged in online learning, resilience is a positive personality trait that facilitates this, but individuals also need to have the ability to self-regulate and the confidence to effectively complete learning tasks, which is reflected in high levels of self-regulated learning self-efficacy. A group intervention study also found that improving self-regulated learning self-efficacy can effectively improve students' academic procrastination [55]. When faced with online learning tasks, students with high selfregulated learning self-efficacy have a strong sense of purpose and value, high learning motivation, and flexible learning strategies which enable them to resist temptation, have a strong belief in completing academic tasks, and effectively promote positive emotional engagement. Therefore, in addition to enhancing students' resilience, cultivating their self-regulated learning self-efficacy is also important for promoting emotional engagement.

The mediating role of self-control

The results of this study showed that resilience can positively predict emotional engagement through selfcontrol. This finding effectively verifies Baumeister's theory of ego depletion, which suggests that the execution of self-control requires the consumption of limited resources, and resilience can provide usable resources for self-control [36–38]. Therefore, individuals with higher levels of resilience can mobilize more resources, have stronger self-control abilities, and consciously align their behavior with standards. Students with high levels of selfcontrol are more likely to reduce interference and temptation in the environment, thus persisting in activities that may be boring or challenging [60]. Previous studies have shown that self-control predicts more study time and less leisure, absence, and procrastination behavior. Tangney et al. also found that children with high self-control are better able to resist temptation, eliminate distractions, use their time effectively, and choose appropriate courses, which allows them to be fully engaged in academic areas [34, 39]. In contrast, individuals with poor self-control not only cannot effectively manage their time and eliminate distractions but may also procrastinate on tasks, which often leads to lower levels of academic engagement and poorer academic performance. Therefore, promoting learning engagement requires not only enhancing students' resilience but also strengthening their self-control abilities.

The mediating role of emotion regulation strategies

This study found that emotion regulation strategies mediate the relationship between resilience and emotional engagement. The results showed that resilience enhances emotional engagement by promoting cognitive reappraisal, while the inhibitory effect of expressive suppression was not significant. In the study of self-regulated learning, emotional regulation has not been fully studied. This study compared the effects of cognitive reappraisal and expressive suppression and found that only cognitive reappraisal can have a positive impact on emotional engagement, which contradicts the findings of Rentzios et al. [61] and is similar to the findings of Zhoc et al. [43], indicating the importance of effective emotional regulation strategies for online learning [6, 43]. The study found that cognitive reappraisal has an enhancing effect on selfcontrol in the process of resilience affecting self-control, while the inhibitory effect of expressive suppression is not significant. In other words, resilience is more conducive to promoting cognitive reappraisal, thereby enhancing emotional engagement. That is, cognitive reappraisal can help positive factors play a greater role. On the one hand, this provides empirical support for the "protective factor-protective factor model" [62], which means that the presence of one protective factor (resilience) enhances the effect of another protective factor (cognitive reappraisal), and positive factors can accumulate. On the other hand, students who have cognitive reappraisal ability can adopt an optimistic attitude, effectively overcome negative emotions in the learning process, encourage individuals to produce new vitality for tasks, enhance effort and motivation, and promote learning engagement [37]. Cognitive reappraisal adjusts students' emotions before they are stimulated, leaving effective resources for learning, which is particularly important for emotional engagement in online learning. The reason why the inhibitory effect of expressive suppression on emotional engagement prediction is not significant may be that, on the one hand, although expressive suppression can effectively reduce the behavioral expression of negative emotions, it may not weaken the subjective experience of emotions. On the other hand, expressive suppression also inhibits the expression and generation of positive emotions, weakens the individual's positive energy, and the positive efficacy of resilience cannot be effectively exerted. This result indicates that cognitive reappraisal strategy is superior to expressive suppression in completing cognitive tasks in both online and offline learning environments, and also reflects the developmental advantages of cognitive reappraisal in preserving individuals' positive resources.

Chain mediating effect

This study found a chain mediation effect of self-regulated learning efficacy, self-control, and emotion regulation strategy (cognitive reappraisal) between resilience and emotional engagement. Resilience not only predicts emotional engagement through the chain mediation effect of self-regulated learning efficacy and self-control but also affects emotional engagement through the chain mediation effect of self-regulated learning efficacy and cognitive reappraisal. The findings validate that personality traits can be precursors or potential factors that influence the SRL process [10]. Firstly, both self-control and emotion regulation strategies belong to the second stage of self-regulated learning, the performance stage. In this stage, individuals need to monitor and control their behavior, emotions, and motivation. The predictive role of self-regulated learning efficacy on self-control and the predictive role of self-regulated learning efficacy on cognitive reappraisal once again verify the sequence of the self-regulated learning theory model. Secondly, according to the social cognitive theory of self-regulated learning, students with strong self-efficacy are more likely to actively use various cognitive strategies, and effectively regulate and monitor their cognition, and learners with high levels of self-control are more likely to effectively monitor and adjust in the learning process, thereby promoting individual emotional engagement [21]. In addition, when learners perceive insufficient emotional engagement, they may call on regulation strategies to maintain or enhance it. Learners with high self-regulated learning efficacy may be more proactive in using appropriate regulation strategies to regulate the learning process. This finding provides insights into the mechanism of the role of resilience in complex cognitive processes. Previous research on SRL has found that high-achieving students use more learning strategies during the learning process, self-monitor the learning process more frequently, and adjust the pace of learning based on learning outcomes [3, 16]. This study illustrates that self-control and emotion regulation strategies are also beneficial selfregulation strategies in the learning process and can have a positive and beneficial impact on online learning emotional engagement.

It is worth noting that the mediation effect of selfregulated learning efficacy is the strongest, once again indicating that self-efficacy is an important factor in determining whether learners will actively engage in learning. The findings support the Social Cognitive Theory that "self-efficacy is a key personal determinant". Self-efficacy has significant effects on effect, performance, persistence, learning, and effort [9, 64]. However, previous studies have mostly confirmed the key role of self-efficacy in self-regulated learning [9, 10, 63], and this study highlights the significant value of self-efficacy for self-regulated learning for online learning. In addition, this study did not find a direct predictive effect of resilience on emotional engagement. We believe that the possible reasons are the relationship between resilience and emotional engagement is completely mediated by self-regulated learning efficacy, self-control, and emotion regulation strategies. The individual's resilience can only promote emotional engagement in online learning through the perception of self-regulated learning efficacy. In this process, the abilities of self-control and emotion regulation strategies are also enhanced, which is also a way to enhance individual emotional engagement. The resilience scale and online learning emotional engagement scale used in the study are different from those used by previous researchers. Whether this cultural difference is the reason for the results of this study still needs further exploration.

Urban-rural differences in the chain mediation effect

This study also found that there are urban-rural differences in the chain mediation effect. In urban groups, self-regulated learning efficacy and cognitive reappraisal completely mediate effect between resilience and online learning emotional engagement. The three intermediate paths are the separate mediation of self-regulated learning efficacy, the separate mediation of cognitive reappraisal, and the chain mediation effect of self-regulated learning efficacy and cognitive reappraisal. In rural groups, self-regulated learning efficacy, self-control, and cognitive reappraisal completely mediate effect between resilience and online learning emotional engagement. However, there are five intermediate paths, namely, the separate mediation of self-regulated learning efficacy, the separate mediation of cognitive reappraisal, the separate mediation of self-control, the chain mediation effect of self-regulated learning efficacy and cognitive reappraisal, and the chain mediation effect of self-control and cognitive reappraisal. It can be found that there is an urbanrural difference in the pathway of self-control affecting emotional engagement in online learning; for urban students, self-control is not a significant predictor of emotional engagement in online learning, but self-control can significantly and positively predict emotional engagement in online learning for rural students. This is consistent with the results of previous studies. Firstly, Relatively poor educational resources and living environments in rural areas may cause rural students to rely more on self-control to overcome difficulties and pursue academic achievement, while urban students may benefit from richer educational resources and social support, making the role of self-control in their academic development relatively less prominent. Secondly, compared to rural college students, urban students are more adaptable to the change in teaching style and have good learning conditions and psychological preparation, so urban students feel less significant self-control from emotional engagement and can complete online learning tasks successfully and timely. Thirdly, the different living environments and the variability of the resources they occupy, especially educational resources, affect the development of students' psychological qualities, while the open urban environment provides students with high-quality educational resources that are more likely to promote the formation of confident, strong, and optimistic psychological qualities, so the online learning process is less affected by psychological resilience. Finally, students from families with low socio-economic status have fewer opportunities and experiences in developing computer competencies, especially for educational purposes, which leads to fewer positive e-learning self-efficacy beliefs [64]. In contrast, urban students have parents who are more educated [46] and are more accustomed to working or learning via the Internet. Overall, there are urban-rural differences in this mediating model, so this result suggests that we should pay attention to its urban-rural contextual differences in the process of enhancing emotional engagement in online learning.

Theoretical contributions

This study, grounded in self-regulated learning (SRL) theory, integrates the analysis of resilience and emotional engagement mechanisms, expanding the traditional SRL theory in multiple ways:

Affective dimension integration: Traditional SRL theories emphasize cognitive strategies like goal-setting and motivational regulation such as self-efficacy, yet lack in affective dimension exploration. This research formalizes emotion into SRL's dynamic cycle. By uncovering emotional engagement's central role in online learning and analyzing emotion regulation strategies' mediating role in resilience-emotional engagement relationship, it supplements SRL theory with emotion-regulation pathways.

Learner trait exploration: Most traditional SRL research focuses on in-process strategy use, neglecting learner traits' impact on self-regulation. Incorporating resilience, this study shows it serves as a psychological resource, enhancing learners' self - regulation during online learning challenges.

Multidimensional synergy analysis: While traditional SRL often isolates cognitive or affective analysis, this study takes a holistic view. It reveals that online learning's affective engagement results from the synergy of cognitive, emotional (e.g., emotion regulation), and volitional (e.g., self-control) strategies.

Online learning context validation: Despite rich SRL research in traditional education, its application to online learning needs verification. Based on the Chinese educational context, this study validates SRL theory's applicability in a collectivist culture, offering new evidence for its generalizability.

In conclusion, this research strengthens the affective dimension in SRL, reveals the interaction between learner traits and dynamic regulation. These findings drive SRL theory towards more integrated, contextualized, and practice-oriented development, providing a basis for online education's theoretical innovation and teaching practice.

Insights and suggestions

This study explores the emotional engagement of college students, which has implications for effectively mobilizing students' initiative and helping them to achieve meaningful learning.

Foster resilience and cultivate positive qualities Resilience, as a positive quality, can effectively promote students' emotional engagement in online learning. Measures should be taken in teaching practice to enhance students' ability to face difficulties, withstand setbacks, cope with stress, and improve their level of resilience. Teachers can guide students to adopt positive attributional styles, enhance their confidence in their academic abilities, and encourage them to think and explore from multiple perspectives and in various ways, cultivating their self-improvement and perseverance.

Optimize learning strategies and enhance self-regulated learning efficacy The effective use of learning strategies can improve students' self-regulated learning ability and effectively promote emotional engagement. Therefore, schools can design corresponding learning strategy courses. The content of learning strategies includes self-regulated learning methods and resource management strategies. In course design, tools for selfevaluation and self-monitoring can be provided to assist students in recording and supervising their learning behaviors. In the special environment of online learning, it is particularly important to cultivate students' management of online resources, reasonably and effectively utilizing the internet, enhancing the ability to reasonably screen, judge, and use online resources, and avoiding the interference of irrelevant information. Educators should have an in-depth understanding of each rural student's learning characteristics, interests and family background, and develop personalized learning plans. For example, for students who have a weak learning foundation but are interested in agricultural production, teachers can guide them to develop a sense of learning efficacy in the learning process by independently learning about agriculture and combining subject knowledge with practical interests.

Train self-control and promote emotional engagement in online learning Self-control plays a partial mediating role between resilience and emotional engagement in online learning. Therefore, promoting self-control can promote academic performance in online learners. Educators should not only focus on imparting knowledge but also pay attention to cultivating students' abilities (selfcontrol ability) and not neglecting their qualities and overall development. In the light of the actual situation in rural areas, a variety of extracurricular activities are carried out, such as practical activities in agricultural science and technology, rural cultural research and so on. In the activities, students need to plan, organize and implement them on their own, which helps to exercise their self-regulation and self-control.

Provide support and improve emotion regulation abil-

ities The role of emotion regulation strategies reminds educators to attach importance to the positive effects of cognitive reappraisal on emotional engagement. Educators can use relevant theories to encourage college students to use cognitive reappraisal strategies and adopt cognitive-behavioral therapy to train rational thinking. Schools can provide personalized guidance and emotional communication through individual counseling or group counseling. In addition to guiding and preventing work, students should actively learn how to regulate their emotions.

Conclusion

This study provides a comprehensive perspective on the factors influencing emotional engagement in online learning among college students. Based on the theoretical model of self-regulated learning, the research integrates two key processes of self-regulated learning. It not only reveals the mechanisms through which resilience influences emotional engagement in learning but also uncovers the complex interplay of various behaviors within the self-regulated learning process. The results indicate that resilience does not directly promote emotional engagement in the online learning environment. However, it can exert a positive effect through the mediating roles of self-regulated learning efficacy, self-control, and emotion regulation strategies (cognitive reappraisal), either independently or in a chain mediation process. Particularly, self-regulated learning efficacy plays a crucial role, while expressive suppression in emotion regulation strategies does not yield positive effects. Identifying the key processes of self-regulated learning contributes to enhancing students' self-regulatory learning abilities, improving self-regulated learning strategies, and fostering their sustainable learning capabilities, ultimately transforming them into proactive and engaged learners.

Limitations and future research

Like most studies, the present study has several limitations: firstly, the study was mainly self-reported, and although the questionnaire was anonymous and did not contain sensitive topics, it was still subject to subjective bias on the part of the investigator. Future research could analyze and assess learners' emotional engagement in a multi-modal way by behavioral observations and physiological indicator measurements (e.g., eye-tracking techniques, galvanic skin response measurements, etc.) to obtain more comprehensive and objective data. Secondly, the data are cross-sectional, and although the model points out the potential direction of the relationship between the variables, future research could collect data from different points in time during the students' online learning process and incorporate multivariate methods of interviews as well as experiments to explore deeper and more complex causal relationships. Finally, the participants in this study were Chinese college students. In Chinese culture, collectivism and academic achievement are highly emphasized. Meanwhile, Chinese higher education has its own distinct features, such as the college entrance examination system and major- setting policies. These cultural and educational elements are likely to exert a unique influence on students' psychological and behavioral aspects. Consequently, they may impact the variables under investigation in our study. To enhance the generalizability of our findings and facilitate the application of relevant theories and practices in a broader scope, future research should involve more cross - cultural and cross - group studies. This will help validate and extend the results of our current study, enabling a more comprehensive understanding and practical implementation of the associated concepts.

Abbreviations

- SRLE Self regulating learning efficiency
- SC Self control
- OLEE Online learning emotional engagement
- CR Cognitive reappraisal
- ES Expressive suppression

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Author contributions

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Data availability

The datasets generated and/or analyzed in this study are not available, but maybe available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

The research was approved by the local ethics committee of Nanjing Normal University. Informed consent was obtained from all participants to be included in the study.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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