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Exploring the influence of teachers' motivating styles on college students' agentic engagement in online learning: The mediating and suppressing effects of self-regulated learning ability

Online learning has gradually become the new mainstream learning norm during the post-epidemic era. To ensure college students' online learning effectiveness, they need to be proactively engaged in their online learning, which means that they need to maintain a high level of agentic engagement. However, it is not clear what factors influence college students' agentic engagement in online learning environments. According to self-determination theory (SDT), the teacher, as an important external factor, can influence students' learning engagement and learning effectiveness. Meanwhile, self-regulated learning (SRL) ability is important for college students in online learning. Based on existing theoretical foundations, therefore, the current study attempts to explore the following research questions: Are there relationships between teachers' motivating styles (including autonomy-supportive style and controlling style), college students' online SRL ability, and college students' online learning agentic engagement? If yes, how does the former influence college students' online learning agentic engagement? To respond to these research questions, random sampling was used to collect a total of 681 valid data from college students with experience in online learning. Then, a pilot test, exploratory factor analysis, and confirmatory factor analysis were first conducted to confirm the reliability and validity of the data. Correlational and mediating analyses were then conducted using SPSS 21.0. According to the results, firstly, teachers' motivating styles (autonomy-supportive style and controlling style) and college students' online SRL ability were positively correlated with college students' online agentic engagement. Secondly, teachers' autonomy-supportive style was positively correlated with college students' online SRL ability, but the controlling style was negatively correlated with their online SRL ability. What's more, college students' online SRL ability, as a mediating factor, acted as a partial mediation between autonomy-supportive style and college students' online agentic engagement, and there was a suppressing effect of college students' SRL ability between teachers' controlling style and college students' agentic engagement. The results imply that teachers should choose motivating styles appropriately based on students' online learning characteristics and content, and college students should develop online SRL ability to improve their agentic engagement and ultimately achieve good online learning effectiveness.

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Introduction

Agentic engagement, differing from learners' cognitive, emotional, and behavioral engagement in learning, calls on students to conduct their own learning through initiative, purposive, and educationally constructive action (Bandura 2018; Reeve 2013). When students agentially engage in learning, they will proactively engage in their own learning by regulating their learning process to develop their skills and achieve good learning outcomes (Pineda-Baez et al. 2019). However, the reality is not as good as it could be (Albaqawi and Nageeb 2022). For example, in traditional learning contexts, many college students just sit quietly, and passively receive any instruction from teachers, but their minds may be agentially disengaged from the learning function; this situation is exacerbated in online learning contexts (Reeve et al. 2020).

Online learning has gradually become the new mainstream learning norm in colleges during the post-epidemic era (Tang and Mo 2022). In online learning environments, however, due to the separation of teaching and learning in time and space, as well as the lack of necessary classroom teaching interaction and effective learning supervision, college students' online learning engagement and learning outcomes have also been influenced to different degrees (Hofer et al. 2021; Li et al. 2022). Additionally, some technical problems have arisen, such as choppy audio and poor internet connections, causing interruptions to verbal and eye contact between the teacher and college students (Almusharraf & Bailey, 2021). All of the above factors can influence college students' online learning agentic engagement. In addition to these unavoidable and uncontrollable external and objective factors, what other factors can influence college students' online learning agentic engagement?

Self-determination theory (SDT) argues that the teacher, as an important external factor, can influence students' learning engagement and learning effectiveness (Deci and Ryan 2002). As the strategy choosing tendency used by teachers to motivate and sustain students' learning, teachers' motivating styles will influence college students' willingness to engage in online learning (Reeve et al. 2020). Teachers' motivating styles can be generalized into two specific mainstreams, autonomy-support style, and controlling style (Ames and Archer 1988). Previous studies have indicated that college students benefit more in learning environments where teachers provide more autonomy support, but when teachers always exert too much control, students' learning effectiveness may be diminished (Jang and Reeve 2021; Lauer-mann and Berger 2021; Reeve et al. 2014; Wu et al. 2022).

Online learning environments facilitate college students' flexibility and autonomy in managing their own learning time, space, and pace of learning (Hong et al. 2021). However, when college students are bestowed excessive freedom in online learning, their routine way of learning can easily be disrupted, creating a sense of confusion (Kim et al. 2018). Students with self-regulated learning (SRL) ability are highly cognitive and show initiative to engage in their SRL cycle process by setting learning goals, selecting appropriate strategies, monitoring the learning process and evaluating effectiveness (Winne 2022). Therefore, college students' SRL ability, as an internal factor, would influence the degree of their learning engagement (Putarek and Pavlin-Bernardic 2020). The significance of self-regulated learning (SRL) ability for mediating learning success has been shown in different learning environments (Jansen et al. 2019; Öztürk 2021).

Overall, according to previous studies, college students' agentic engagement, SRL ability and teachers' motivating styles all have a profound impact on their learning effectiveness. However, teachers and college students face different issues in online learning contexts than in traditional classrooms. It is not known whether the choice of teachers' motivating styles and college students' SRL

ability in online learning contexts have different influences on college students' online learning agentic engagement; this is therefore the issue which this study explored.

Theoretical background and research questions

Teachers' motivating styles. Teachers' motivating styles refer to teachers' tendency to use strategies to motivate and sustain students' learning (Deci and Ryan 2002), especially representing teachers' interpersonal sentiments and behaviors (Reeve 2009). According to SDT, motivating style is a relatively stable psychological trait that presents as a continuous bipolar distribution: from high control to medium control, medium support for autonomy and high support for autonomy. Among them, the level of a rank of control is collectively known as controlling style, which refers to the teacher's use of language, behavior, and other interpersonal information in instruction to compel students to think or behave in a way required by teachers (Angelica and Katz 2020; Assor et al. 2005; Reeve 2009). Contrary to this, autonomy-supportive style represents the different levels of teachers' autonomy support (Deci et al., 1981), which represents the interpersonal interaction and behavior teachers provide to acknowledge, develop, and spark college students' inner motivation (Reeve et al. 2004). However, some teachers with a controlling style believe in behaviorist reward and punishment strategies, believing that effective teaching requires firm and sustained control over the classroom and student behavior, and that any behavior outside of the lesson plan is a disruptive and threatening factor (Vermote et al. 2022). In other words, different teachers tend to choose different motivating styles according to their own teaching style and students' learning characteristics, and neither of the two motivation styles is superior or inferior.

It is an obligation of teachers to actively involve students in the instruction and to benefit from it, as argued by many studies (Atta-Owusu and Fitjar 2021; Singh et al. 2022). Meanwhile, a teacher's autonomy-supportive or controlling instructive style has a different impact on students' motivation, engagement, and final learning outcomes (Li et al. 2021; Parker et al. 2021). Autonomy-supportive style plays a role in college students' satisfaction, well-being, and adaptive environment (e.g., engagement, positive behavior) (Jang and Reeve 2021; Lauer-mann and Berger 2021), while controlling style plays a role in college students' dissatisfaction and maladaptive environment (e.g., disengagement, passive behavior) (Wu et al. 2022). However, previous studies have also pointed out that for some teachers the controlling style is particularly useful to motivate their college students' engagement (Vermote et al. 2022), whereas other teachers have argued that providing more autonomy support for college students is better for their learning (Reeve et al. 2014). In online learning environments where face-to-face teacher-student interaction no longer exists, it is unclear how the teacher's motivating styles apply and how it affects college students' online engagement.

Agentic engagement. Engagement refers to college students' active involvement in a learning activity or process (Wellborn 1992). It consists of three factors, namely behavioral, emotional, and cognitive engagement (Fredricks et al. 2004; Skinner et al. 2009). In recent years, moreover, given the recognition of learner agency (Bandura 2018) and the depth of research on learning engagement, agency has been proposed as a fourth dimension of engagement according to student-initiated pathways (Reeve and Tseng 2011). Students can intentionally and actively enrich the learning content, improve the learning environment, and personalize the learning process, rather than being limited to passively

receiving knowledge and participating in teaching and learning activities following the teacher’s instruction.

Students’ agentic engagement represents their subjective initiative in the learning process (Reeve et al. 2022). It is consistent with the view that “people need to be conscious of their role and influence and shape the environment they live in, not just become a product of it” (Bandura 2018). Related studies have suggested that agentic engagement is central to successful learning and can explain unique differences in academic achievement that are not explained by other dimensions of engagement (Reeve 2013). According to SDT, teachers, as a social factor closely related to their students, influence their development with their teaching and interpersonal characteristics (Chiu 2022). However, less research has been done on agentic engagement than on any of the other three (Benlahcene et al. 2021). Especially in online learning environments, it is not clear what factors will influence college students’ online learning agentic engagement. Thus, college students’ online agentic engagement was adopted as a dependent variable in this study.

Self-regulated learning. Self-regulated learning (SRL) is a learning style that creates an initial and constructive learning process in which learners need to set learning goals and self-monitor and control their cognitive and metacognitive processes to achieve their learning outcomes (Zimmerman 1990; Pintrich 2000). SRL has been shown to be a vital factor for achieving success in different learning functions (Öztürk 2021). A self-regulating learner generally needs to actively conduct a goal setting, self-planning, self-monitoring process to develop their self-regulated learning (Theobald 2021).

Some studies have argued that SRL ability plays an important role in achieving good learning outcomes, whether in an online or offline learning environment (Xu et al. 2023). College students’ SRL ability is affected by many personal factors (e.g., experiences, habits, conceptions, prior knowledge, epistemological beliefs) (Butler and Cartier 2018). Overall, SRL benefits college students in online learning environments, and involves their motivation, cognition, engagement, behavior, performance, and external environmental factors.

Research model and questions. This study explored the relationships between teachers’ autonomy-supportive style, controlling style, college students’ SRL ability, and agentic engagement in online learning environments. The research model (Fig. 1) shows the potential relationships between the four variables in this

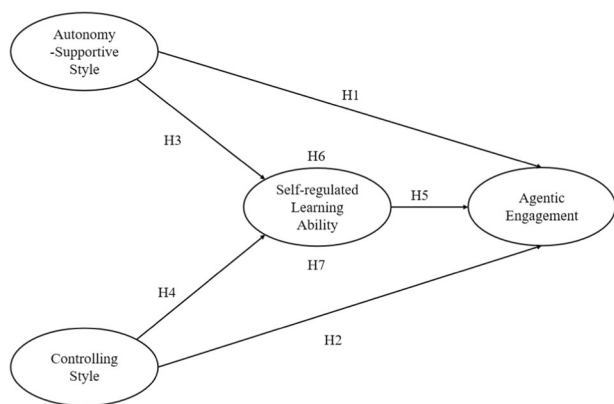


Fig. 1 Research model. The figure shows the potential relationships between autonomy-supportive style, controlling style, self-regulated learning ability, and agentic engagement.

study. Following are the specific explanations of the research questions.

Students’ agentic engagement reflects their initiative in learning (Reeve et al. 2020), and emphasizes that the relationship between students and the learning environment is not one of mere dependence, but of students consciously applying their role to influence and shape the learning environment. The level of college students’ agentic engagement directly affects their learning performance and their self-development (Zambrano et al. 2022). When the learning context moves from offline to online, college students will encounter some challenges in being able to agenticly engage in online learning contexts. For example, unfamiliarity with a new learning environment and new teaching strategies may lead to a decrease in student agentic engagement (Wang et al. 2022).

To overcome these difficulties, teachers should play their role to the fullest in full-time online learning environments. Teachers’ motivating styles will affect students’ learning engagement and motivation. Teachers’ autonomy-supportive style, as one of the motivating styles, benefits college students because of the satisfaction of the students’ need for autonomy (Reeve 2013), which can help them further develop engagement, self-regulation, and learning achievement (Yesiltepe et al. 2021). Therefore, powerful reciprocal influences have shown the factors between students’ agentic engagement and teachers’ autonomy support, which both influence college students’ academic outcomes (Patall et al. 2022; Pineda-Baez et al. 2019). Contrary to this, controlling style reflects more control by teachers over college students’ learning behaviors in the classroom. Previous studies have confirmed that teachers’ controlling style is usually detrimental to college students (Vermote et al. 2020). In online learning environments, although teachers and college students cannot interact face to face, the verbal control of the teacher from the other side of the screen may still have a negative impact on students. Based on this, the following research questions were posed:

Question 1: Is there a relationship between teachers’ autonomy-supportive style and college students’ online learning agentic engagement? How does teachers’ autonomy-supportive style influence college students’ online learning agentic engagement?

Question 2: Is there a relationship between teachers’ controlling style and college students’ online learning agentic engagement? How does teachers’ controlling style influence college students’ online learning agentic engagement?

Online learning creates a freer, more resourceful learning environment for college students, but more freedom means a lack of supervision from teachers (Bai and Gu 2022). As one of three basic psychological needs, the relatedness between college students and teachers is known to be very important to college students’ self-development (Van Egmond et al. 2020). To overcome this challenge, college students’ SRL ability is a vital factor in terms of whether they can sustain a normal learning process in online learning environments. However, many researchers have also argued that it is not easy for learners with poor online SRL ability to achieve good online learning outcomes (Rivers et al. 2021), and college students cannot initiate the self-regulated process and have trouble regulating themselves during learning processes for a variety of reasons such as unfamiliarity with SRL strategies, lack of metacognitive knowledge, lack of self-control in the regulatory process, and so on (Gambo and Shakir 2021; Theobald 2021). Teachers should therefore provide appropriate assistance. Notably, Zhou et al. (2021) suggested that relatedness positively affects college students’ online SRL ability. Therefore, teachers play an important role in SRL. Chiu (2021)

also found that the more autonomy support provided to college students, the more likely they are to conduct SRL in online learning environments. Contrary to this, when more controlling instructional behaviors are adopted by teachers, college students' routine online SRL processes can be inhibited and disrupted. Based on this, the following research questions were posed:

Question 3: Is there a relationship between teachers' autonomy-supportive style and college students' online SRL ability? How does teachers' autonomy-supportive style influence college students' online SRL ability?

Question 4: Is there a relationship between teachers' controlling style and college students' online SRL ability? How does teachers' controlling style influence college students' online SRL ability?

SRL, as an important learning strategy, requires students to proactively manage goals, time, and the learning environment to attain good learning achievement (You and Kang 2014). Meanwhile, agentic engagement refers to the active and constructive contribution of students to learning (Reeve and Tseng 2011). The level of college students' agentic engagement is also an important antecedent for college students to achieve expected academic outcomes (Reeve et al. 2020). According to the meaning of the two terms, we learn that they both emphasize the constructive role of the learning environment and the subjective role of college students in the learning function. The level of college students' online SRL ability reflects the level of college students' initiative, which, in turn, has an important influence on whether college students are agenticly engaged in the online learning process (Reeve et al. 2020). Thus, the level of SRL ability may have an impact on college students' online agentic engagement. The following research question was therefore proposed:

Question 5: Is there a relationship between college students' online SRL ability and their online learning agentic engagement? How does college students' online SRL ability influence their online learning agentic engagement?

SDT has pointed out that teachers' autonomy-supportive style, one of two teachers' motivating styles, can meet college students' basic needs and improve their learning motivation (Deci et al. 1981). Kim et al. (2021) found that teachers' autonomy support can positively influence college students' SRL self-efficacy. In addition, college students' online self-regulated ability plays an important role in their engagement, as shown by many studies (Fletcher 2016; Putarek and Pavlin-Bernardic 2020; Yoon et al. 2021). For example, Putarek and Pavlin-Bernardic revealed that perceived academic control mediated the effects of SRL on learning engagement. Yoon et al. (2021) pointed out that the use of autonomy-supportive style for SRL in flipped classrooms leads to higher levels of SRL ability and engagement. In short, teachers' motivating styles influence college students' online SRL ability, which, in turn, influences their engagement. However, so far, little empirical research has explored the role that college students' online SRL ability plays in mediating the influence of teachers' motivating styles on college students' online agentic engagement, especially in full-time online learning environments. Therefore, the following questions were proposed.

Question 6: Can college students' online SRL ability act as a mediating variable between teachers' autonomy-supportive style and college students' online agentic engagement?

Question 7: Can college students' online SRL ability act as a mediating variable between teachers' controlling style and college students' online agentic engagement?

Method

Participants and data collection. Random sampling was used in this study, and the target population was college students who had conducted online learning in China. WJX, an online platform in China which provides a powerful questionnaire collection system (Wu et al. 2018), was used for presentation of the online questionnaire and data collection in this study. The link to this online questionnaire was widely distributed to college students in one university in southern China by their teachers. Participants were given sufficient time to complete the questionnaire. Finally, a total of 702 college students participated in this study. The anonymous and voluntary principles of participation in the study, and the confidentiality of the information collected were explained to the participants in the first part of the questionnaire. This study was granted approval by the ethical committee of South China Normal University (Ethics approval number: SCNU-AIE-2023-002).

Instrument. The questionnaire consisted of two parts. Fundamental information about the participants was collected, such as gender, grade and relevant information about online learning including the main ways of online teaching in the first part. The second part comprised items with a 5-point Likert scale (from 1 "strongly disagree" to 5 "strongly agree"), which measured teacher autonomy-supportive style, controlling style, agentic engagement, and self-regulated learning ability.

Teachers' motivating styles scale. This scale, adapted from the scale developed by Lauerermann and Berger (2021), consisted of two subscales: autonomy-supportive style (8 items) and controlling style (5 items). A higher score means a better match of student-perceived teachers' motivating style in online learning. For example, "My teachers encourage me to find solutions to problems on my own in online learning" and "During the online learning process, my teachers almost never consider my opinions."

Agentic engagement scale. Based on Reeve's (2013) scale concerning agentic engagement, the online agentic engagement scale was adapted to assess college students' agentic engagement in the context of online learning. To make them more relevant to online learning, nine items were adopted as the scale. The higher the score, the better the agentic engagement. For example, "I try to make what I learn interesting."

Self-regulated learning scale. College students' online self-regulated learning was investigated through the scale adapted from Barnard et al. (2009). Six sub-dimensions were included: setting goals, constructing the learning environment, applying learning strategies, managing learning time, seeking help and self-evaluation. Higher scores mean a higher level of online self-regulated learning, for example, "I'm not going to lower the quality of my learning just because it's online."

Reliability and validity analysis. First, a pilot test was performed to ensure the normality of the questionnaire. In the process of questionnaire development, since the language of the original questionnaires was English, we first asked two researchers who are proficient in English and in related research fields of online learning to translate the questionnaire into Chinese, and then we asked two senior scholars in online learning studies to adapt the Chinese version of the questionnaire appropriately according to China's educational conditions. Then, five teachers and 10 college students who had participated in online teaching and learning were invited to fill in the questionnaire, and they were asked to

give suggestions on whether the content of the questionnaire was reasonable and whether the presentation was appropriate. According to the suggestions, the final version of the questionnaire was determined for the formal investigation. Finally, 702 college students participated in the formal investigation, and 681 valid data were collected. These data were randomly divided into two equal parts, one for exploratory factor analysis (EFA), and another for confirmatory factor analysis (CFA) (Hair et al. 2014).

Second, reliability of data can be confirmed according to internal consistency and composite reliability (CR) by EFA and CFA. Table 1 shows that the criteria of Cronbach's alpha and composite reliability (CR) were all higher than 0.9, which indicated good composite reliability. In addition, the values of factor loadings and average variance extracted were all above 0.5, which represented that the convergent validity of all variables was acceptable.

Third, CFA was performed to confirm the validity according to whether the following values reached the threshold: firstly, the values of the model fit indexes of the current model all reached the threshold; secondly, the average variance-extracted (AVE) values were greater than 0.5 (Fornell and Larcker, 1981); thirdly, the factor loadings (FLs) of all of the items were greater than 0.6. The specific results are shown in Tables 1, 2. Therefore, there was acceptable convergent validity for the current study.

Common method bias test. Harman's one-factor test was conducted to verify that common method bias (CMB) was not significant in this study (Lindell and Whitney 2001; Podsakoff et al. 2003). The result showed that the single factor accounted for 26.471% of the covariance amongst the model indicators (below 40%) (Podsakoff et al. 2003). Thus, common method bias had little impact on the results of this study.

Results

SPSS 21.0 and AMOS 24.0 were applied to analyze the data. Firstly, SPSS 21.0 was used for exploratory factor analysis, demographic analysis, and Pearson's correlation analysis to verify the potential relationships of the four variables. Then, AMOS 24.0 was used to conduct confirmatory factor analysis. Then, the Bootstrap test was conducted to examine the mediating effects through PROCESS template model 4 in SPSS 21.0. If 0 is not contained in the Bootstrap confidence interval (CI), there is a significant mediation effect (Lim et al. 2004).

Table 1 The construct reliability and validity analysis.

Variables	Cronbach's α	CR	AVE	FL
ASS (4 items)	0.938	0.935	0.783	0.825-0.933
CS (4 items)	0.946	0.948	0.819	0.823-0.971
AE (4 items)	0.933	0.935	0.784	0.823-0.919
SRL (11 items)	0.949	0.950	0.636	0.621-0.878

CR composite reliability, AVE average variance extracted, FL factor loading.

Table 2 Model Fit Indices of the confirmatory factor analysis.

χ^2/df	RMSEA	GFI	CFI	NFI	AGFI
5.668	0.076	0.914	0.966	0.959	0.883

Demographic information. A total of 681 valid data were collected for further analysis. The data consisted of 611 females (89.7%) and 70 males (10.3%). There were 206 (30.3%) first year students, 225 (33.0%) second years and 250 (36.7%) third years.

Correlational analysis. The results of means, standard deviations of autonomy-supportive style (ASS), controlling style (CS), agentic engagement (AE), and online SRL are demonstrated in Table 3. The results showed significant correlations among ASS, CS, SRL, and AE. ASS and SRL were positively correlated with AE ($r = 0.777^{**}$; $r = 0.832^{**}$), ASS was positively correlated with SRL ($r = 0.785^{**}$), while CS was negatively correlated with SRL ($r = -0.109^{**}$). A significant correlation between CS and AE was not found ($r = -0.003$).

The mediating role of SRL in the relationship between ASS and AE. PROCESS template model 4 was applied to confirm the mediation model, with college students' SRL ability as the mediator. Figure 2 has shown the results.

As shown in Table 4, teachers' autonomy-supportive style (ASS) was positively associated with college students' agentic engagement without the mediator ($\beta = 0.342$, $t = 10.101$, $p < 0.001$); Q1 was therefore responded to. When SRL was included, teachers' autonomy-supportive style was positively associated with college students' SRL ability ($\beta = 0.705$, $t = 32.100$, $p < 0.001$), which was also positively related to college students' agentic engagement ($\beta = 0.660$, $t = 17.692$, $p < 0.001$); thus, Q3 and Q5 were responded to. As for the mediating effect, it was considered significant that through college students' SRL ability, teachers' autonomy-supportive style was an indirect predictor of college students' agentic engagement. College students' SRL ability partially mediated the relation between

Table 3 Descriptive statistics of model variables and correlations among model variables.

Variables	M	SD	ASS	CS	AE	SRL
ASS	3.906	0.743	1			
CS	2.328	1.104	-0.17**	1		
AE	3.739	0.785	0.777**	-0.003	1	
SRL	3.888	0.679	0.785**	-0.109**	0.832**	1

Note. ** $p < 0.01$, means significant difference.

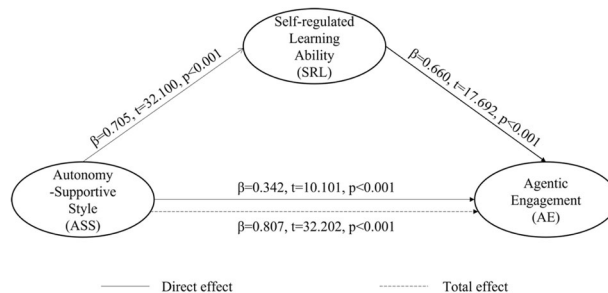


Fig. 2 Model of autonomy-supportive style and agentic engagement, mediated by self-regulated learning ability. The figure shows the relationships between autonomy-supportive style, self-regulated learning ability, and agentic engagement. Autonomy-supportive style and self-regulated learning ability are positively related to college students' online learning agentic engagement; autonomy-supportive style is positively related to college students' SRL ability; college students' SRL ability partially mediated the relation between teachers' autonomy-supportive style and college students' agentic engagement.

teachers' autonomy-supportive style and college students' agentic engagement; thus, Q6 was responded to. The results above indicate that teachers' autonomy-supportive style could improve college students' SRL ability, which in turn led to an increase in college students' agentic engagement. Table 5 shows the results of the mediating effects.

The suppressing role of SRL in the relationship between CS and AE. PROCESS template model 4 was applied to confirm the mediation model, with college students' self-regulated learning ability as the mediator. Figure 3 has shown the results.

As shown in Table 6, teachers' controlling style (CS) was positively associated with college students' agentic engagement without the mediator ($\beta = 0.063, t = 4.199, p < 0.001$); Q2 was therefore responded to. When SRL was included, teachers' controlling style was negatively associated with college students' SRL ability ($\beta = -0.067, t = -2.857, p < 0.001$); hence, Q4 was responded to. As for the mediating effect, as observed in Table 6, direct and indirect effects were significant ($\beta = 0.063, 95\% \text{ CI} = [0.034, 0.093]$; $\beta = -0.065, 95\% \text{ CI} = [-0.121, -0.014]$), but the total effect was not significant ($\beta = -0.002, 95\% \text{ CI} = [-0.056, 0.052]$). According to the comparison of indirect effect and direct effect (as shown in Table 7), when college students' SRL ability is included, the magnitude of the effect between teachers' controlling style and college students' agentic engagement is larger. That is, there is a suppressing effect of college students' SRL ability between teachers' controlling style and college students' agentic engagement (Mackinnon et al. 2000). In addition, although the total effect was not significant, it was still considered significant that through college students' SRL ability, teachers' controlling style was an indirect predictor of college students' agentic

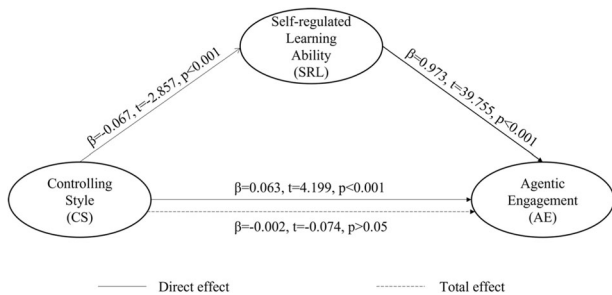


Fig. 3 Model of controlling style and agentic engagement, mediated by self-regulated learning ability. The figure shows the relationships between controlling style, self-regulated learning ability, and agentic engagement. Controlling style and self-regulated learning ability are positively related to college students' online learning agentic engagement; controlling style is negatively related to college students' SRL ability; there is a suppressing effect of college students' SRL ability between teachers' controlling style and college students' agentic engagement.

engagement (Preacher and Hayes 2008); thus, Q7 was responded to.

The above results indicate that teachers' controlling style should have a positive effect on learners, but learners' self-regulated learning ability obscures the positive effect, which results in a general negative effect. That is, the more teachers control college students, the more they will weaken their self-regulated learning ability, thus leading to a decline in their agentic engagement in online learning. Overall, teachers' controlling style and college students' SRL ability can improve college students' agentic engagement, but the negative effect of teachers' controlling style on college students' online SRL ability suppresses the improvement in college students' agentic engagement.

Discussion

This study was carried out to respond to the research questions proposed above about the relationships between teachers' motivating styles (autonomy-supportive style and controlling style), college students' agentic engagement, and college students' SRL ability in online learning contexts by conducting relevant data analysis. Following are specific explanations of the results.

Firstly, according to the results, there is a significant correlation between teachers' autonomy-supportive style and college students' agentic engagement, where the former can positively influence the latter. Likewise, there is a significant relationship between teachers' controlling style and college students' agentic engagement, where the former can positively influence the latter in online learning environments. Q1 and Q2 were therefore answered. These responses are in line with the conclusions of previous research (De Loof et al. 2021; Jang et al. 2016; Michou et al. 2021). College students in classes would show greater resiliency led by autonomy-supportive teachers (Reeve et al. 2020), which can support the answer to Q1. However, the response to Q2 contradicts the findings of previous studies, which tend to argue that teachers' controlling style can negatively influence students' learning engagement (Cohen et al. 2022; De Loof et al. 2021; Li et al. 2021; Moe and Katz, 2022). The reasons for the results of the current study may be as follows. Chirkov and Ryan (2001) once pointed out that due to college students' cultural differences, the level of benefit from teachers' autonomy support or controlling differs. In addition, although many studies have confirmed that an autonomy-supportive style is

Table 5 Direct effect, indirect effect, and total effect.

	β	SE	95%CI	
			LL	UL
Direct effect	0.342	0.034	0.275	0.408
Indirect effect	0.465	0.055	0.360	0.577
Total effect	0.807	0.026	0.000	0.756

Table 4 The mediation model of college students' online SRL ability between teachers' autonomy-supportive style and college students' agentic engagement.

Predictors	SRL				AE			
	β	SE	t	95%CI	β	SE	t	95%CI
ASS	0.705***	0.022	32.100	(0.662, 0.748)	0.342**	0.034	10.101	(0.276, 0.409)
SRL					0.660***	0.038	17.692	(0.586, 0.733)
R ²		0.622				0.734		
F		556.943				621.213		

***p < 0.001, **p < 0.01.

Table 6 The mediation model of college students' online self-regulated learning ability between teachers' controlling style and college students' agentic engagement.

Predictors	SRL				AE			
	β	SE	t	95%CI	β	SE	t	95%CI
CS	-0.067***	0.023	-2.857	(-0.113, -0.021)	0.063***	0.015	4.199	(0.033, 0.093)
SRL					0.973***	0.025	39.755	(0.925, 1.021)
R ²	0.012				0.700			
F	8.162				527.247			

Note. ***p < 0.001, means extremely significant difference.

Table 7 Direct effect, indirect effect, and total effect.

	β	SE	95%CI	
			LL	UL
Direct effect	0.063	0.015	0.034	0.093
Indirect effect	-0.065	0.027	-0.121	-0.014
Total effect	-0.002	0.027	-0.056	0.052

more beneficial to college students' self-development, in the traditional Chinese educational scenario, the class teaching system has always been applied, which requires a teacher to deal with a group of college students at the same time. To maintain good classroom discipline, a controlling style is more conducive to proper classroom teaching and learning. In online learning environments, although teachers and college students are not in the same physical space, they are still in the same virtual online learning space, characterized by collectivism (Kavrayici 2021), in which teachers usually use a controlling style as culturally normative classroom practice (Reeve et al. 2014). Thus, the findings of this study confirmed the positive correlations between teachers' autonomy-support style and controlling style and college students' online agentic engagement. In the future, the choice of teachers' motivating styles can be made according to the specific teaching scenarios, course organization, and college students' learning characteristics.

Secondly, for Q3 and Q4, the results indicated that teachers' autonomy-supportive style is positively related to college students' online SRL ability, whereas there is a negative correlation between teachers' controlling style and college students' online SRL ability. The above results were consistent with the findings of previous related studies (Bai and Gu 2022; Gan et al. 2020; Huh et al. 2017). Self-determination theory (SDT) holds that learning environment plays an important role in fostering college students' SRL ability (Boekaerts and Niemivirta 2000). As a significant role in the educational context, teachers' teaching strategies and motivating styles are closely linked to the satisfaction of learners' basic needs (Deci and Ryan 2002). SRL calls on college students to give their initiative free rein in goal setting, self-instruction, self-monitoring, and self-evaluation to achieve their academic achievement (Pintrich 2000), which cannot be done without adequate autonomy support from teachers. Teachers with autonomy-supportive style could take college students' perspectives, feelings, and perceptions into account, and provide them with appropriate information and choices, allowing them to make their own decisions (Kim et al. 2021). Therefore, teachers' autonomy-supportive style can positively influence college students' online SRL ability. Q3 was therefore answered. Contrary to this, controlling teachers are always putting pressure on college students and controlling their thoughts (Angelica and Katz 2020). Especially in online learning environments, it is even more difficult for teachers to manage online classrooms than traditional face-to-face

teaching (Puiu et al. 2023). Some teachers tend to adopt a controlling style to better manage online classes and maintain a normal teaching schedule, such as forcing college students to clock in on prescribed software, but this controlling style is opposed to the philosophy of SRL. Therefore, the findings answered Questions Q3 and Q4. In the future, in college students' online SRL processes, more learning autonomy support and less control from teachers should be given to college students when they need it.

Thirdly, according to the results, there is a significant correlation between college students' online SRL ability and their agentic engagement, where the former can positively influence the latter. Q5 was thus answered. This result was consistent with previous studies (Albaqawi and Nageeb 2022; Mega et al. 2014). Albaqawi and Nageeb (2022) once confirmed that there was a moderate significant positive correlation between academic engagement and the academic SRL score. When the learning environment moves from off-line to online, the conclusion of the current study is similar to that of previous studies. When college students conduct online SRL, they are necessarily engaged in the process of monitoring their own learning process, performing self-assessment, and adjusting their learning strategies in a timely manner (Zheng et al. 2018). Agentic engagement reflects students' constructive contribution to the instruction they receive (Reeve and Tseng 2011). Therefore, to achieve good online learning outcomes, the process of online SRL is a process in which students are agentially engaged. Therefore, undoubtedly, when college students' online SRL ability improves, it also positively influences the motivation and depth of their online agentic engagement. Q5 was answered. In the future, teachers can provide learning strategies and guidance to enhance college students' online SRL ability, thereby improving their agentic engagement in online learning.

Finally, according to the results, college students' online SRL ability, as a mediating factor, acted as a partial mediation between autonomy-supportive style and college students' online agentic engagement. Q6 was thus responded to. College students' online SRL ability, as a mediating factor, had a suppressing effect; that is, its intervention cancels out the positive effect of controlling style on college students' online agentic engagement and makes the whole path negatively correlated. Q7 was therefore answered. The following are possible interpretations of the above conclusions. Firstly, "Self-regulated" reflects that teachers should give college students appropriate freedom and help them when they need it, rather than just suppressing and controlling them (Valiente-Barroso et al. 2020); therefore, autonomy support from teachers is a necessary prerequisite for college students to develop their SRL ability. Meanwhile, when college students conduct online SRL, they are necessarily engaged in the process of regulating their own learning process, self-assessing, and adjusting their learning strategies in a timely manner (Zheng et al. 2018). Therefore, to achieve good online learning outcomes, the process of online SRL is a process in which college students are agentially engaged. In

other words, teachers' autonomy support, as a prerequisite, can positively influence the development of college students' online SRL ability, which in turn motivates them to be agenticly engaged in the learning process. Q6 was therefore responded to. Contrary to this, the indirect effect between controlling style and college students' online agentic engagement mediated by their online self-regulated learning was negative. There are individual differences between college students (Zheng et al. 2020). As each college student has different prior knowledge or experiences, they understand and interpret the learning environment differently (Beghin and Markovits 2022). Thus, for college students who struggle to self-regulate their learning, teachers' controlling style benefits them, but it may be detrimental to others (Russell et al. 2021). Furthermore, to satisfy the basic psychological needs of autonomy, relatedness, and collaboration, learning together would enhance feelings of relatedness and a sense of autonomy as learners share and discuss their learning strategies to actively engage in and contribute to the SRL process. However, online learning environments create difficulties for collaborative communication between college students and teachers. Unsurprisingly, normal self-regulated learning processes may be disrupted, thus affecting college students' online agentic engagement. What's more, the previous results have demonstrated that college students' agentic engagement can be improved in their SRL process. Nevertheless, some teachers would adopt an over-controlling style to teach college students to make online learning achieve identical pedagogical outcomes as traditional learning, which undoubtedly inhibits the process of self-regulated learning. Especially for college students, who are already adults and are capable of independent thinking (Garnett 2009), if teachers continue to exert more control over them, they may become resistant and unwilling to actively engage in the learning process. This results in the positive impact of the controlling style on agentic engagement being "suppressed" by SRL ability, reflecting a decrease in college students' online agentic engagement. Thus, Q7 was responded to. Overall, the findings implicate that teachers should be aware of the extent to which they provide autonomy support and control when teaching online. For example, when it is apparent to the teacher that college students are not engaged, are not motivated in the online classroom and do not take the initiative to answer questions, perhaps the controlling style is more likely to motivate their agentic engagement. However, when the online classroom atmosphere is better and students are motivated to speak and share their ideas, teachers should adopt the autonomy-supportive style to support their agentic construction of knowledge in the learning context.

Conclusion, limitations, and future research

To conclude, this study confirmed the relationships between teachers' motivating styles, college students' online SRL ability, and college students' online agentic engagement. First of all, the findings indicated that there is a significant correlation between teachers' autonomy-supportive style and controlling style and college students' agentic engagement, where the former can positively influence the latter. Q1 and Q2 were therefore responded to. Secondly, the results indicated that teachers' autonomy-supportive style is positively related to college students' online SRL ability, whereas there is a negative correlation between teachers' controlling style and college students' online SRL ability. Q1 and Q2 were therefore answered. Thirdly, the findings demonstrated that there is a significant correlation between college students' online SRL ability and their agentic engagement, where the former can positively influence the latter. Q5 was responded to. Finally, college students' online SRL ability, as a mediating factor, acted as a partial mediation between

autonomy-supportive style and college students' online agentic engagement. Q6 was thus answered. College students' online SRL ability, as a mediating factor, had a suppressing effect; that is, its intervention cancels out the positive effect of controlling style on college students' online agentic engagement and makes the whole path negatively correlated. Q7 was responded to. This study offers a more comprehensive perspective to understand the relationships between teachers' motivating styles, college students' SRL ability and college students' online agentic engagement. Findings can benefit researchers, teachers, and college students in their efforts to choose appropriate motivating styles to promote college students' online learning agentic engagement and further enhance college students' online learning effectiveness.

Although the current study has remarkable strengths, some limitations still exist. Only one college's data were collected. Thus, data may not be representative of all college students in China, which may impact the universality of this study's results. In addition, only four variables were investigated, and the study relied only on questionnaire data.

In future studies, cross-college data could be collected to develop more generalized perspectives on college students' online agentic engagement. In addition, the other three types of engagement (i.e., emotional, behavioral, and cognitive engagement) can be regarded as dependent variables, which may be affected by other external environmental factors. Finally, future studies could apply multiple research methods, such as interviews and qualitative analysis, to ensure the authority of the research findings.

Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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References

- Albaqawi HM, Nageeb SM (2022) The relationship between psychological well-being, academic engagement, and self-regulated learning among student nurses. *Int J Educ Sci* 36(1-3):83–90. <https://doi.org/10.31901/24566322.2022/36.1-3.1217>
- Almusharraf NM, Bailey D (2021) Online engagement during COVID-19: Role of agency on collaborative learning orientation and learning expectations. *J Comput Assist Learn* 37(5):1285–1295. <https://doi.org/10.1111/jcal.12569>
- Ames C, Archer J (1988) Achievement goals in the classroom: student learning strategies and motivation processes. *J Educ Psychol* 80(3):260–267. <https://doi.org/10.1037/0022-0663.80.3.260>
- Angelica M, Katz I (2020) Emotion regulation and need satisfaction shape a motivating teaching style. *Teach Teach* 27(5):370–387. <https://doi.org/10.1080/13540602.2020.1777960>
- Assor A, Kaplan H, Kanat-Maymon Y, Roth G (2005) Directly controlling teacher behaviors as predictors of poor motivation and engagement in girls and boys: The role of anger and anxiety. *Learn Instr* 15(5):397–413. <https://doi.org/10.1016/j.learninstruc.2005.07.008>
- Atta-Owusu K, Fitjar RD (2021) What motivates academics for external engagement? Exploring the effects of motivational drivers and organizational fairness. *Sci Public Policy* 49(2):201–218. <https://doi.org/10.1093/scipol/scab075>
- Bai X, Gu X (2022) Effect of teacher autonomy support on the online self-regulated learning of students during COVID-19 in China: the chain mediating effect of parental autonomy support and students' self-efficacy. *J Comput Assist Learn* 38(4):1173–1184. <https://doi.org/10.1111/jcal.12676>
- Bandura A (2018) Toward a psychology of human agency: pathways and reflections. *Perspect Psychol Sci* 13(2):130–136. <https://doi.org/10.1177/1745691617699280>
- Barnard L, Lan WY, To YM, Paton VO, Lai SL (2009) Measuring self-regulation in online and blended learning environments. *Int Higher Educ* 12(1):1–6. <https://doi.org/10.1016/j.iheduc.2008.10.005>

- Beghin G, Markovits H (2022) Reasoning strategies and prior knowledge effects in contingency learning. *Mem Cogn* 50(6):1269–1283. <https://doi.org/10.3758/s13421-022-01319-w>
- Benlahcene A, Awang-Hashim R, Kaur A, Wan-Din WZ (2021) Perceived autonomy support and agentic engagement among Malaysian undergraduates: the mediatory role of personal best goals. *J Furth Higher Educ* 46(1):33–45. <https://doi.org/10.1080/0309877X.2021.1879743>
- Boekaerts M, Niemivirta M (2000) Self-regulated learning: finding a balance between learning goals and ego-protective goals. In: Boekaerts M, Pintrich PR, Zeidner M (eds) *Handbook of self-regulation*, San Diego, CA: Academic Press, p 417–450. <https://doi.org/10.1016/B978-012109890-2/50042-1>
- Butler DL, Cartier SC (2018) Advancing research and practice about self-regulated learning: The promise of in-depth case study methodologies. In: Schunk DH, Greene JA (eds) *Handbook of self-regulation of learning and performance*. Routledge/Taylor & Francis Group, p 352–369
- Chirkov VI, Ryan RM (2001) Parent and teacher autonomy-Support in Russian and U.S. adolescents: Common effects on well-being and academic motivation. *J Cross-Cult Psychol* 32(5):618–635. <https://doi.org/10.1177/0022022101032005006>
- Chiu TKF (2021) Student engagement in K-12 online learning amid COVID-19: A qualitative approach from a self-determination theory perspective. *Interact Learn Environ* 29:1–14. <https://doi.org/10.1080/10494820.2021.1926289>
- Chiu TKF (2022) School learning support for teacher technology integration from a self-determination theory perspective. *ETR&D-Educ Tech Res Dev* 70(3):931–949. <https://doi.org/10.1007/s11423-022-10096-x>
- Cohen R, Katz I, Aelterman N, Vansteenkiste M (2022) Understanding shifts in students' academic motivation across a school year: the role of teachers' motivating styles and need-based experiences. *Eur J Psychol Educ* 38:963–988. <https://doi.org/10.1007/s10212-022-00635-8>
- De Loof H, Struyf A, Pauw JBD, Van Petegem P (2021) Teachers' motivating style and students' motivation and engagement in STEM: the relationship between three key educational concepts. *Res Sci Educ* 51(suppl 1):109–127. <https://doi.org/10.1007/s11165-019-9830-3>
- Deci EL, Ryan RM (2002) *Handbook of self-determination research*. University of Rochester Press, Rochester, NY
- Deci EL, Nezlek J, Sheinman L (1981) Characteristics of the rewarder and intrinsic motivation of the rewardee. *J Pers Soc Psychol* 40(1):1–10. <https://doi.org/10.1037/0022-3514.40.1.1>
- Deci EL, Schwartz AJ, Sheinman L, Ryan RM (1981) An instrument to assess adults' orientations toward control versus autonomy with children: Reflections on intrinsic motivation and perceived competence. *J Educ Psychol* 73(5):642–650. <https://doi.org/10.1037/0022-0663.73.5.642>
- Fletcher AK (2016) Exceeding expectations: scaffolding agentic engagement through assessment as learning. *Educ Res* 58(4):400–419. <https://doi.org/10.1080/00131881.2016.1235909>
- Fornell C, Larcker DF (1981) Evaluating structural equation models with unobservable variables and measurement error. *J Mark Res* 18(1):39–50. <https://doi.org/10.2307/3151312>
- Fredricks JA, Blumenfeld PC, Paris AH (2004) School engagement: Potential of the concept, state of the evidence. *Rev Educ Res* 74(1):59–109. <https://doi.org/10.3102/00346543074001059>
- Gambo Y, Shakir MZ (2021) Review on self-regulated learning in smart learning environment. *Smart Learn Env* 8(1):12. <https://doi.org/10.1186/s40561-021-00157-8>
- Gan Z, Liu F, Yang CCR (2020) Student-teachers' self-efficacy for instructing self-regulated learning in the classroom. *J Educ Teach* 46(1):120–123. <https://doi.org/10.1080/02607476.2019.1708632>
- Garnett RF (2009) Liberal learning as freedom: a capabilities approach to undergraduate education. *Stud Philos Educ* 28(5):437–447. <https://doi.org/10.1007/s11217-009-9126-6>
- Hair JF, Black WC, Babin BJ, Anderson RE (2014) *Multivariate data analysis: Pearson new international edition*. Pearson Education Limited, Essex, England
- Hofer SI, Nistor N, Scheibenzuber C (2021) Online teaching and learning in higher education: Lessons learned in crisis situations. *Comput Hum Behav* 121:106789. <https://doi.org/10.1016/j.chb.2021.106789>
- Hong JC, Lee YF, Ye JH (2021) Procrastination predicts online self-regulated learning and online learning ineffectiveness during the coronavirus lockdown. *Pers Individ Dif* 174:110673. <https://doi.org/10.1016/j.paid.2021.110673>
- Huh Y, Reigeluth CM, Reigeluth CM (2017) Online K-12 Teachers' Perceptions and Practices of Supporting Self-Regulated Learning. *J Educ Comput Res* 55(8):1129–1153. <https://doi.org/10.1177/0735633117699231>
- Jang H, Kim EJ, Reeve J (2016) Why students become more engaged or more disengaged during the semester: A self-determination theory dual-process model. *Learn Instr* 43:27–38. <https://doi.org/10.1016/j.learninstruc.2016.01.002>
- Jang HR, Reeve J (2021) Intrinsic instructional goal adoption increases autonomy-supportive teaching: A randomized control trial and intervention. *Learn Instr* 73:101415. <https://doi.org/10.1016/j.learninstruc.2020.101415>
- Jansen RS, Van Leeuwen A, Janssen J, Jak S, Kester L (2019) Self-regulated learning partially mediates the effect of self-regulated learning interventions on achievement in higher education: a meta-analysis. *Educ Res Rev* 28:100292. <https://doi.org/10.1016/j.edurev.2019.100292>
- Kavrayici C (2021) The relationship between classroom management and sense of classroom community in graduate virtual classrooms. *Turk Online J Distance Educ* 22(2):112–125. <https://doi.org/10.17718/tojde.906816>
- Kim TD, Yang MY, Bae J, Min BA, Lee I, Kim J (2018) Escape from infinite freedom: Effects of constraining user freedom on the prevention of dropout in an online learning context. *Comput Hum Behav* 66:217–231. <https://doi.org/10.1016/j.chb.2016.09.019>
- Kim YE, Yu SL, Shin J (2021) How temptation changes across time: effects of self-efficacy for self-regulated learning and autonomy support. *Educ Psychol* 42(3):278–295. <https://doi.org/10.1080/01443410.2021.2009774>
- Lauermann F, Berger JL (2021) Linking teacher self-efficacy and responsibility with teachers' self-reported and student-reported motivating styles and student engagement. *Learn Instr* 76(3):101441. <https://doi.org/10.1016/j.learninstruc.2020.101441>
- Li J, Yao M, Liu H, Zhang L (2021) Influence of personality on work engagement and job satisfaction among young teachers: mediating role of teaching style. *Curr Psychol* 42:1817–1827. <https://doi.org/10.1007/s12144-021-01565-2>
- Li Q, Qiang Q, Liang JC, Pan XZ, Zhao W (2022) The influence of teaching motivations on student engagement in an online learning environment in China. *Australas J Educ Technol* 38(6):8–20. <https://doi.org/10.1007/s12144-021-01565-2>
- Lim JH, Shin SW, Kim DK, Park DH (2004) Bootstrap confidence intervals for steady-state availability. *Asia Pac J Oper Res* 21(3):407–419. <https://doi.org/10.1142/S021759590400031X>
- Lindell MK, Whitney DJ (2001) Accounting for common method variance in cross-sectional research designs. *J Appl Psychol* 86(1):114–121. <https://doi.org/10.1037/0021-9010.86.1.114>
- Mackinnon DP, Krull JL, Lockwood CM (2000) Equivalence of the mediation, confounding and suppression effect. *Prev Sci* 1(4):173–181. <https://doi.org/10.1023/A:1026595011371>
- Mega C, Ronconi L, De Beni R (2014) What makes a good student? How emotions, self-regulated learning, and motivation contribute to academic achievement. *J Educ Psychol* 106(1):121–131. <https://doi.org/10.1037/a0033546>
- Michou A, Altan S, Mouratidis A, Reeve J, Malmberg LE (2021) Week-to-week interplay between teachers' motivating style and students' engagement. *J Exp Educ* 91(1):166–185. <https://doi.org/10.1080/00220973.2021.1897774>
- Moe A, Katz I (2022) Need satisfied teachers adopt a motivating style: The mediation of teacher enthusiasm. *Learn Individ Differ* 99:102203. <https://doi.org/10.1016/j.lindif.2022.102203>
- Öztürk M (2021) The effect of self-regulated programming learning on undergraduate students' academic performance and motivation. *Interact Technol Smart Educ* 19(3):319–337. <https://doi.org/10.1108/ITSE-04-2021-0074>
- Parker JS, Parris L, Lau M, Dobbins A, Shatz L, Porush S, Wilkins B (2021) Perceived teacher autonomy support and self-determination skill expression: predictors of student engagement among African American high school students. *J Black Psychol* 47(6):445–475. <https://doi.org/10.1177/00957984211009190>
- Patall EA, Kennedy AAU, Yates N, Zambrano J, Lee DE, Vite A (2022) The relations between urban high school science students' agentic mindset, agentic engagement, and perceived teacher autonomy support and control. *Contemp Educ Psychol* 71(1):102097. <https://doi.org/10.1016/j.cedpsych.2022.102097>
- Pineda-Baez C, Manzuoli CH, Sanchez AV (2019) Supporting student cognitive and agentic engagement: Students' voices. *Int J Educ Res* 96(3):81–90. <https://doi.org/10.1016/j.ijer.2019.06.005>
- Pintrich PR (2000) The role of goal orientation in self-regulated learning. In: Boekaerts M, Pintrich P, Zeidner M (eds) *Handbook of self-regulation*. Academic Press, San Diego, CA, p 451–502. <https://doi.org/10.1016/B978-012109890-2/50043-3>
- Podsakoff PM, MacKenzie SB, Lee JY, Podsakoff NP (2003) Common method biases in behavioral research: a critical review of the literature and recommended remedies. *J Appl Psychol* 88(5):879–903. <https://doi.org/10.1037/0021-9010.88.5.879>
- Preacher KJ, Hayes AF (2008) Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behav Res Methods* 40(3):879–891. <https://doi.org/10.3758/BRM.40.3.879>
- Puiu S, Idowu SO, Meghisan-Toma GM, Badircea RM, Doran NM, Manta AG (2023) Online education management: a multivariate analysis of students' perspectives and challenges during online classes. *Electronics* 12(2):454. <https://doi.org/10.3390/electronics12020454>
- Putarek V, Pavlin-Bernardic N (2020) The role of self-efficacy for self-regulated learning, achievement goals, and engagement in academic cheating. *Eur J Psychol Educ* 35(3):647–671. <https://doi.org/10.1007/s10212-019-00443-7>
- Reeve J (2009) Why teachers adopt a controlling motivating style toward students and how they can become more autonomy supportive. *Educ Psychol* 44(3):159–175. <https://doi.org/10.1080/00461520903028990>

- Reeve J (2013) How students create motivationally supportive learning environments for themselves: The concept of agentic engagement. *J Educ Psychol* 105(3):579–595. <https://doi.org/10.1037/a0032690>
- Reeve J, Cheon SH, Jang H (2020) How and why students make academic progress: Reconceptualizing the student engagement construct to increase its explanatory power. *Contemp Educ Psychol* 62(1):101899. <https://doi.org/10.1016/j.cedpsych.2020.101899>
- Reeve J, Cheon SH, Yu TH (2020) An autonomy-supportive intervention to develop students' resilience by boosting agentic engagement. *Int J Behav Dev* 44(4):325–338. <https://doi.org/10.1177/0165025420911103>
- Reeve J, Jang H, Carrell D, Jeon S, Barch J (2004) Enhancing students' engagement by increasing teachers' autonomy support. *Motiv Emot* 28:147–169. <https://doi.org/10.1023/B:MOEM.0000032312.95499.6f>
- Reeve J, Jang HR, Shin SH, Ahn JS, Matos L, Gargurevich R (2022) When students show some initiative: Two experiments on the benefits of greater agentic engagement. *Learn Instr* 80(2):101564. <https://doi.org/10.1016/j.learninstruc.2021.101564>
- Reeve J, Tseng CM (2011) Agency as a fourth aspect of students' engagement during learning activities. *Contemp Educ Psychol* 36(4):257–267. <https://doi.org/10.1016/j.cedpsych.2011.05.002>
- Reeve J, Vansteenkiste M, Assor A, Ahmad I, Cheon SH, Jang H, Kaplan H, Moss JD, Olausson BS, Wang CKJ (2014) The beliefs that underlie autonomy-supportive and controlling teaching: a multinational investigation. *Motiv Emot* 38(1):93–110. <https://doi.org/10.1007/s11031-013-9367-0>
- Rivers DJ, Nakamura M, Vallance M (2021) Online self-regulated learning and achievement in the era of change. *J Educ Comput Res* 60(1):104–131. <https://doi.org/10.1177/07356331211025108>
- Russell JM, Baik C, Ryan AT, Molloy E (2021) Fostering self-regulated learning in higher education: making self-regulation visible. *Act Learn High Educ* 23(2):97–113. <https://doi.org/10.1177/1469787420982378>
- Singh M, James PS, Paul H, Bolar K (2022) Impact of cognitive-behavioral motivation on student engagement. *Heliyon* 8(7):e09843. <https://doi.org/10.1016/j.heliyon.2022.e09843>
- Skinner EA, Kindermann TA, Furrer CJ (2009) A motivational perspective on engagement and disaffection: Conceptualization and assessment of children's behavioral and emotional participation in academic activities in the classroom. *Educ Psychol Meas* 69(3):493–525. <https://doi.org/10.1177/0013164408323233>
- Tang JT, Mo DJ (2022) The transactional distance in the space of the distance learning under post-pandemic: a case study of a middle school in Northern Taiwan using gather to build an online puzzle-solving activity. *Interact Learn Environ*. <https://doi.org/10.1080/10494820.2022.2121731>
- Theobald M (2021) Self-regulated learning training programs enhance university students' academic performance, self-regulated learning strategies, and motivation: a meta-analysis. *Contemp Educ Psychol* 66:101976. <https://doi.org/10.1016/j.cedpsych.2021.101976>
- Valiente-Barroso C, Suarez-Riveiro JM, Martinez-Vicente M (2020) Self-regulated learning, school stress and academic achievement. *European J Ed Psychol* 13(2):161–176. <https://doi.org/10.30552/ejep.v13i2.358>
- Van Egmond MC, Hanke K, Omarshah TT, Berges AN, Zango V, Sieu C (2020) Self-esteem, motivation, and school attendance among sub-Saharan African girls: a self-determination theory perspective. *Int J Psychol* 55(5):842–850. <https://doi.org/10.1002/ijop.12651>
- Vermote B, Aelterman N, Beyers W, Aper L, Buysschaert F, Vansteenkiste M (2020) The role of teachers' motivation and mindsets in predicting a (de) motivating teaching style in higher education: a circumplex approach. *Motiv Educ* 44(2):270–294. <https://doi.org/10.1007/s11031-020-09827-5>
- Vermote B, Vansteenkiste M, Aelterman N, Van der Kaap-Deeder J, Beyers W (2022) Teacher' psychological needs link social pressure with personal adjustment and motivating teaching style. *J Exp Educ* 91(4):696–717. <https://doi.org/10.1080/00220973.2022.2039584>
- Wang Y, Cao Y, Gong S, Wang Z, Li N, Ai L (2022) Interaction and learning engagement in online learning: The mediating roles of online learning self-efficacy and academic emotions. *Learn Individ Differ* 94(2):102128. <https://doi.org/10.1016/j.lindif.2022.102128>
- Wellborn JG (1992) Engaged and disaffected action: the conceptualization and measurement of motivation in the academic domain. *University of Rochester* 53(2-B):1099
- Winne PH (2022) Modeling self-regulated learning as learners doing learning science: How trace data and learning analytics help develop skills for self-regulated learning. *Metacogn Learn* 17(3):773–791. <https://doi.org/10.1007/s11409-022-09305-y>
- Wu G, Zhang L, Liu X, Liang Y (2022) How school principals' motivating style stimulates teachers' job crafting: A self-determination theory approach. *Curr Psychol*. <https://doi.org/10.1007/s12144-022-03147-2>
- Wu SJ, Bai X, Fiske ST (2018) Admired rich or resented rich? How two cultures vary in envy. *J Cross-Cult Psychol* 49(7). <https://doi.org/10.1177/0022022118774943>
- Xu Z, Zhao Y, Liew J, Zhou X, Kogut A (2023) Synthesizing research evidence on self-regulated learning and academic achievement in online and blended learning environments: a scoping review. *Educ Res Rev* 39:100510. <https://doi.org/10.1016/j.edurev.2023.100510>
- Yesiltepe A, Sayar S, Cal A (2021) Investigation of the effect of the life satisfaction and psychological well-being of nursing students on their happiness levels. *Perspect Psychiatr Care* 58(2):541–548. <https://doi.org/10.1111/ppc.13012>
- Yoon M, Hill J, Kim D (2021) Designing supports for promoting self-regulated learning in the flipped classroom. *J Comput High Educ* 33(2):398–418. <https://doi.org/10.1007/s12528-021-09269-z>
- You JW, Kang M (2014) The role of academic emotions in the relationship between perceived academic control and self-regulated learning in online learning. *Comput Educ* 77:125–133. <https://doi.org/10.1016/j.compedu.2014.04.018>
- Zambrano J, Kennedy AAU, Aguilera C, Yates N, Patall EA (2022) Students' beliefs about agentic engagement: a phenomenological study in urban high school physical science and engineering classes. *J Educ Psychol* 114(5):1028–1047. <https://doi.org/10.1037/edu0000690>
- Zheng LQ, Li X, Chen FY (2018) Effects of a mobile self-regulated learning approach on students' learning achievements and self-regulated learning skills. *Innov Educ Teach Int* 55(6):616–624. <https://doi.org/10.1080/14703297.2016.1259080>
- Zheng Y, Yu SL, Liu ZY (2020) Understanding individual differences in lower-proficiency students' engagement with teacher written corrective feedback. *Teach High Educ* 28(2):301–321. <https://doi.org/10.1080/13562517.2020.1806225>
- Zhou X, Chai CS, Jong MSY, Xiong X (2021) Does relatedness matter for online self-regulated learning to promote perceived learning gains and satisfaction? *Asia-Pacific Edu Res* 30(3):205–215. <https://doi.org/10.1007/s40299-021-00579-5>
- Zimmerman BJ (1990) Self-regulated learning and academic achievement: an overview. *Educ Psychol* 25(1):3–17. https://doi.org/10.1207/s15326985ep2501_2

Author contributions

All authors contributed equally to the conception of the idea, implementing, and analyzing the experimental results, writing the manuscript, and reading and approving the final version of the manuscript.

Competing interests

The authors declare no competing interests.

Ethics approval

The questionnaire and methodology for this study were approved by the Ethics Committee of South China Normal University (Ethics approval number: SCNU-AIE-2023-002).

Informed consent

Written informed consent for participation was not required for this study in accordance with the anonymous principle of participation in the study.

Additional information

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