



Grit and college students' learning engagement: Serial mediating effects of mastery goal orientation and cognitive flexibility

Hui Zhao¹ · Zhen Zhang¹ · Shupeng Heng¹

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Abstract

This study explored the relationship between grit and learning engagement among Chinese college students and examined the mechanisms behind that relationship based on character strengths and self-determination theories. 1025 college students from Chinese universities were surveyed by questionnaire. A positive correlation was found between grit and mastery goal orientation, cognitive flexibility, and learning engagement. Furthermore, both mastery goal orientation and cognitive flexibility mediated the connection between grit and learning engagement, and served as serial mediators. This study elucidates how grit influences learning engagement in higher education and provides a theoretical basis for improving college students' learning engagement.

Keywords Grit · Learning engagement · Mastery goal orientation · Cognitive flexibility

Introduction

Enhancing learning engagement is a vital element in improving students' "learning to learn" literacy and education quality (Jia et al., 2020). Learning engagement refers to a positive, consistent, and emotionally satisfying state students experience during their studies, characterized by absorption in learning-related tasks, dedication to learning, and vigor toward learning (Schaufeli et al., 2002). Learning engagement is an indicator of students' involvement in the learning process and a key measure of learning ability (Fredricks et al., 2004), and is an effective way to improve academic performance and reduce dropout rates (Wang & Eccles, 2012). It is also a crucial indicator of the effectiveness of higher education (Kim, 2014) and significantly impacts students' academic performance and achievement (Reeve & Tseng, 2011; Zhao et al., 2021). Therefore, an investigation into how to enhance students' learning engagement is essential.

Self-determination theory postulates that individuals engage in activities that interest them and contribute to their growth and development in a self-determined manner (Ryan

& Deci, 2000). Grit is the trait of "perseverance and interest for long-term goals" (Duckworth & Quinn, 2009). Gritty students tend to adhere to goals and interests and study hard despite setbacks or obstacles. This quality is crucial in promoting academic achievement (Tang et al., 2021) and success (Usher et al., 2019) in the learning environment. However, grit and academic performance have been found to have no, or only a moderate, correlation (Credé et al., 2017; Lam & Zhou, 2019) with academic achievement (Al-Mutawah & Fateel, 2018). Given these mixed results, grit's influence on education is controversial and requires further exploration. Robinson (2015) argued that a relatively limited amount of research has identified the connection between grit and engagement. Research on whether learning engagement mediates grit's relationship with other outcome factors (Lan & Moscardino, 2019; Yoon et al., 2018) is also limited, and has not revealed the underlying mechanisms between grit and learning engagement. However, grit is more closely linked to learning engagement than achievement, which may indicate that engaging in learning is a more direct outcome of grit (Tang et al., 2019). Therefore, this study investigated the positive connection between grit and learning engagement, and the mechanisms involved.

Grit level varies with age and education (Duckworth et al., 2007). A steady increase in adults' grit from ages 20 to 60 (Duckworth & Eskreis-Winkler, 2013). Whether grit substantially impacts learning engagement in the university

✉ Hui Zhao
zhaohui@htu.edu.cn

¹ Faculty of Education, Henan Normal University, Xinxiang, China

environment needs further investigation (Hodge et al., 2018). Additionally, grit is not equally beneficial for all students worldwide (Allen et al., 2021). For example, grit positively predicted academic motivation in Mexican American adolescents (Piña-Watson et al., 2015); however, an analysis of grit among African American high school students indicated that student achievement was not significantly impacted by it (Dixson et al., 2017). This suggests that cultural factors may affect grit's importance for learning. Indeed, cultural factors may explain why Asian American youths tend to exhibit task persistence and invest more effort in academic tasks than European American students (Hsin & Xie, 2014). Perseverance has a greater impact on achievement than in Western cultures than in East Asian cultures (Xu et al., 2023). In the Chinese culture, the concept of "grit" is valued, as reflected in a nationally known fable, "The foolish old man removed the mountains," that shows that one can achieve any goal with enough grit. Thus, research focusing on Chinese culture is necessary to comprehensively test how grit influences college students' learning engagement.

Character strengths theory asserts that individuals' positive personality traits reflect their advantages through motivation, cognition, and behavior (Peterson & Seligman, 2004). Therefore, this study proposes that mastery goal orientation and cognitive flexibility may explain how grit impacts college students' learning engagement in the Chinese cultural context. The main objectives were to (a) investigate grit's relationship with learning engagement among Chinese college students and (b) identify the mechanisms underlying the above relationship. Consequently, it elucidates how grit contributes to learning engagement in higher education, further expands the theory of character strengths and self-determination, and enhances the analytical framework for learning engagement in higher education.

Grit and learning engagement

The learning process is gradual and requires constant effort (Binning et al., 2018). Learning engagement reflects high mental energy while learning, being deeply engrossed in learning, and a sense of inspiration, significance, enthusiasm, and pride for engaging in learning (Alrashidi et al., 2016). Engaged students feel energized and passionate and become "immersed" when they learn. Grit refers to consistency of interest and a high level of persistent effort to achieve long-term goals, which is a critical personality trait from the perspective of positive psychology (Duckworth et al., 2007). Many personal traits associated with grit are known to contribute to successful performance, including self-regulation (regulating thoughts, emotions, and behaviors that interfere with task performance), self-control (resisting transient temptations to accomplish long-term objectives), and task persistence (completing a task that has already been begun)

(Hwang & Nam, 2021). Grit demonstrates a student's ability to persevere despite obstacles, an essential characteristic for academic success (Duckworth et al., 2007). It is difficult for students with low grit to actively strive because they easily become discouraged when encountering obstacles and their interest in a goal tends to wane quickly. However, grit is malleable and can be enhanced through deliberate practice, interest maintenance, and other measures (Hellman & Gwinn, 2017).

In organizational contexts, researchers agree that gritty individuals exhibit strong work engagement (Suzuki et al., 2015). As a result, these individuals devote more energy to their tasks, as they are persistent and passionate about achieving long-term goals (Southwick et al., 2019). In academic contexts, grit can promote students' academic (Lee & Rhee, 2021), curricular (Robinson, 2015), and school engagement (Muenks et al., 2017; O'Neal et al., 2018). Gritty students put more time and effort toward their studies, which significantly impacts their academic success. Character strengths theory postulates that grit helps individuals invest more time and energy in trying or sticking to tasks that interest them (Peterson & Seligman, 2004); one dominant strength is maintaining individual academic performance (Weber & Ruch, 2012). Self-determination theory emphasizes that individuals' behavior is based on their innate, intrinsic tendencies (Ryan & Deci, 2000). Gritty individuals tend to succeed academically is because they persevere through difficulties and work hard to achieve goals, internalizing the value of learning and enhancing their motivation (Jiang et al., 2018). A few studies have demonstrated that grit plays a key role in engaging students in learning (e.g., Lan and Moscardino, 2019; Yoon et al., 2018), and gritty students reported greater learning engagement (Lan & Moscardino, 2019). Gritty learners are likely to maintain self-regulated learning, suggesting grit acts on perceived achievement through learning engagement (Yoon et al., 2018). Although these studies have explored the strong connection between grit and learning engagement, how grit affects learning engagement remains unclear. Moreover, the abovementioned studies focused on adolescents (Lan & Moscardino, 2019) or non-Chinese students (Yoon et al., 2018). Therefore, based on character strengths and self-determination theories, hypothesis is proposed:

Hypothesis 1: Grit and learning engagement are positively correlated.

The mediating role of mastery goal orientation

Motivation to achieve is the essential driving force affecting learning engagement (Christenson et al., 2012). Achievement motivation theory regards goal orientation as a form of motivation reflecting beliefs about developing one's abilities and guiding individuals to navigate

and participate in their environment (Dweck & Leggett, 1988). The theory posits that different achievement goals produce a variety of behavioral patterns and emotional processes (Dweck & Leggett, 1988). Achievement goal orientation is divided into mastery and performance types. Mastery-oriented individuals pay more attention to intrinsic value, acquire new knowledge and skills to improve their abilities, and exhibit a higher tolerance for failure. Performance-oriented individuals are more concerned with gaining validation through external approval; thus, they tend to avoid difficulty or uncertainty (Sackett et al., 2017). This study focused on students who exhibit a mastery goal orientation and achieve deep learning. Mastery goal orientation stems from mastery motivation; its most powerful component is the belief that effort and results are related (Valentini & Rudisill, 2006). Mastery motivation drives individuals to make independent, focused, and sustained efforts to master complex skills or tasks or solve complex problems that are at least moderately challenging (Morgan et al., 1990). Conversely, performance-goal-oriented students see learning as a way to demonstrate excellence (Valentini & Rudisill, 2006); they strive to prove they are more capable than others and avoid poor performance, so they tend to accept superficial learning (Alhadabi & Karpinski, 2020). Mastery-oriented students prefer classes that provide tasks that are at least moderately challenging, to learn new things.

Based on the character strengths theory, gritty individuals voluntarily take purposeful action despite challenges, choosing long-term, ambitious goals (Peterson & Seligman, 2004). Self-determination theory posits that individuals' internal tendencies determine their goals (Ryan & Deci, 2000). Grit is closely related to executive brain function, and goal-oriented behavior involves executive brain function (Barkley, 2005). Grit involves long-term perseverance and a high level of interest, which may indicate that gritty individuals tend to maintain a mastery goal orientation (Kim, 2015; Wolters & Hussain, 2015). Through strong mastery goals and intrinsic motivation, persistence positively correlates with achievement (Karlen et al., 2019). Putwain et al. (2018) reported that mastery methods can be used to predict achievement based on behavioral engagement. Furthermore, students who exhibit mastery goal orientations regard tasks that are at least moderately challenging as opportunities and maintain a desire to acquire knowledge and skills for self-development through higher learning engagement (Huang et al., 2019). A recent study also indicates that grit positively affects students' academic performance through mastery goal orientation (Alhadabi & Karpinski, 2020). Based on the above, gritty students can maintain a mastery goal orientation when faced with new knowledge or at least moderate challenges, increasing learning engagement. Therefore, hypothesis is proposed:

Hypothesis 2: Mastery goal orientation mediates the relationship between grit and learning engagement.

The mediating role of cognitive flexibility

Cognitive flexibility, a key factor of cognitive control, refers to individuals' ability to adjust thinking strategies in changing environments to overcome fixation and adapt to new situations (Moore & Malinowski, 2009). Cognitive flexibility includes the abilities to find alternative solutions to a given problem and proactively adapt to the environment and the self-efficacy to believe that you are flexible enough (Zhou et al., 2021). Cognitive flexibility describes the ability to select appropriate responses and inhibit irrelevant responses during an activity (Rende, 2000). Cognitively flexible individuals are willing to listen to and consider different perspectives and can find effective ways to cope with seemingly unsolvable problems. Based on character strengths theory and motivation, the cognitive factors in the connection between grit and learning engagement need to be considered. Currently, it is not clear whether grit and cognitive flexibility are significantly related. Some researchers believe that gritty individuals may oppose switching strategies or shifting to more meaningful objectives (Lucas et al., 2015). For example, perseverance predicted effort on difficult puzzles by reducing cognitive flexibility (Kalia et al., 2019). Conversely, another study demonstrated that gritty students showed strong intrinsic motivation and attempted a greater variety of cognitive strategies (Wolters & Hussain, 2015). To persevere, gritty students actively adjust their cognitive and learning strategies when encountering difficulties or challenges (Jiang et al., 2018). Duckworth and Gross (2014) asserted that grit facilitates success in achieving long-term goals by promoting individual flexibility in strategies adopted to achieve enduring goals. Thus, this study investigates whether grit positively predicts cognitive flexibility to examine this inconsistency in research findings.

Cognitive flexibility promotes students' positive attitudes toward and motivation for learning and enhances learning preparation (Vitiello et al., 2011). Cognitively flexible students can acquire more new knowledge and have a rich accumulation of learning (Li et al., 2006) because this flexibility affects the efficiency of learning new knowledge and solving new problems and helps them better adapt to learning (Chow et al., 2016; Mu & Chen, 2013). Additionally, such individuals are more focused and insightful (Das et al., 2017). Flexible thinking significantly supports learners in selecting knowledge information, adapting to different roles, and embracing changes in new learning environments (Bentley, 2014). Cognitively flexible students become active participants rather than passive listeners in the learning process, resulting in greater learning engagement in the learning process (Orakçı, 2021). Empirical studies show

that cognitive flexibility positively correlates with students' learning engagement (Çelikkaleli, 2014; Tseng et al., 2020). This study aimed to verify how gritty students appropriately consider multiple factors and try to change strategies to seek solutions and answers. Such students do so by coping with changing learning problems and environments. Ultimately, these individuals will better devote themselves to learning. Thus, hypothesis is proposed:

Hypothesis 3: Cognitive flexibility mediates the relationship between grit and learning engagement.

The serial mediating role of mastery goal orientation and cognitive flexibility

The type and level of motivation affect the specific cognitive processes students use in learning (Covington, 2000). Achievement goal orientation determines whether individuals adopt active or avoidant strategies to deal with challenges and learning opportunities (Elliot & Church, 1997). Mastery-oriented students try to gain novel insights about the study material before them; therefore, they use deep cognitive processing to improve comprehension (Sins et al., 2008). Deep cognitive processing involves comprehending the material being learned, identifying patterns in a flexible manner, and combining new information with previous knowledge (Toraman et al., 2020). Mastery-oriented students tend to monitor their ongoing performance and promptly modify and improve their cognitive and learning strategies (Vrugt & Oort, 2008). Individuals possessing cognitive flexibility may exhibit a heightened awareness of their will before taking action (Orakçı, 2021). According to research, a positive correlation exists between approach motivation and cognitive flexibility (Baas et al., 2011; Shao et al., 2018). Thus, mastery goal orientation may exert a positive influence on cognitive flexibility.

Character strengths theory postulates that individuals' positive character qualities influence future achievement through intrinsic factors such as cognition and motivation (Peterson & Seligman, 2004). Extended construction theory holds that individuals will have a non-specific goal orientation when they experience positive emotions, and

consequently become more focused and actively seek self-development (Fredrickson & Branigan, 2005). Passionate individuals are inclined to try new methods, develop new problem-solving strategies, and try untested methods to complete tasks (Fredrickson & Branigan, 2005). Encompassing persistent interests or passions, grit promotes individual development and expansion of the cognitive and behavioral range. Building upon the above analysis and Hypotheses 1–3, grit, characterized by the power of persistence and passion, may promote students' cognitive flexibility by enhancing a learning goal orientation, ultimately sustaining elevated levels of learning engagement. Therefore, hypothesis is proposed:

Hypothesis 4: Grit affects learning engagement through the serial mediating role of mastery goal orientation and cognitive flexibility.

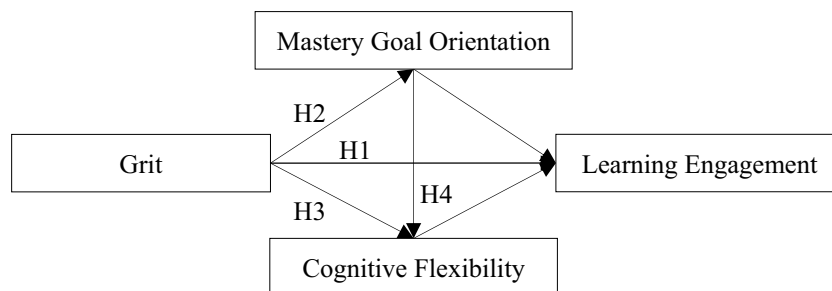
Based on character strengths and self-determination theories, this study explored the connections between grit, mastery goal orientation, cognitive flexibility, and learning engagement to determine how grit affects learning engagement. The results elucidate the mechanisms by which grit and learning engagement are related. Effective interventions can be developed in order to increase the learning engagement of Chinese college students. Figure 1 depicts the hypothesized model.

Materials and methods

Participants and procedure

Participants were recruited from three universities in Henan Province, China, using a convenience sampling method, participated voluntarily, and completed informed consent forms. The anonymous questionnaire stated that the information obtained would be used only for this study and would be kept strictly confidential. To ensure data quality and reduce homology bias, the study used two-time points to collect data, with a two-week interval between them. Grit, mastery goal orientation, and demographic variables were measured

Fig. 1 Hypothesized model



at the first time point, while cognitive flexibility and learning engagement were determined at the second time point. Participants recorded their Chinese ID number's last six digits as an anonymous identification code, which enabled us to match the questionnaires for each participant. First author's institutional ethics committee supervised the study.

We distributed 12,000 pairs of questionnaires. We removed the questionnaires of 21 participants whose pre- and post-data did not match. After all questionnaires had been matched, we excluded questionnaires with anomalous responses (identical answers or the presence of an obvious response pattern) as being invalid. The percentage of questionnaires with missing values was small, and the most primitive method was used to remove the four questionnaires with severe missing values. There were seven questionnaires with missing values of less than 5%. The missing values were filled in using the mean interpolation method, which considers the characteristics of different sample data (Zhang et al., 2016). Finally, the paired questionnaires of 1,025 participants were included in the analysis, for an effective recovery rate was 85.42%. Participant ages ranged from 18 to 24 years. The sample included 427 men (41.7%) and 598 women (58.3%). There were 397 urban students (38.7%) and 628 rural students (61.3%).

Measures

Grit was measured using the eight-item Short Grit Scale (Duckworth & Quinn, 2009), which has demonstrated high reliability in determining the grit of Chinese participants (e.g., Lei et al., 2019). The scale has two dimensions: consistency of interest and perseverance of effort. Items are rated using a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree). The confirmatory factor analysis (CFA) results for this measure showed that all items had acceptable loadings on this single factor ($\chi^2/df = 2.944$, $IFI = 0.978$, $CFI = 0.978$, $RMSEA = 0.044$). Cronbach's alpha in this study was 0.72.

Mastery goal orientation was selected from an achievement goal scale revised by Elliot and Church (1997). The scale has been validated for assessing the achievement goals of Chinese college students (He, 2020), and has six items. Items were rated on a 5-point Likert scale. The CFA results for this measure in this study showed that all items had acceptable loadings on this single factor ($\chi^2/df = 2.974$, $IFI = 0.993$, $CFI = 0.993$, $RMSEA = 0.044$). Cronbach's alpha in this study was 0.78.

Cognitive flexibility was assessed using the cognitive flexibility scale developed by Martin and Rubin (1995). The scale's reliability has been widely verified by cognitive flexibility research in China (e.g., Zhang et al., 2019). The 12 items are rated using a 5-point Likert scale. CFA results for this measure in this study indicated that all items

had acceptable loadings on this single factor ($\chi^2/df = 2.835$, $IFI = 0.965$, $CFI = 0.964$, $RMSEA = 0.042$). Cronbach's alpha in this study was 0.78.

Learning engagement was measured using the 9-item Utrecht Work Engagement Scale (Schaufeli et al., 2006). The psychometric properties of this scale have been validated for use with Chinese participants to assess learning engagement (e.g., Zhao et al., 2021). The scale assesses vigor and absorption. Items are rated on a 5-point Likert scale. The CFA results for this measure in this study indicated that all items had acceptable loadings on this single factor ($\chi^2/df = 2.862$, $IFI = 0.989$, $CFI = 0.989$, $RMSEA = 0.043$). Cronbach's alpha in this study was 0.89.

Gender and birthplace were controlled when examining grit's relationship with learning engagement; we collected this information at the first time point to prevent interference with the outcome variables. Gender and urban-rural factors influence Chinese college students' learning engagement more than school subjects, school types, and socioeconomic status (Yang & Zhang, 2016). The different social role perceptions of male and female students in China and the economic gap between rural and urban areas have led to significant differences in students' learning engagement (Liu, 2015). Moreover, gender has been associated with mastery goal orientation (Hou, 2019) and cognitive flexibility (Zhao et al., 2022) in surveys of Chinese participants. Thus, gender and birthplace cannot be ignored in the study of college students' learning engagement (Zhao et al., 2021).

Data analysis method

SPSS version 23.0 and Amos version 23.0 were selected for preliminary analysis of the measured variables (including reliability, CFA and correlation analysis) and the common method bias test. The mediation model was assessed using the SPSS PROCESS macro.

Results

Test of common method bias

To assess common method bias, the data underwent Harman's one-factor test and the unmeasured latent methods construct (ULMC) approach (Tang & Wen, 2020). Harman's one-factor test indicated that the maximum factor variance explained was 24.24% in the unrotated exploratory factor analysis, less than the critical criterion of 40%. Subsequently, using the ULMC approach, a two-factor model was constructed using all items as indicators of an unmeasured latent methods factor, considering the relevant factors of grit, mastery goal orientation, cognitive

flexibility, and learning engagement. When comparing the two-factor model with a model containing all factors, no significant difference between the two models was found ($\Delta\chi^2/\Delta df = 0.308$, $\Delta GFI = -0.014$, $\Delta IFI = -0.019$, $\Delta CFI = -0.019$, $\Delta RMSEA = 0.004$). The results suggest that the data did not suffer from serious common method bias.

Correlations between the primary variables

Spearman correlations revealed that grit significantly correlated with mastery goal orientation, cognitive flexibility, and learning engagement (Table 1). Moreover, gender and birthplace exhibited significant positive correlations with cognitive flexibility.

Test of mediating effect

The SPSS PROCESS macro compiled by Hayes (2013) was used to examine the association between grit and learning engagement with mastery goal orientation and cognitive flexibility as mediators, while controlling for gender and birthplace.

The results (Table 2; Fig. 2) show that in the path of “grit → learning engagement,” grit directly and positively predicted learning engagement ($\beta = 0.48$, $p < 0.001$). Therefore, Hypothesis 1 was supported. In the path of “grit → mastery goal orientation → learning engagement,” grit positively predicted mastery goal orientation ($\beta = 0.32$, $p < 0.001$), which in turn positively predicted learning engagement ($\beta = 0.31$, $p < 0.001$). Grit predicted learning engagement by enhancing mastery goal orientation. Thus, Hypothesis 2

Table 1 Descriptive statistics and correlation analysis

	<i>M</i>	<i>SD</i>	1	2	3	4	5	6
1 Gender	0.42	0.49	—					
2 Birthplace	0.61	0.49	-0.05	—				
3 Grit	3.02	0.50	0.04	-0.02	—			
4 Mastery goal orientation	3.58	0.61	-0.05	-0.03	0.26**	—		
5 Cognitive flexibility	3.13	0.46	0.08*	-0.13**	0.48**	0.33**	—	
6 Learning engagement	2.93	0.64	0.00	-0.04	0.51**	0.43**	0.40**	—

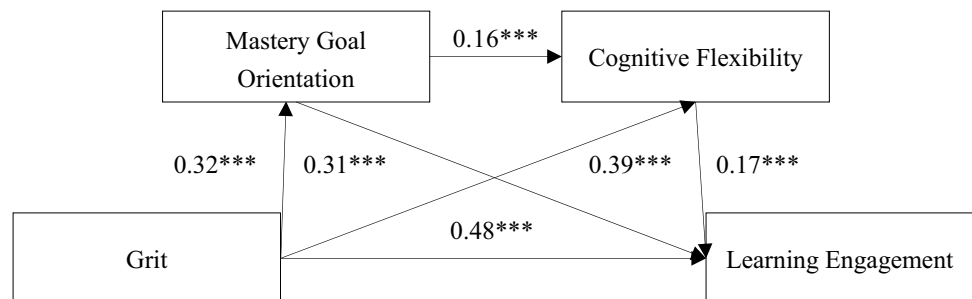
Gender: female = 0, male = 1; Birthplace: urban = 0, rural = 1; * $p < 0.05$, ** $p < 0.01$

Table 2 Results of hypothesis testing

Variable	Mastery goal orientation			Cognitive flexibility			Learning engagement		
	<i>B</i>	<i>SE</i>	<i>t</i>	<i>B</i>	<i>SE</i>	<i>t</i>	<i>B</i>	<i>SE</i>	<i>t</i>
Constant	2.65	0.12	22.66***	1.41	0.09	14.99***	-0.14	0.14	-1.00
Gender	-0.07	0.04	-1.93	0.06	0.03	2.52*	-0.01	0.03	-0.18
Birthplace	-0.03	0.04	-0.82	-0.10	0.03	-4.17***	-0.01	0.03	-0.37
Grit	0.32	0.04	8.75***	0.39	0.03	15.34***	0.48	0.04	12.81***
Mastery goal orientation				0.16	0.02	7.90***	0.31	0.03	11.04***
Cognitive flexibility							0.17	0.04	3.97***
<i>R</i> ²	0.07			0.29			0.36		
<i>F</i>	26.67***			104.94***			115.11***		

Gender: female = 0, male = 1; Birthplace: urban = 0, rural = 1; * $p < 0.05$, *** $p < 0.001$

Fig. 2 Serial mediation model showing grit’s effect on learning engagement and the mediating role of mastery goal orientation and cognitive flexibility. Values are standardized coefficients. *** $p < 0.001$



was supported. In the path of “grit → cognitive flexibility → learning engagement,” grit positively predicted cognitive flexibility ($\beta = 0.39, p < 0.001$), which in turn positively predicted learning engagement ($\beta = 0.17, p < 0.001$). Thus, Hypothesis 3, was supported. In addition, mastery goal orientation positively predicted cognitive flexibility ($\beta = 0.16, p < 0.001$), supporting Hypothesis 4. This indicated mastery goal orientation was closely related to students’ cognitive flexibility. Gender ($\beta = 0.06, p < 0.05$) and birthplace ($\beta = -0.10, p < 0.001$) significantly predicted cognitive flexibility. Male students had greater cognitive flexibility than female students. Moreover, urban students indicated greater cognitive flexibility than rural students.

Table 3 presents the confidence intervals (CIs) of the different paths. For the direct effect, the bootstrap 95% CI was [0.404, 0.550], which did not contain zero, indicating that grit significantly positively predicted learning engagement. In the path of “grit → mastery goal orientation → learning engagement,” the bootstrap 95% CI was [0.071, 0.133]. In the path of “grit → cognitive flexibility → learning engagement,” the bootstrap 95% CI was [0.026, 0.104]. In the path of “grit → mastery goal orientation → cognitive flexibility → learning engagement,” the bootstrap 95% CI was [0.003, 0.016]. The above results indicate significance for all three indirect paths. The mediating effect of mastery goal orientation was 0.101, accounting for 58.05% of the total mediating effect. The mediating effect of cognitive flexibility was 0.064, accounting for 36.78% of the total mediating effect. The serial mediating effect of mastery goal orientation and cognitive flexibility was 0.009, accounting for 5.17% of the total mediating effect. In the relationship between grit and learning engagement, mastery goal orientation had the strongest mediating effect. This result shows that grit primarily improves college students’ learning engagement by enhancing mastery goal orientation.

Discussion

How grit affects learning engagement has remained unclear. This study unveils the underlying mechanisms of grit’s effect on learning engagement among Chinese college students.

Our findings suggest that grit can enhance learning engagement. Moreover, mastery goal orientation and cognitive flexibility mediated the connection between grit and learning engagement. Notably, a serial mediating effect suggests that gritty students exhibit a mastery goal orientation, which enhances their cognitive flexibility and, in turn, promotes engagement in learning.

Theoretical implications

This study affirmed and extended the positive effect of grit, demonstrating its ability to enhance learning engagement. Robinson (2015) highlighted the relative scarcity of studies exploring the potential connection between grit and engagement. This study directly addressed this gap in the literature. Grit’s influence on education remains a topic of debate and requires further investigation (Al-Mutawah & Fateel, 2018; Usher et al., 2019). We found that the higher the learner’s grit level, the more likely they were to devote themselves to studying. These findings contradict those of a previous study on academic performance (Al-Mutawah & Fateel, 2018), but align with other studies that focus primarily on the direct connection between grit and learning engagement, while neglecting the underlying mechanisms (Chen & Chen, 2021; Tang et al., 2022). In accordance with self-determination theory, internal conditions that satisfy basic psychological needs promote learning-related behavioral outcomes (Jiang et al., 2018; Ryan & Deci, 2000). This study effectively delineated the internal mechanism of grit’s effect on learning engagement, thereby providing support for, and increasing the explanatory power of character strengths theory and self-determination theory in learning. These results also enrich the theoretical system of learning engagement by clarifying the critical influence of active traits on learning engagement. Gritty individuals possess strong adaptive motivation (Datu, 2021) and are more committed to behaviors that require deep thought (Duckworth et al., 2011); they may persist through adversity (Schimschal et al., 2021) due to their strong belief in their capacity to learn (Allen et al., 2021). Grit motivates students to engage in learning (Jiang et al., 2019) to attain higher levels of achievement. Gritty learners display strong self-control, readily participate in learning activities, and

Table 3 Effect of grit on learning engagement

	Effect	Boot SE	Boot LLCI	Boot ULCI
Direct effect	0.477	0.037	0.404	0.550
Total indirect effect	0.174	0.027	0.123	0.225
1 Grit → mastery goal orientation → learning engagement	0.101	0.016	0.071	0.133
2 Grit → cognitive flexibility → learning engagement	0.064	0.020	0.026	0.104
3 Grit → mastery goal orientation → cognitive flexibility → learning engagement	0.009	0.003	0.003	0.016

LLCI: lower-level confidence interval; ULCI: upper-level confidence interval

effectively regulate their learning processes (Yoon et al., 2018). Moreover, they spend additional time practicing to improve their skills (Kaufman & Duckworth, 2017). In these ways, grit contributes to enhancing college students' learning engagement.

It was found that mastery goal orientation mediates the relationship between grit and learning engagement. Our findings extend those of earlier literature indicating that grit affects fundamental motivation (Karlen et al., 2019). How grit promotes success in various domains may be precisely described, unraveling the connection between grit, motivation, and behavior. Achievement motivation theory suggests that different achievement goal orientations result in different behaviors and affect learning outcomes (Dweck & Leggett, 1988). Thus, this study's findings further extend achievement goal theory. Specifically, Chinese cultural values emphasize the importance of effort; however, the emphasis on education and effort can reinforce the recognition of a mastery goal orientation (Liu et al., 2020). Gritty individuals seek meaning, maintain a passion for tasks, and attribute meaningful influences to learning (Von-Culin et al., 2014). As a result of grit, individuals develop self-confidence in their ability to achieve academic goals and are able to take a proactive approach to learning (Dworkin & Serido, 2017). Students with greater interest and effort in learning are likelier to adopt active learning goals (Alhadabi & Karpinski, 2020). Grit helps individuals maintain the mastery goal orientation, relying on enhanced motivation for meaning seeking and achieving academic goals. Achievement goals influence the way students perceive achievement contexts as well as the way they think and behave in these contexts, which relates to the learning experiences they undertake (Daumiller & Dresel, 2020). Mastery goal orientation refers to viewing task participation as a goal in itself (Honicke et al., 2020). The study reinforces the finding of Benita et al., (2014), demonstrating a positive association between mastery goal orientation and various adaptive student outcomes (e.g., higher engagement in learning). Mastery-oriented students have greater intrinsic motivation since they recognize the intrinsic value of learning (Miller et al., 2021). Moreover, they perceive failure as a result of insufficient effort, which fosters a sense of enjoyment in the learning process and places importance on exerting effort (Park et al., 2018).

Grit and learning engagement were found to be mediated by cognitive flexibility. The results indicated that grit could act on behavior through cognitive processes (Kalia et al., 2018), supporting the character strengths theory. Gritty students are self-regulated learners who actively adjust their cognitive strategies to respond positively to learning dilemmas when encountering difficulties or challenges (Jiang et al., 2018). These individuals are willing to change cognitive strategies and set short-term goals to accomplish long-term objectives (Duckworth & Gross, 2014). Furthermore,

they use their intellectual skills flexibly when encountering novel situations. Cognitive flexibility is a critical component of executive functioning, emphasizing changing one's original perspective and understanding an object from multiple perspectives (Feng & Feng, 2022). With cognitive flexibility, individuals are more capable of acquiring new knowledge and can conform, assimilate, and construct new knowledge and apply it to new environments according to the needs of new adaptations (Li et al., 2006). Higher levels of cognitive flexibility have an increasing impact on learning autonomy (Orakçı, 2021), enabling students to effectively choose and employ active learning approaches in response to various learning situations (Toraman et al., 2020). Cognitive flexibility affects college students' effectiveness in learning new knowledge and adaptability to learning (Mu & Chen, 2013). Therefore, cognitively flexible students are active and engaged learners in complex learning environments (Tseng et al., 2020).

Grit and learning engagement were found to be serially mediated by mastery goal orientation and cognitive flexibility. Character strengths theory posits that positive characteristics will show their dominant effect through individuals' thoughts and motivations (Peterson & Seligman, 2004). Using the above findings to demonstrate the positive effects of grit on cognition through motivation, which in turn affects learning engagement, extends character strengths theory. Students' cognitive processes in the learning environment are influenced by their motivation to achieve (Lee et al., 2014). Mastery-oriented individuals are more inclined to employ deep cognitive and metacognitive strategies to facilitate deep learning (Bong, 2009). For deep learning approaches to be effective, cognitive flexibility must be utilized to perform a variety of activities, ultimately contributing to learning outcomes (Toraman et al., 2020). Achievement motivation and learning intention largely determine the cognitive strategies applied in various learning situations (Sins et al., 2008). Because mastery-oriented students are concerned with self-development, they are more actively involved in metacognitive processes such as monitoring and assessing their current performance and promptly modifying their cognitive and learning strategies (Vrugt & Oort, 2008).

This study revealed the connection between grit and learning engagement in Chinese culture by investigating how grit affects college students' engagement in learning. The research suggests that grit is not valued in all world cultures, nor does it benefit all students (Allen et al., 2021). African American students, for example, show that no association was found between grit and academic achievement (Dixon et al., 2017), whereas it strongly predicted academic achievement in East Asian students (Xu et al., 2023). The nature of grit may operate differently in collectivist cultures (e.g., the Philippines) compared to individualist cultures (e.g., the United States) (Datu et al., 2016). In collectivist cultures,

there is still a distinct lack of research on grit (Datu, 2021). However, culture is an essential factor when evaluating the role of grit. Grit can also vary with education level and age (Duckworth et al., 2007). University education should value grit as an attribute of learners. Prior studies have focused primarily on the association between grit and learning engagement in adolescents (e.g., Chen and Chen, 2021; Lan and Moscardino, 2019) or non-Chinese students (e.g., Yoon et al., 2018). In this study, grit was correlated with learning engagement among Chinese college students, reflecting the connection between grit and success in the Chinese fable of “The foolish old man removed the mountains” and partially supporting the findings of Xu et al. (2023). These findings provide a theoretical framework for future grit research across cultures and age groups as well as useful theoretical insights for school psychologists, educators, and other scholars who are conducting research on grit.

Practical implications

Our findings suggest that schools and teachers should focus more on enhancing grit in college students to promote on learning engagement. Grit can be developed, and is the focus of intervention programs (Hellman & Gwinn, 2017). Research has previously focused on enhancing grit by increasing a growth mindset, stress tolerance, self-control, and learning strategies (Shechtman et al., 2013). Teachers could conduct psychological interventions to promote a virtuous grit and learning engagement cycle. In interventions designed to promote grit, teachers should consider teaching a strategy of effort maintenance when cultivating students’ academic interests. However, these interventions should also make students aware of the certainty and universality of failure and setbacks, not only their possible harm. Pleasure and persistence are strongest for moderately challenging tasks (Redding et al., 1988). Interventions can promote students’ grit development by providing high-quality, carefully targeted challenges (Hellman & Gwinn, 2017). Finally, teachers can highlight the deeds of famous individuals and promote awareness of role models. Hellman and Gwinn (2017) encouraged increasing grit by learning from role models’ behaviors. Suitable role models could affect the daily quality development of college students and encourage them to complete academic assignments through unremitting effort.

Universities and teachers should strive to help students develop a mastery goal orientation to maintain high levels of learning engagement. To achieve this, teachers should incorporate mastery education into instructional plans. By helping students understand the benefits of a mastery-oriented approach, interventions are effective in promoting the adoption of mastery goals and improving positive learning outcomes (Edwards et al., 2023). Successful completion of goal-directed activities is a critical component of mastery,

so mastery-oriented individuals have the most significant preference for and enjoyment of moderately complex tasks (Redding et al., 1988). Students can develop mastery goals in educational settings by completing moderately challenging tasks (Post & van-der-Molen, 2020). Instructional plans should include providing tasks that are at least moderately challenging to encourage student participation and focus on learning (Barrett & Morgan, 2018). It is important that students have ample opportunities to participate in classroom decisions and rules and to perform group tasks (Lüftenegger et al., 2014). Teachers can use formal or informal rewards as incentives and recognition for student effort and achievement (Valentini & Rudisill, 2006). By implementing these strategies, teachers can guide students to experience the joy of achievement and help them gradually establish an accurate, clear view of success and failure rather than avoiding challenges.

School administrators and teachers should actively work to improve college students’ cognitive flexibility to enhance learning engagement. The key is to use “random access teaching,” a strategy that intentionally promotes cognitive flexibility, to teach the same content in various situations, and from multiple perspectives. Random access teaching establishes a channel for the flexible application of knowledge between different situations and concepts (Spiro et al., 1991). Therefore, teachers should emphasize professional knowledge education and implement random access teaching. Auxiliary educational methods, such as multimedia demonstrations, practical exercises, group discussions, and knowledge competitions, can also be used; knowledge can be explained and taught using different dimensions and perspectives. Additionally, researchers have found that task difficulty impacts cognitive flexibility levels (Salden et al., 2006). Thus, teachers should match learning tasks to the level of challenge. These strategies could develop students’ cognitive readiness, improve cognitive flexibility, and promote learning engagement.

Limitations and future research directions

Several limitations have been identified. First, the mediation model controlled for gender and birthplace, but did not consider conscientiousness as a control variable. Grit and conscientiousness have been shown previously to be closely related (Suzuki et al., 2015). In the context of colleges and universities, future research may benefit from controlling for conscientiousness. Second, motivational and cognitive factors were identified as contributing to the underlying mechanisms of grit’s effect on learning engagement. However, grit is a key predictor of perceived stress (Estevez, 2021). Future research should investigate whether other mediating pathways, such as perceived stress, affect learning engagement. Third, the boundary conditions of the relationship between

grit and learning engagement were not examined. Based on self-determination theory, there is an innate tendency for individuals to grow and develop psychologically, this tendency's natural expression depends on certain environmental factors (Ryan & Deci, 2000). Individuals have more remarkable persistence on tasks of moderate difficulty than complex ones (Redding et al., 1988). Mastery motivation is strongly influenced by persistence on moderately challenging tasks (Barrett & Morgan, 2018). A certain percentage of the difference in student engagement can be explained by the task difficulty (Lynch et al., 2013). In the future, the role of task difficulty can be introduced to explore its interaction effect regarding grit and learning engagement. Finally, grit is a malleable trait that can be addressed before college, which can alter its trajectory. Grit is a trait that develops relatively early (Hwang & Nam, 2021); it relies on the executive functions of the brain, yet the maturation of the neural system responsible for decision-making, goal pursuit, and response inhibition is not completed until late adolescence (Steinberg, 2013). The above findings reflect that childhood and adolescence are critical for enhancing grit. Therefore, future research should investigate interventions to promote grit at a younger age to promote mastery goal orientation, cognitive flexibility, and increased learning engagement in college students.

Conclusion

Chinese college students' grit affects their learning engagement. gritty college students have a mastery goal orientation and a high degree of cognitive flexibility, which contribute to learning engagement. These findings are expected to inspire further study on grit's positive impact in higher education. Furthermore, the results could serve as a basis for interventions to improve college students' learning engagement.

Author contributions HZ conceived the research idea, and structured and drafted the manuscript; ZZ and SH collected the data. All authors contributed to the article and approved the final manuscript.

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Data availability The datasets supporting the conclusions of this study are available from the corresponding author on reasonable request.

Declarations

Ethical approval All procedures performed in the study involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments. The study has been approved by Ethics Committee of Henan Normal University.

Informed consent Informed consent was obtained from all individual participants included in the study.

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

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