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Serial mediating role of future time perspective and grit in the relationship between growth mindset and academic engagement

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This study examined the effect of growth mindset on academic engagement and the parallel and serial mediating roles of future time perspective and grit in the relationship between growth mindset and academic engagement. The participants were 565 Chinese university students. They were asked to complete the Growth Mindset Scale, the General Future Time Perspective Scale for College Students, the Grit Scale, and the Chinese College Student Academic Engagement Questionnaire. The results showed that growth mindset positively predicted academic engagement; Future time perspective and grit can act as parallel mediators in the effects of growth mindset on academic engagement; Future time perspective and grit form serial mediators in the effect of growth mindset on academic engagement. Educators can enhance the academic engagement of university students by fostering the growth mindset, establishing the future time perspective and shaping the grit to stimulate their willingness to proactively set up future development goals and internal motivation for learning.

One of the most critical ways to improve the quality of education is to increase student engagement[1]. Academic engagement (AE) is a psychological process that is characterized by students' effort, interest, enjoyment, and total commitment[2]. Engagement is not only a measure of the quality of the student learning process, but also an important predictor of academic achievement[3]. Compared to students with high engagement, students with low engagement have poorer academic expectations, they have a higher probability of feeling negative emotions such as anxiety and boredom, and have a certain chance of displaying disruptive behavior[4], which may even lead to dropouts[5]. The current situation of students' AE in Chinese universities is not optimistic, especially the negative impact of absenteeism. Five university students with 80% absenteeism were interviewed who rationalized absenteeism and believed that it was common[6]. More than 30% of the students had ever engaged in online truancy behavior[7]. Hidden truancy is more prevalent in universities, where students attend every class but ignore teaching activities[8]. Therefore. How to effectively promote students' AE in order to avoid or reduce problematic classroom behaviors and dropouts is a crucial issue in the higher education setting.

Engagement is a changeable, fluid state[9]. Mindset is one of the important intra-individual factors, which are people's beliefs about whether their abilities and traits are malleable[10]. According to The implicit theories of intelligence, individuals with a growth mindset (GM) believe that their intelligence and abilities are not always unchanged, but can be improved through effort. An individual's mindset governs how he or she behaves, and different mindsets influence individuals to make different choices and actions[11]. Previous studies have also shown that differences in students' mindsets affect their level of engagement in the academic process. Students with GM are more active in participating in class or other academic activities than students with the fixed mindset, and they are also typically more concerned about their academic knowledge acquisition[12].

As an extremely important intra-individual belief, GM plays an integral role in students' AE in the academic environment. In the currently reviewed literature, the positive effects of GM on AE have gained the attention of several scholars[13,14]. However, whether there are other indirect pathways in the mechanism of GM's effect on AE remains to be explored in depth. Therefore, this study not only investigated the predictive role of GM on AE, but also introduced future time perspective (FTP) and Grit. There are no studies in the reviewed literature that have examined the possibility of FTP as a mediator, and almost no studies that have investigated in any systematic way the possible serial effects of FTP and grit in the mechanisms of GM effects on AE. This study constructs a

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theoretical framework based on implicit theories of intelligence, future time perspective theory, grit theory, and socioemotional selectivity theory, which provides a theoretical basis with implications for other future related studies. And from a practical perspective, the findings provide educators with valuable insights and actionable suggestions for promoting AE among university students.

Literature review
Relationship between growth mindset and academic engagement

The concept of GM stems from the ideas articulated by Dweck et al.[10] in the implicit theory of intelligence, which led to the proposal of two opposing mindsets, growth mindset and fixed mindset. Fixed mindset assumes that abilities are inherent and immutable, while GM believe that intelligence or abilities are not static and can be shaped and changed through training[11]. Different mindsets lead individuals to choose different goals, and variations in goals further lead to different motivations and behaviors[15]. Thus, a shift in mindset can cause changes in the way people perceive, the way they take action, and ultimately the outcome.

AE goes beyond superficial behaviors such as completing required assignments or taking examinations. The true meaning of engagement lies in the student's ability to recognize the value of learning itself and to have spontaneous learning initiative[9]. Myint and Khaing[16] argued that the main observation of AE is whether students are actively and positively engaged in the various activities of learning. The positive correlation between GM and AE is reflected in some previous empirical studies[17,18]. Some studies have also shown that GM can positively predict AE[12,19]. Contrary to fixed mindset, GM individuals tend to be able to view failure experiences dialectically and focus more on the valuable gains of the process, thus possessing a more optimistic and positive attitude in the face of adversity. In the meanwhile, they strongly believe that self-development is unlimited and that perseverance can enhance strengths[14]. Such positive emotions significantly contribute to changes in various aspects of AE.

Given the importance of AE in improving the quality of education and the positive effect that GM produces on students' AE, this study proposes the first hypothesis (Ha1): GM positively predicts AE.

Future time perspective as a mediator

The future time perspective (FTP) is characterized by planning and achieving future goals and reflects an individual's overall future attention[20]. Based on the viewpoint mentioned in implicit theories of intelligence[11], GM can trigger individuals' forward thinking and perception of the future. Students who are optimistic about their future development are more inclined to set long-term goals, have clearer perceptions of the future and take action. In future time perspective theory[21], FTP involves the cognitive, emotional, and behavioral tendencies of an individual's conception of self-development. Thus, from the perspective of theoretical linkage, GM is an important psychological basis for the emergence of FTP. Several studies have similarly provided evidence that GM, which actively constructs goals and plans for the future, enhances students' FTP[22,23]. Both GM and FTP are important factors in personal development and achievement, and encouraging positive GM and FTP can support individuals in overcoming challenges and working towards their goals.

The cognitive process of FTP involves appreciation and awareness of future possibilities[24]. Students who have a vision for the future and consider long-term goals are more likely to identify with the significance of academic outcomes in their future self-development and the rewards that may come with them, and as a result, are inclined to spend more time and energy engaging in their studies[25]. Sun et al.[26] also noted in their study that students with high levels of FTP possessed a deeper desire to achieve their goals, which motivated them to improve their self-control, such as suppressing the urge for prolonged leisure and recreation in exchange for a sense of fulfillment after delayed gratification, and consequently, tdemonstrate more consistency and positivity in their daily studies. Feng et al.[27] concluded that FTP can stimulate students' self-efficacy. As students come to identify with their abilities, the more they are able to generate motivation and thus actively engage in learning.

Given the above elaboration of the relationship between GM, FTP and AE, it can be seen that FTP might serve as an indirect pathway for GM to influence AE. Therefore, this study proposes the second hypothesis (Ha2): FTP mediate the relationship between GM and AE.

Grit as a mediator

Grit is the relentless and passionate pursuit of a certain goal, which is a vital trait in the quest of success[28]. the Grit theory suggests that growth mindset fosters an individual's intention to tap into a deeper self-potential of beliefs as well as willingness to persevere in the face of challenges[29]. Therefore, GM is one of the ways to develop grit. Several studies have similarly confirmed that GM and grit are closely related. Findings of Lee and Kim[30] revealed that enhancing students' growth mindset and grit was effective in improving their overall self-directed learning ability. Park et al.[31] also suggested that GM and grit can predict each other's development. Individuals are more likely to uphold affirmative personal convictions when they see that their skills may be progressively enhanced through practice and training, thus motivating them to strive towards set goals and show higher levels of grit in the process.

Grit, a non-cognitive mental attribute, is intrinsically linked to motivation, which is advantageous for achieving long-term objectives[32]. Students with grit are more likely to be strongly motivated to direct their full engagement in academic activities driven by achievement goals[33]. Zhang et al.[34] showed that grit was able to predict students' AE more effectively than social-emotional competence. In the online learning environment, English language learners with resilience traits are more inclined to engage in online learning when they have a sense of self-efficacy[35]. Grit was a mediating variable between the relationship of GM and AE in a survey of high school students[13].

The aforementioned research shows that GM, grit, and AE are strongly correlated, and grit may serve as an indirect pathway for GM to influence AE. Therefore, this study proposes the third hypothesis (Ha3): Grit mediate the relationship between GM and AE.

Future time perspective and grit as serial mediators

The possibility of FTP and grit individually as mediating variables in the mechanism of GM's effect on AE has been mentioned in the above statement. Not only that, there is also evidence of correlation between FTP and grit in both theory and empirical studies. According to the Socio-emotional Selectivity Theory, the individual's perception of time determines how they evaluate and choose their goals, which in turn shapes corresponding behavioral tendencies[36]. When individuals perceive future time as expansive and fulfilling, they tend to pursue goals that lead to the acquisition of knowledge or skills and are more inclined to take part in self-improvement-related activities[37]. Thus, individuals who hold high levels of FTP harbor ambitions to achieve their goals, which contributes to driving their grit. Also, several empirical investigations conducted by previous researchers have shown a correlation between FTP and grit[38]. Indeed, students with higher FTP have a more specific and clear list of goals for the future and tend to be better at delaying gratification[26]. Being able to choose to forego some instant gratification when weighing immediate pleasures against future benefits is consistent with the core of grit[23].

In the above discussion, drawing on Socioemotional Selectivity Theory[36], we hypothesize that FTP facilitates the development of grit. This relationship may be explained by several mechanisms: goal orientation (FTP provides grit with direction and purpose), delayed gratification (individuals with high FTP are more willing to exert effort for long-term rewards), and sustained motivation (awareness of future importance enhances persistence in the face of difficulties). While most existing empirical studies emphasize the influence of FTP on grit, it is important to acknowledge the theoretical plausibility of a reverse effect (grit→FTP). According to self-perception theory[39], individuals may infer their beliefs or attitudes by observing their own behavior, particularly in the absence of clear internal cues. Therefore, when individuals consistently demonstrate perseverance and sustained effort in real-life contexts, they may infer that they are "future-oriented" and possess long-term goals, thereby fostering a more positive and extended FTP. In summary, while the proposition that "grit influences FTP" holds theoretical plausibility, it currently lacks robust empirical support. Given that prevailing empirical studies and developmental psychological models predominantly favor the "FTP predicts grit" pathway, the present study adopts this directional relationship to examine how FTP affects long-term behavioral motivation through grit. Nevertheless, to mitigate potential causal bias, future research could employ longitudinal or cross-lagged designs to further explore potential dynamic interactions between these constructs.

The tendency of the GM to set long-term goals and to be optimistic about future developments coincides with FTP's anticipation and concern for the future[11,21]. An outlook on the future in turn influences students to make specific and cautious goal settings, and preparing for difficulties in advance makes them less likely to give up midway, enhancing grit[40]. Self-discipline and focus on academic tasks help students reduce academic burnout and distraction, which in turn increases engagement[34].

Based on all the discussions about the relationship between GM, FTP, grit and AE, it can be speculated that FTP and grit might be able to form serial mediators in the effect of GM on AE. Therefore, this study proposes the fourth hypothesis (Ha4): The effect of GM on AE is serially mediated by FTP and grit.

Figure 1 depicts the conceptual framework for this study, which includes the four variables, as well as arrows indicating to their correlations.
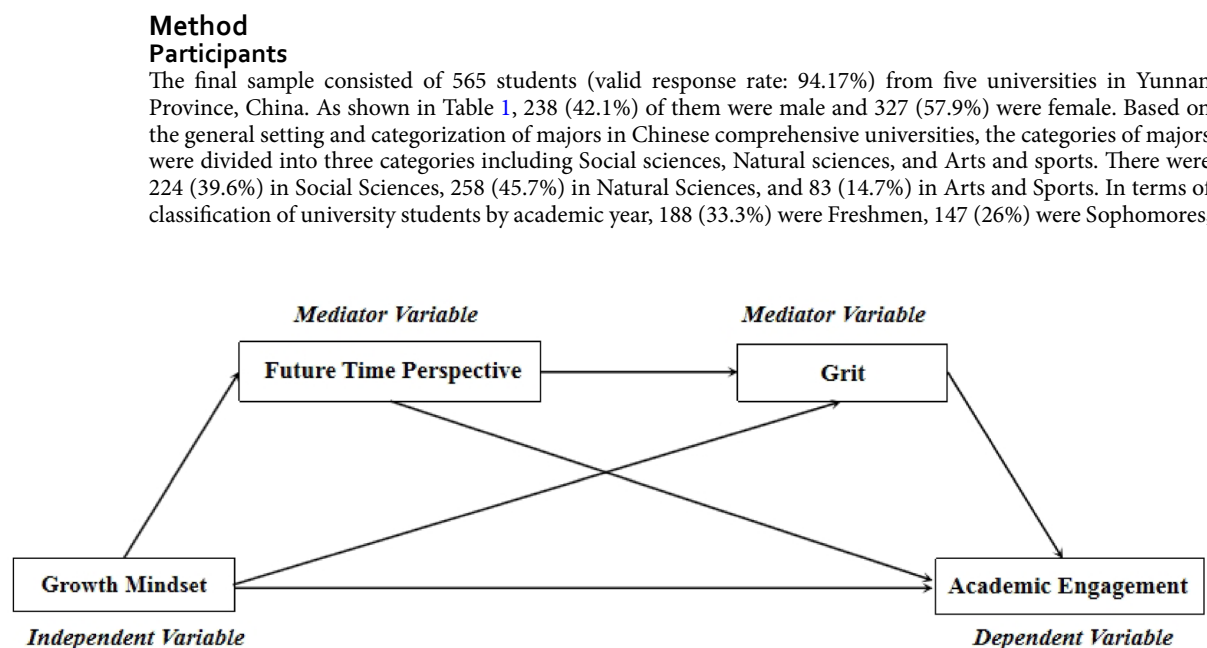
Method

Participants

The final sample consisted of 565 students (valid response rate: 94.17%) from five universities in Yunnan Province, China. As shown in Table 1, 238 (42.1%) of them were male and 327 (57.9%) were female. Based on the general setting and categorization of majors in Chinese comprehensive universities, the categories of majors were divided into three categories including Social sciences, Natural sciences, and Arts and sports. There were 224 (39.6%) in Social Sciences, 258 (45.7%) in Natural Sciences, and 83 (14.7%) in Arts and Sports. In terms of classification of university students by academic year, 188 (33.3%) were Freshmen, 147 (26%) were Sophomores,

Fig. 1. Conceptual framework.

Variables	Categories	Frequency	Percent (%)
Gender	Male	238	42.1
	Female	327	57.9
Major	Social Sciences	224	39.6
	Natural Sciences	258	45.7
	Arts and Sports	83	14.7
Academic year	Freshman	188	33.3
	Sophomore	147	26.0
	Junior	171	30.3
	Senior	59	10.4
Location of residence	Urban	389	68.8
	Rural	176	31.2

Table 1. Descriptive statistics (n = 565).

171 (30.3%) were Juniors, and 59 (10.4%) were Seniors. The students' location of residence was categorized into two groups, with 389 students (68.8%) coming from urban areas and 176 students (31.2%) were from rural areas.

Measurement tools
Growth mindset
Growth Mindset Scale (GMS) developed by Dweck[41] as translated by Zhao et al.[23] was used. It consists of 6 questions with 3 forward scoring items and 3 reverse scoring items. The scale was rated on a 6-point scale, with 1 indicating "completely disagree" and 6 indicating "completely agree". Higher scores on the scale indicate a greater bias toward GM. GMS has been utilized extensively and has shown good validity and reliability in earlier research[17,42]. In this study, the Cronbach's alpha of GMS was 0.905, and the value of AVE was 0.678 > 0.5, indicating high reliability.

Future time perspective
General Future Time Perspective Scale for College Students (GFTPSCS) developed by Song[21] was employed, which contains 20 items with five dimensions: future image, future efficacy, future purpose consciousness, far goal orientation, and behavioral commitment. Scoring is based on a four-point scale, with "completely consistent" earning 4 points and "not at all consistent" earning 1. Five of the questions were reverse scored. A higher overall score suggests a stronger FTP. Other research have confirmed that GFTPSCS has acceptable validity and reliability[22,26]. In the present study, the Cronbach's alpha of the scale was 0.815, and the value of AVE was 0.574 > 0.5, indicating high internal consistency of the scale.

Grit
The 12-item Grit Scale (GS) compiled by Duckworth et al.[28] and translated by Xie et al.[43] was employed, it includes two dimensions, the two dimensions were perseverance of effort (PE) and consistency of interests (CI). Perseverance of effort includes 6 items, 1, 4, 6, 9, 10, and 12, which are scored positively. Consistency of interests consists of 6 items, including 2, 3, 5, 7, 8, and 11, all of which are reverse-scored. The scale is graded on a five-point scale (1 = extremely not me, 5 = extremely me). Higher total scores on the scale indicate higher levels of grit. The GS has consistently demonstrated strong reliability and validity in numerous studies, especially in studies with Chinese students as samples[23,34]. In the present study, the Cronbach's alpha of GS was 0.746, and the value of AVE was 0.798 > 0.5, indicating good reliability.

Academic engagement
The Chinese College Student Academic Engagement Questionnaire (CCSAEQ) developed by Wang[44] was employed. It has 12 items and consists of three dimensions: behavioral engagement, emotional engagement, and cognitive engagement. Items 1–5 measured behavioral engagement, items 6–9 measured cognitive engagement, and items 10–12 measured emotional engagement. The scale is rated on a 6-point scale ranging from "strongly disagree" to "strongly agree", with higher scores indicating higher levels of AE. Other research have shown good reliability and validity tests for this scale[45]. In this study, the Cronbach's alpha of CCSAEQ was 0.781, and the value of AVE was 0.695 > 0.5, indicating good reliability.

Procedure
For this study, firstly, 5 out of 32 universities in Yunnan Province were selected by simple random sampling method. Followed by stratified random sampling, based on the ratio of the number of students in each major category to the overall number of students, thus determining the number of students to be sampled from each major category in each university. The questionnaires were distributed on paper to the participants selected through the sampling procedure, after permission had been obtained from all the universities surveyed. All questionnaires were anonymized and participants were assured that the information would only be used for academic research. No incentives were offered to participants. Authorization for this study was obtained from the Ethics Committee of Universiti Sains Malaysia on September 13, 2024 (protocol code: USM/JEPeM/PP/24070600). Research involving human participants was conducted in accordance with the principles of the

Declaration of Helsinki. All research procedures were performed in accordance with relevant guidelines and regulations.

Statistical analysis strategy

This study employed SPSS 26.0, PROCESS macro, and Smart-PLS 4 for data processing, encompassing outlier detection, common method bias (CMB) testing, descriptive statistics, reliability and validity analysis of scales, correlation analysis, and sequential mediation analysis. The mediation model was examined using the Bootstrap method (5000 resamples) to assess the significance of each mediation effect and the confidence intervals of the pathways, thereby elucidating the underlying mechanisms of the mediating paths.

Results

Data screening

The data screening procedure included detection and processing of missing data, ineligible data and outlier problems. This study screened the total data through SPSS 26.0. A total of 600 students from five universities in Yunnan Province participated in this study. 35 participants' questionnaire data were identified as invalid questionnaires, with 9 participants not completing all questionnaire items, and 26 participants who chose the same answer for multiple items resulting in significant regularities in the questionnaire. Due to the low percentage of missing values and ineligible data, these samples were directly deleted. The detection of outliers assists the researcher in identifying unusual conditions or potential risks in the data prior to formal data analysis[46]. In the present study, univariate outliers detection was performed through SPSS 26.0, and the results of the data distribution of the box plot (Supplementary: Fig. S1) showed that there were no outliers in the dataset.

Common method bias

Since the study's data was derived from self-report, processes and statistical techniques were employed to address the possibility of social desirability bias affecting the questionnaire results. Questionnaire completion was anonymous, which contributed to a more realistic reflection of participants' views and feelings, thereby reducing the likelihood of Common method bias. In addition, we performed a Harman's single factor test using SPSS 26.0 to investigate the data for the existence of common method bias, and the results showed that 11 factors had an eigenroot greater than 1, and the first of these factors had a variance explained of 34.8% that is below the critical criterion of 40%[47], indicating that no serious common method bias exists in this study.

Descriptive statistics and variance inflation factor (VIF)

The variables' descriptive statistics (mean, standard deviation, skewness, and kurtosis) and VIF values were displayed in Table 2. The standard deviation runs from 0.57 to 1.09, while the mean values vary from 2.63 to 4.68. We calculated the value of the variance inflation factor (VIF) in order to verify the stability of the regression model by checking the multicollinearity. The value for VIF needs to be less than 5[48]. It can be seen that the values

Constructs	M	SD	Skewness	Kurtosis	VIF
GM					
GM1	4.39	1.04	− 0.28	0.18	2.498
GM2	4.68	0.90	− 0.78	1.54	1.881
GM3	4.47	0.99	− 0.23	− 0.15	2.694
GM4	4.61	0.93	− 0.65	1.17	2.415
GM5	4.56	1.00	− 0.78	1.29	2.096
GM6	4.62	0.92	− 0.60	1.13	2.178
FTP					
BC	2.81	0.71	− 0.07	− 1.00	1.685
FI	3.23	0.57	− 0.38	− 0.62	1.532
FO	3.07	0.59	− 0.28	− 0.57	1.551
FE	2.63	0.74	− 0.43	− 0.62	1.593
FPC	2.75	0.79	− 0.12	− 1.15	1.564
Grit					
PE	3.82	0.87	− 0.35	− 0.92	1.548
CI	3.57	0.90	− 0.26	− 0.99	1.548
AE					
BE	4.37	1.02	− 0.43	− 0.85	1.616
CE	4.22	1.01	− 0.28	− 0.73	1.628
EE	4.14	1.09	− 0.25	− 0.81	1.608

Table 2. Descriptive statistics and variance inflation factor (VIF). *M* mean, *SD* standard deviation, *BC* behavioral commitment, *FI* future image, *FO* far-goal orientation, *FE* future efficacy, *FPC* future purpose consciousness, *PE* perseverance of effort, *CI* consistency of interests, *BE* behavioral engagement, *CE* cognitive engagement, *EE* emotional engagement.

Construct	Cronbach's alpha	CR	AVE
Growth mindset	0.905	0.927	0.678
Behavioral commitment	0.872	0.912	0.722
Future image	0.816	0.878	0.644
Far-goal orientation	0.854	0.896	0.632
Future efficacy	0.828	0.897	0.744
Future purpose consciousness	0.881	0.918	0.737
Perseverance of effort	0.922	0.939	0.721
Consistency of interests	0.898	0.922	0.662
Behavioral engagement	0.897	0.924	0.709
Cognitive engagement	0.845	0.896	0.683
Emotional engagement	0.852	0.910	0.772

Table 3. Results for reliability and convergent validity.

	GM	FTP	Grit	AE
GM				
FTP	0.684			
Grit	0.542	0.799		
AE	0.549	0.787	0.882	

Table 4. Results for discriminant validity.

of VIF for the constructs provided in Table 2 are all less than 5. Thus, there is no multicollinearity issue in the structural model.

Measurement model
Before formally analyzing the data, we first assessed the reliability and validity of the model by measuring the composite reliability (CR), Cronbach's alpha, convergent validity, and discriminant validity. In general, Cronbach's alpha, composite reliability (CR), and factor loadings should all be at least 0.7 or higher, and average variance extracted (AVE) must be greater than 0.5[49] to be considered to have acceptable reliability and convergent validity. As shown in Table 3, Cronbach's alpha, CR, AVE and all met the standards. The results of factor loadings are in Table S1 (Supplementary Information).

The model's discriminant validity was then assessed via the Heterotrait-Monotrait ratio (HTMT), where HTMT values less than 0.9 imply good discriminant validity between the constructs[50]. The results in Table 4 show that the HTMT values between each of the two variables passed the test with a threshold of less than 0.9, thus indicating good discriminant validity.

Structural model
We assessed the structural model after the measurement model passed the validity and reliability tests. The main metrics tested included R^2 (coefficient of determination) and Q^2 (predictive relevance), which measure the variance explained by the model as well as the predictive power of the model, respectively. R^2 values are considered high above 0.67, medium between 0.33 and 0.67, and low between 0.19 and 0.33[51]. The results of the R^2 of FTP is 0.352, the R^2 of grit is 0.4, and the R^2 of AE is 0.53, which indicated that the explanatory power of these variables is at a medium level. The calculation of Q^2 was derived from "PLSpredict" in Smartpls4, where Q^2 less than 0 indicates that there is no predictive correlation, and Q^2 greater than 0 indicates that the exogenous variables are predictively relevant to the endogenous variables[49]. The Q^2 of FTP is 0.35, the Q^2 of Grit is 0.199, and the Q^2 of AE is 0.217, which indicates good predictive relevance of the model.

Hypothesis testing
Figure 2 presents an illustration of the serial mediation model utilized in the current investigation, with the pointing of arrows demonstrating the relationship between the potential variables and labeling the each path coefficients as well as the t-values.

Bootstrapping (5000 repeated sampling) in SmartPLS4 was used to test the path coefficients, t-values and *p* values between the variables as a way of assessing the significance of each path. With sample sizes larger than 30 in the study, the quartile at normative distribution can be used as the critical value, which is usually 1.96. When the t-value is greater than the critical value, it is possible to claim that there is a significant level with a certain level of error[49]. Table 5 demonstrates the direct effect paths between all variables, as can be seen that growth mindset positively influences university students' academic engagement ($\beta = 0.093$, t = 2.604). This result supports the hypothesis of Ha1.

Next, we used Bootstrapping to test for serial mediation. The confidence interval is bias corrected (95%), Which is evaluated according to whether or not 0 is included in the confidence interval. If the value of the
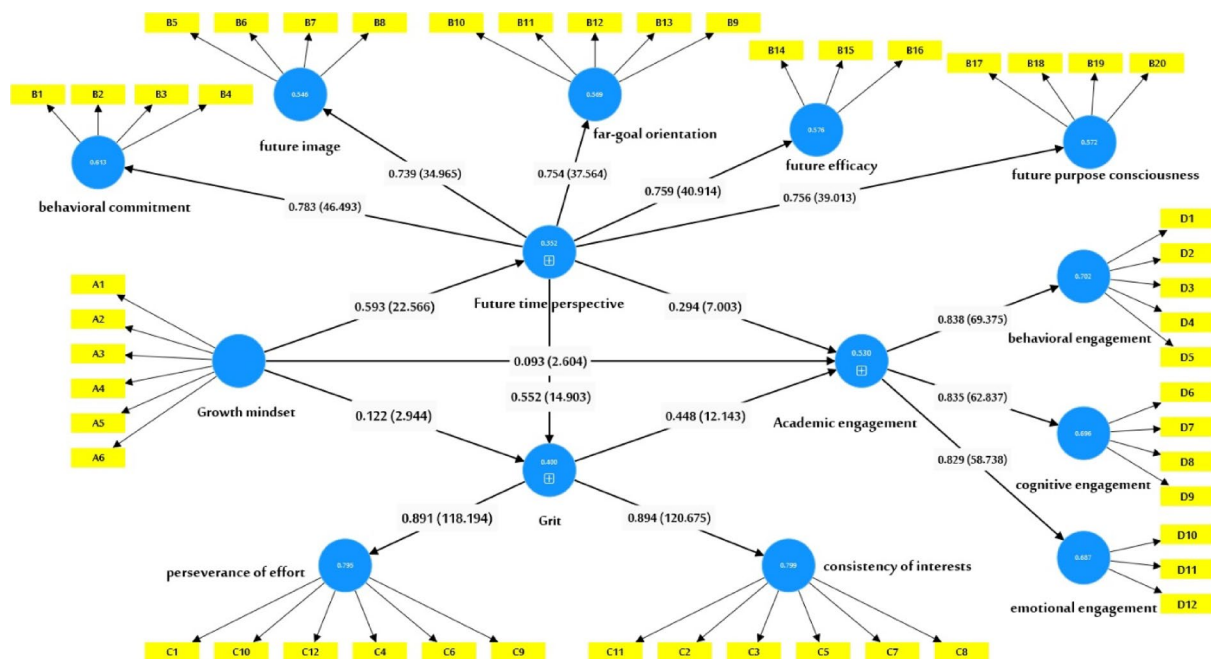
Fig. 2. Structural model path diagram.

Relationship	Estimate	SE	t	p
GM→AE	0.093	0.036	2.604	0.009
GM→FTP	0.593	0.026	22.566	<0.001
FTP→AE	0.294	0.042	7.003	<0.001
GM→Grit	0.122	0.042	2.944	0.003
Grit→AE	0.448	0.037	12.143	<0.001
FTP→Grit	0.552	0.037	14.903	<0.001

Table 5. Direct effects between variables. *GM* growth mindset, *FTP* future time perspective, *AE* academic engagement.

Hypothesis	Path	Estimate	SE	t	p	95% CI	Decision
Ha2	GM→FTP→AE	0.174	0.026	6.643	<0.001	[0.124, 0.224]	Supported
Ha3	GM→Grit→AE	0.055	0.019	2.845	0.004	[0.018, 0.095]	Supported
Ha4	GM→FTP→Grit→AE	0.147	0.018	8.218	<0.001	[0.114, 0.184]	Supported

Table 6. Hypothesis testing for mediating effects in smart PLS. *GM* growth mindset, *FTP* future time perspective, *AE* academic engagement.

confidence interval does not contain 0, the mediation effect is significant; if it does, it means it is not significant[49]. As described in Table 6, The effect value for the indirect path GM→FTP→AE is 0.174 with a 95% confidence interval [0.124, 0.224], and it can be seen that 0 is out of range, indicating a significant mediating effect. Indirect path GM→Grit→AE effect value is 0.055, 95% confidence interval [0.018, 0.095], does not contain 0, indicating a significant mediating effect. GM→FTP→Grit→AE effect value is 0.147, 95% confidence interval [0.114, 0.184], which means that it does not contain 0, indicating a significant serial mediation effect. These results showed that FTP and grit not only individually mediated the relationship between GM and AE, but also formed a serial mediator. the paths proposed by Ha2, Ha3, and Ha4 were all supported.

To enhance the robustness of the results, this study employed a dual-validation strategy to examine the sequential mediation effects. Subsequent to the initial analysis, we conducted additional chain mediation analyses using Model 6 in Hayes's[52] PROCESS macro. The indirect effects were tested through the bootstrap method with 5000 resamples at a 95% confidence interval. The regression results of the mediation model (Table 7) revealed that GM had a significant positive effect on AE (B = 0.51, $p < 0.001$), thereby corroborating Hypothesis Ha1.

Outcome variable	Predictive variable	R^2	F	B	SEs	t	LLCI	ULCI
Equation 1								
FTP	GM	0.35	296.69	0.38***	0.02	17.22	0.34	0.42
Equation 2								
Grit	GM	0.40	190.96	0.12**	0.04	2.89	0.04	0.19
	FTP			0.86***	0.06	13.94	0.74	0.99
Equation 3								
AE	GM	0.54	218.57	0.10*	0.04	2.53	0.02	0.17
	FTP			0.51***	0.07	7.42	0.38	0.65
	Grit			0.49***	0.04	11.99	0.41	0.57
Equation 4								
AE	GM	0.22	158.00	0.51***	0.04	12.57	0.43	0.59

Table 7. Regression results of mediating effects model. *GM* growth mindset, *FTP* future time perspective, *AE* academic engagement. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

	Estimate	Boot SE	Boot LLCI	Boot ULCI
Total effect	0.51***	0.04	0.43	0.59
Direct effect	0.10*	0.04	0.02	0.17
Total indirect effect	0.41***	0.03	0.35	0.48
GM→FTP→AE (Ha2)	0.20***	0.03	0.14	0.25
GM→Grit→AE (Ha3)	0.06**	0.02	0.02	0.10
GM→FTP→Grit→AE (Ha4)	0.16***	0.02	0.12	0.20

Table 8. Hypothesis testing for mediating effects in SPSS PROCESS. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

The bootstrap analysis (N = 5000 samples) confirmed significant mediating effects in the relationship between GM and AE. As shown in Table 8, the total effect of GM on AE was significant (B = 0.51, 95% CI [0.43, 0.59]), with the direct effect remaining significant but substantially reduced (B = 0.10, 95% CI [0.02, 0.17]) after accounting for mediators. Specifically, FTP served as the primary mediator (GM→FTP→AE: B = 0.20, 95% CI [0.14, 0.25]), while Grit's independent mediation was weaker (GM→Grit→AE: B = 0.06, 95% CI [0.02, 0.10]). Notably, a sequential mediation path emerged (GM→FTP→Grit→AE: B = 0.16, 95% CI [0.12, 0.20]). These results emphasize the critical roles of FTP and Grit in connecting GM to AE. FTP directly and indirectly enhanced AE by fostering Grit. whereas Grit was a minor but meaningful mediator. Ha2, Ha3, and Ha4 were all accepted. Overall, all three mediating pathways demonstrated statistical significance and consistent effect directions across both analytical approaches, indicating robust findings that further validate the proposed mediation model.

Discussion

This study constructed a serial mediation model to delve deeper into the underlying mechanisms between GM and AE, in particular to assess the key role played by FTP and grit. Among the findings we first tested the direct effect of pathways, which showed that GM positively influenced AE. This is consistent with the findings of several past studies[12,14,18]. Individuals who have GM, as opposed to those who have a fixed mindset, tend to view failure more dialectically, focusing on what important gains they have made and drawing lessons from them. It is more probable that students with high GM levels will be more involved and enthusiastic about their studies.

The findings support Ha2, suggesting that FTP can serve as a mediator between GM and AE (B = 0.20, 95% CI [0.14, 0.25]). FTP reflects an individual's tendency to have a rosy outlook on the future and a willingness to take practical action to reach long-term goals[21], and that GM centers on an individual's optimistic and positive attitude toward the development of self-efficacy[17]. The findings of this study are in line with the results reported by Wang[22] and Zhao et al.[23], who both demonstrated a strong correlation between GM and FTP in their investigations. A possible explanation is that students with GM, guided by the belief that "my efforts are valuable for future development", are more likely to make careful and prudent plans for their future lives, resulting in more positive FTP.

Denovan et al.[25] proposed that FTP takes an important position in influencing AE. Students with higher FTP level regard current learning behavior as an important foundation for future development, thereby triggering internal motivation and needs for self-development[53], and thus AE may be viewed as a beneficial investment in the future. Furthermore, students with high levels of FTP are hopeful and expectant about the future, which typically promotes their self-efficacy[27]. The belief that present-day dedication and effort will lead to positive future outcomes is likely to further drive students behaviorally, emotionally, and cognitively towards academics.

The findings support Ha3, suggesting that grit mediates the relationship between GM and AE (B = 0.06, 95% CI [0.02, 0.10]). The positive role of GM in developing grit has been noted in both theory and empirical

studies[13,29], which is consistent with the findings of the present study. Students with GM believe that hard work and persistence will always pay off at some point in the future, and this confidence is the source of their ability to stay motivated. Meanwhile, they view situational stress and dilemmas as temporary hindrances and are constantly trying to find solution strategies[54], making them more likely to exhibit grit qualities.

In addition, several studies have provided support for the conclusion that grit positively affects AE[33,55,56]. Maintaining zeal and tenacity throughout time to accomplish long-term objectives is the essence of grit[28], and this kind of focus and perseverance carries great positive energy. Girt is closely related to good self-control and self-regulation, where students consciously restrain their hedonic impulses and self-monitor their learning progress[57]. Alhadabi and Karpinski[58] also showed that students with high levels of grit have a higher likelihood of achieving good academic performance. The self-confidence and pleasant emotions that come with academic success promote their greater willingness to engage in their studies autonomously, thus creating a positive cycle.

The above elaboration of the relationship between GM, grit and AE emphasizes the positive impact of GM, grit on AE. The GM that aspires to improve through hard work may trigger an individual's perception of the future and determination to set clear and achievable goals. Students are more likely to develop grit in the process when they believe that effort raises the threshold of competence. They have an intense desire to follow valuable tendencies, and self-monitoring their academic success may help them devote more time and energy to their studies.

The findings support Ha4, suggesting that FTP and grit form serial mediators in the relationship between GM and AE (B = 0.16, 95% CI [0.12, 0.20]). According to Socioemotional Selectivity Theory, an individual's perception of future time influences the selection of goals. When time is realized to be sufficient and free, long-term developmental goals are more likely to be chosen[36], resulting in stronger behavioral motivation, which inspires individuals to persevere in reaching their goals. Zhao et al.[23] also provided corresponding evidence in an empirical study, and the results showed that FTP can influence grit. Students with long-term FTP were more probable to exhibit high levels of grit qualities compared to those who lacked long-term goals and plans for the future and were in a period of disorientation.

The mediation analysis revealed distinct pathways through which GM enhances AE. Notably, FTP emerged as the primary mediator (indirect effect = 0.20), underscoring its pivotal role in translating GM into sustained academic effort by fostering long-term goal orientation. The serial mediation via FTP→Grit further highlighted the interdependence of these constructs (indirect effect = 0.16), suggesting that grit's contribution to engagement may depend on prior activation of future-oriented motivation. In contrast, grit alone exhibited a weaker mediating effect (indirect effect = 0.06). Compared to Grit, GM may more readily activate cognitive-motivational processes associated with FTP, such as goal planning through FTP. This finding aligns with temporal motivation theory[59]: FTP's focus on long-term outcomes provides a more direct cognitive framework for translating GM into concrete learning behaviors, whereas the role of Grit—though significant—may require the foundation of future-oriented cognition to be fully effective.

This study details the internal psychological mechanisms by which GM influences AE. Students believe that abilities can be molded and enhanced, and this perception may influence their expectations and optimism for the future, leading to a greater willingness to put in the effort and energy to invest in their self-development path. Students need to remain focused on their goals during this process and therefore exhibit higher grit, which may further impact their ability to demonstrate problem-solving resilience in frustrating situations and thus actively increase the amount of time they engage in academics.

Overall, the discussion of the results reveals a strong link between GM, FTP, grit, and AE, which contributes to enriching and expanding the previous findings on the mechanisms of effect of GM on AE, and in particular emphasizes the important roles that FTP and grit play in it.

Additionally, the fact that the direct effect of GM on AE remained statistically significant (B = 0.10, $p < 0.05$) after accounting for all specified mediators indicates that other indirect pathways may also be at play. For instance, according to social cognitive theory[60], constructs such as academic self-efficacy or emotional regulation (not included in the present model) could potentially mediate this relationship. These factors may act independently or interact with FTP or grit. Future studies should consider expanding the mediation model to capture a more comprehensive view of the psychological mechanisms involved.

Implications

This study integrates the Implicit Theories of Intelligence, Future Time Perspective Theory, Grit Theory, and Socioemotional Selectivity Theory to construct and validate a chain-mediation motivation model involving four core variables, thereby advancing theoretical understanding of sustained learning motivation. First, the study refines the explanatory framework of Implicit Theories of Intelligence by demonstrating that a growth mindset influences academic engagement not directly, but indirectly through FTP and grit, deepening insights into the "belief–motivation–behavior" mechanism. Second, FTP is identified as a central component in the model—serving both as a bridge between beliefs and personality traits and as a key source of behavioral motivation—highlighting its generative role in individual motivational systems. Third, unlike prior research that treats grit as a stable trait, this study emphasizes its developmental malleability and mediating function under cognitive influence, thereby extending the theoretical boundaries of grit. Lastly, drawing on Socioemotional Selectivity Theory, the study explains how perceptions of future time shape goal setting and resource allocation, extending the theory beyond aging contexts into adolescent academic motivation.

Overall, this research moves beyond prior studies focused on pairwise variable relationships by systematically constructing and empirically validating a chain model—"GM→FTP→Grit→AE". It not only synthesizes multiple theoretical perspectives but also offers a robust framework and empirical basis for understanding how learning motivation dynamically evolves across cognition, time perception, personality traits, and behavior.

This study explored the mechanisms of GM, FTP and grit on AE among university students. Its practical implication is to provide some feasible measures to promote AE among university students, especially to inspire educational stakeholders (university institutions, lecturers, and parents) to promote the level of AE through the aspects of growth mindset training, developing future time perspective, and molding grit personalities.

Universities can organize courses or lectures on growth mindset to help students update their knowledge of the mindset, understand and accept the concept of GM, and use it to guide their studies and lives. Educators should also guide students to face setbacks and failures with an optimistic and relaxed mindset, and to change from the fear of failure to the joy of correcting mistakes, so as to effectively enhance their ability to endure and awaken their inherent power of growth.

Universities can conduct special future situation simulation activities in group counseling, allowing students to experience different time perspective and decision-making in the corresponding situations set up, so as to enhance students' awareness of the importance of future development. Universities can also organize career planning guidance classes, inviting industry experts or alumni to share their career development plans and time management strategies, in order to motivate students to clarify their future career goals and formulate implementable execution plans.

Grit is not innate. Enhancing the quality of grit requires that the education of perseverance and endurance permeate daily life, which relies on the cooperation between universities and families. Universities can strengthen parental concern and support for students' studies by organizing online lectures, thus realizing the whole process of grit cultivation.

This study emphasizes the importance of GM, FTP and grit in developing students' AE and provides valuable and applicable measures for practitioners in the field of education. Emphasis was placed on developing students' broad mindset, assisting them in clarifying their future development goals, and enhancing their grit in the academic process, all of which cannot be achieved without the attention of educational administrators and the support of a positive university climate.

Limitations and future directions

First, the survey was limited to university students, future surveys can be conducted among other student groups, such as middle school student groups or postgraduate students, and can also be extended to other different countries and cultural regions. Surveying different participants may yield new findings that could contribute to a more in-depth discussion of the association between GM, FTP, grit, and AE. Secondly, the data for this study came from students' self-reports, which could be skewed by social desirability bias. In light of this, future studies need to consider collecting data from multiple directions (peers, teachers, and parents) to increase the objectivity of the results. Lastly, it should be mentioned that this study used a cross-sectional design in quantitative research, which did not allow for the establishment of causal relationships between variables. Future studies can further adopt a longitudinal research design where data are collected at different points in time to observe changes. Additionally, adding a qualitative research component, such as interviews, might provide a more comprehensive analysis of the topic under investigation. For instance, complex bidirectional mechanisms may exist between grit and FTP. Future research could employ longitudinal tracking and cross-lagged analyses to further elucidate their dynamic causal relationships.

Conclusion

This study aimed to examine the association between GM, FTP, grit, and AE among Chinese university students. Data from 565 Chinese university students were obtained by questionnaire and modeled using PLS-SEM and PROCESS macro. The results of the study showed that FTP and grit were not only able to mediate the effect of GM on AE individually, but also able to form a serial mediator. After revealing the interactions between these variables, the possible reasons and mechanisms behind them were explained. By exploring the mediating roles of FTP and grit, it provides a deeper understanding of the internal influencing mechanisms that promote university students' AE, and in doing so, offers some implementable suggestions to enhance AE. This study enriches the existing body of knowledge and provides a basis for subsequent investigations.

Data availability

The datasets generated and/or analyzed during the current study are not publicly available due to the data for this article is included in the dissertation but are available from the corresponding author on reasonable request.

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Author contributions

The author, LWJ, contributed to all aspects of this study, including research conceptualization, data collection and statistical analysis, interpretation of results, writing of the final manuscript. SBH provided critical academic opinions and suggestions for revision. All authors reviewed and approved the final version of the manuscript.

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Declarations

Competing interests

The authors declare no competing interests.

Ethical considerations

This study was approved by the Human Research Ethics Committee USM (HREC) (approval no. USM/JEPeM/PP/24070600) on September 13, 2024.

Informed consent

Informed consent was obtained from all subjects and/or their legal guardian(s).

Additional information

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