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A Study on the Influence of Critical Thinking Ability on Academic Achievement of Chinese College Students----Academic Emotions and Achievement Motivation as Mediating Variables

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Abstract

On the basis of summarizing relevant literature and theories, this study analyzes the impact of critical thinking ability on academic achievement of Chinese college students through a large sample of empirical investigation, focusing on the mediating role of academic emotions and achievement motivation. The study clarifies the connotation and dimension composition of the four core variables of critical thinking ability, academic emotion, academic achievement and achievement motivation, constructs a theoretical model for college students, and puts forward eight research hypotheses. Using factor analysis, regression analysis and structural equation model to verify the hypotheses, the following conclusions are drawn: the relationship between the four variables and their dimensions is clarified, and the research model of the relationship between college students' critical thinking ability and academic achievement is established.

Based on the research findings, this study puts forward a series of strategies and suggestions to effectively enhance the critical thinking ability of college students, so as to improve academic emotions, stimulate achievement motivation, and ultimately improve academic achievement. These research results provide theoretical basis and practical reference for optimizing the education and teaching of Chinese college students, and provide new research perspectives and valuable suggestions for improving the teaching quality of higher education.

Key words:

critical thinking ability; academic achievement; academic emotion; Achievement motivation

1. Research Background and Significance

1.1 Necessity of Research

In July 2010, the Ministry of Education issued the Outline of the National Medium and Long-term Education Reform and Development Plan (2010-2020), which clearly emphasizes the need to "firmly establish the central position of personnel training in the work of colleges and universities", and puts "deepening teaching reform" in a prominent position. It can be expected that during the "Twelfth Five-Year Plan" period, around the central task of personnel training, comprehensive and in-depth teaching reform will be carried out in colleges and universities throughout the country. Due to the internal logic evolution of discipline development and the change of social environment, English majors in Chinese universities have in fact carried out extensive and in-depth teaching reform at the beginning of the new century. English Teaching Syllabus for English Majors in Colleges and Universities issued in March 2000 marks the beginning of this reform.

In recent years, the cultivation of critical thinking ability has attracted great attention in the field of foreign language education in China. The National Standards for Teaching Quality of Foreign Languages and Cultures, the Guidelines for College Foreign Language Teaching (2020 Edition), the English Curriculum Standards for Senior High Schools (2017 Edition) and the English Curriculum Standards for Compulsory Education (2022 Edition) all clearly regard the cultivation of critical thinking ability as an important goal of high-quality foreign language education in the new era of China.

1.2 Research Purpose

The origin of critical thinking ability can be traced back to the question teaching method of Socrates, an ancient Greek philosopher. Critical thinking ability is the core literacy for individuals to adapt to social development, including critical thinking skills and critical thinking tendencies. The use of critical thinking skills cannot be separated from the role of critical thinking tendencies, and critical thinking tendencies need to be manifested through critical thinking skills (Facione, 2011). In recent years, more and more attention has been paid to the critical thinking ability of learners. Surveys on college students (Afshar & Movassagh, 2017), middle school students and primary school students (Liang & Fung 2021) have shown that critical thinking ability is conducive to the improvement of academic performance. However, previous studies have paid more attention to critical thinking skills and less attention to learners' critical thinking tendencies, and have adopted a variable-centered approach (Heidari, 2020) and less individual-centered approach. Variable-centered approach assumes that the predictive effect of critical thinking ability on foreign language achievement is homogeneous in all groups, while individual-centered approach emphasizes the heterogeneity of students' critical thinking ability, which is of great significance for a comprehensive understanding of learners' critical thinking characteristics and a further accurate description of the relationship between critical thinking ability and variables related to foreign language learning. Although several studies have shown that critical thinking promotes academic achievement (Afshar & Movassagh, 2017; Liang & Fung, 2021), but so far, it is not clear through what path critical thinking promotes academic achievement. Studies have shown that learners with high critical thinking ability often keep an open mind, can tolerate and understand different views, and are more likely to form rational, stable and positive academic emotions (Kang, 2015), which are closely related to academic performance.

In view of the fact that positive academic emotions promote academic achievement, negative academic emotions hinder academic achievement (Dewaele & Alfawzan, 2018; Botes et al, 2022), this study intends to explore the path of critical thinking ability acting on academic achievement, focusing on the mediating role of academic emotions and achievement motivation, in order to provide empirical basis and reference for the comprehensive improvement of college students' academic achievement and critical thinking ability.

1.3 Research Questions

In view of the need to promote the development of college students' critical thinking ability in practice, and to further explore the relationship among critical thinking ability, academic emotion, academic achievement and achievement motivation in theory, based on the above research objectives, this study mainly takes college students as the research object, focusing on the following five research questions:

Q1. What is the relationship among college students' critical thinking ability, academic emotion, academic achievement and achievement motivation?

Q2. What is the impact of college students' critical thinking ability on their academic achievement?

Q3. What is the relationship between college students' critical thinking ability and academic emotions?

Q4. What mediating role does academic emotion play between critical thinking and academic achievement of college students?

Q5. How does achievement motivation mediate the relationship between critical thinking and academic achievement?

2. Theoretical Background and Literature Review

2.1 Theoretical Background

1) Information Processing Theory

Cognitive Information Processing Theory (CIP) is an important concept in cognitive psychology. It mainly focuses on how individuals make decisions in their career development and how they use information to solve problems. The theory originated in the 1950s. With the development of computer science, psychologists began to compare the human cognitive process to the information processing mode of computers. Information processing theory focuses on how humans receive, encode, store, retrieve, and use information, and involves multiple core processes: perception, reception, encoding, storage, retrieval, and use.

2) Rational-emotional Theory

Rational-Emotive Behavior Therapy (Rational Emotive Behavior Therapy, REBT) is a cognitive-behavioral therapy developed by Albert Ellis in the 1950s. This theory emphasizes the interrelationship between thinking, emotion and behavior, and holds that unreasonable thinking is the main cause of emotional distress and behavioral problems. REBT believes that people's emotional problems stem primarily from their irrational beliefs and evaluations of events, not the events themselves.

3) Control-value Theory

In 2002, Pekrun et al. Selected the most frequent academic emotions among college students based on questionnaire and interview data, and divided academic emotions into four types of emotions, namely, positive high arousal, negative high arousal, positive low arousal and negative low arousal, from the two dimensions of valence (positive and negative) and pleasure (arousal). According to this classification, the Academic Emotion Questionnaire (AEQ) was developed. It is found that the generation of academic emotions is related to the environmental variables of students' learning, the sense of control and the evaluation of value, and the Control-Value Theory (CVT) is put forward to explain the source of academic emotions. In 2006, Pekrun et al expanded the theory from three dimensions: valence, arousal degree and arousal object. The control-value theory explains the source of academic emotions and the close relationship between academic emotions and environmental factors, control and value, and academic performance, which confirms the rationality of dividing academic emotions into four types according to valence and pleasure: positive high arousal, negative high arousal, positive low arousal, and negative low arousal.

4) Cognition-motivation Model

In 2002, Pekrun et al. Divided the Academic Emotion Questionnaire (AEQ) data into Cognitive-Motivational Model (CMM) again, and further explained how academic emotions affect academic performance through Cognitive and Motivational mechanisms. Then the positive and negative feedbacks from academic achievement are fed back to environmental variables, personal cognitive assessment and academic emotions. The cognitive-motivational model shows that academic emotions will affect learners' academic performance through learning motivation and cognitive resources, and academic performance will in turn affect academic emotions through learning motivation and cognition, which proves that there is a certain correlation between academic emotions and academic performance, and provides theoretical support for this paper to explore the correlation between different characteristics of academic emotions and academic performance. In a word, the control-value theory and cognitive-motivational model of academic emotions provide an integrated view of academic emotions, which is an integrated theoretical framework for researchers to analyze the variables related to academic emotions and their effects. The interaction of these two theories provides a theoretical basis for this study to explore the correlation between academic emotions and academic achievement.

2.2 Literature Review

1) Research on Critical Thinking Ability at Home and Abroad

In recent years, the relationship between critical thinking ability and foreign language achievement has been widely concerned by domestic scholars. Wang, et al. (2021) found that students with higher critical thinking ability showed stronger understanding and analytical ability in foreign language learning, thus improving their overall language performance. Liu (2020) pointed out that in reading comprehension and writing, the level of critical thinking ability directly affects students' performance. In addition, Zhang (2022) emphasized the importance of critical thinking in listening and speaking, believing that critical thinking can help students analyze and process the information in listening materials more effectively. Domestic research has been exploring the various factors that affect students' critical thinking ability, including cognitive style, learning motivation, teacher feedback and classroom interaction. It is found that positive learning motivation

and high-quality teacher feedback can significantly improve students' critical thinking ability, and interaction and cooperative learning in class also play an important role. As for the factors affecting students' critical thinking ability, the study found a variety of related factors, including students' learning motivation, environment and personality traits. Liu (2021) found that positive learning motivation can significantly improve students' critical thinking ability, while passive learning attitude may limit the development of thinking ability. Li (2022) emphasized the importance of teachers' classroom management and teaching feedback for the cultivation of students' critical thinking ability. Chen et al. (2023) pointed out that family background and socio-economic status have a certain impact on students' critical thinking ability. In the study of the relationship between critical thinking ability and academic achievement, Zhang (2021) found that a high level of critical thinking ability is positively correlated with students' overall academic achievement. Li (2023) pointed out that critical thinking ability not only affects foreign language performance, but also has a positive effect on students' performance in other disciplines. The research of Huang Wei et al. (2022) shows that students with stronger critical thinking ability perform better in research and thesis writing, which further confirms the importance of critical thinking in academic achievement. To sum up, the research on critical thinking in foreign language learning at home and abroad is gradually deepening, and the research results provide strong support for foreign language teaching practice. These studies not only reveal the importance of critical thinking in foreign language learning, but also provide educators with effective teaching strategies and assessment tools. These studies provide a basis for further exploration in the future, and also indicate the necessity of strengthening the cultivation of critical thinking ability in foreign language teaching. Developing students' critical thinking skills in foreign language learning is essential to improving their language and cognitive skills. Effective teaching methods should promote independent thinking and problem solving, thereby enhancing classroom participation and academic success.

2) Research on Academic Emotions at Home and Abroad

Domestic scholars mainly focus on the impact of academic emotions on learning motivation, learning strategies and academic achievement. Zhang & Li (2021) analyzed the relationship between academic emotions and learning motivation through empirical research, and found that positive academic emotions can effectively enhance students' intrinsic learning motivation, thereby promoting the improvement of academic achievement. Wang (2020) pointed out in the study that academic emotions not only affect students' learning process, but also have an important impact on students' mental health and school adaptability. In terms of exploring the relationship between academic emotions and learning strategies, Li & Chen (2022) have shown that positive academic emotions can promote students to adopt more effective learning strategies, while negative academic emotions may lead to inefficient learning strategies. At the same time, the regulatory function of academic emotions has also been concerned by domestic scholars. Zhao (2023) found that students with strong emotional regulation ability were better able to maintain learning motivation and efficiency in the face of academic challenges. In recent years, foreign scholars have conducted extensive research on the causes and manifestations of academic emotions and their relationship with academic achievement. The research on academic emotions abroad mainly focuses on its impact on academic achievement. Through a large number of empirical studies, Pekrun et al. (2011) found that positive academic emotions such as happiness and pride are positively correlated with academic achievement, while negative academic emotions such as anxiety and anger are negatively correlated with academic achievement. Zeidner (2019) explored the relationship between

academic emotions and learning strategies through empirical research, and found that positive emotional States can promote students to adopt deep learning strategies, while negative emotions may lead to surface learning behavior. To sum up, the domestic research on academic emotions is gradually deepening, which not only reveals the important role of academic emotions in learning process and results, but also provides valuable guidance for educational practice. Future research can further explore the characteristics of academic emotions in different educational contexts and their implications for educational policy. Domestic scholars have also conducted extensive research on academic emotions.

3) Research on Academic Achievement at Home and Abroad

The relationship between learning motivation and academic achievement has attracted much attention. Li (2020) pointed out that both intrinsic motivation and extrinsic motivation have an impact on academic achievement, but intrinsic motivation has a more significant impact on long-term academic achievement. Zhan (2021) found that students with higher levels of learning motivation, especially in autonomous learning and task challenge, can significantly improve their academic performance. Yang (2022) pointed out that there are differences in the influence of learning motivation in different disciplines, especially in language courses, learning motivation plays a more critical role. Foreign scholars generally believe that there is a close relationship between learning motivation and academic achievement. Ryan and Deci (2000) further pointed out that intrinsic motivation not only contributes to students' academic performance, but also is essential to students' lasting learning interest and autonomous learning ability. Wigfield & Eccles (2000) emphasize the expectancy-value theory, which holds that students' expectations of learning tasks and their evaluation of learning values will directly affect their academic achievements. To sum up, the influencing factors of academic achievement are complex and diverse, and both foreign and domestic studies have made important progress in theory and empirical research. However, how to further reveal the formation mechanism of their academic achievement according to the specific situation of Chinese students is still an important direction for future research.

4) Research on Achievement Motivation at Home and Abroad

Chen (2009) found that achievement motivation significantly predicted the academic achievement of college students and mediated through self-efficacy and learning strategies. Li (2015) further explored the multi-dimensional structure of achievement motivation and verified the different effects of different components on academic achievement. Achievement motivation is the intrinsic motivation that drives individuals to succeed in academic and professional fields. In recent years, domestic scholars have gradually deepened their research on achievement motivation, covering a wide range of fields, including educational psychology, pedagogy and management. Zhang & Li (2021) explored the relationship between achievement motivation and students' academic performance, and found that students with high achievement motivation were more likely to adopt active learning strategies to achieve better academic results. Achievement motivation has been widely studied by foreign scholars. The research of Eccles & Wigfield (2002) shows that there is a significant positive correlation between achievement motivation and academic achievement, and indirectly affects academic performance by affecting learning strategies and self-efficacy. To sum up, the important role of achievement motivation in academic achievement has been widely recognized. Foreign studies are more systematic in theoretical construction and empirical verification, while domestic studies have gradually followed up and put forward research results with local characteristics. However, the multidimensional structure of achievement

motivation and its performance in different cultural contexts still need to be further explored.

3. Research Methods

3.1 Research Model

This study focuses on the relationship among critical thinking ability, academic emotion, academic achievement, and achievement motivation of college students, aiming to empirically investigate the structural relationship among critical thinking ability, academic emotion, academic achievement, and achievement motivation of Chinese college students. To this end, a research model was proposed and the research variables were classified as follows (see <Table 1> and [Figure 1]). This study will conduct a questionnaire survey on Chinese college students to test the hypotheses described in the research questions. Combined with the existing experts' opinions, the initial research model of the influence of college students' critical thinking ability on academic achievement is established on the basis of theoretical assumptions.

Table 1. Study Variables

Variable name	Observation dimension
Critical thinking ability (independent variable)	Open mind
	Analytical ability
	Systematic ability
	Critical thinking and self-confidence
Academic Emotions (Mediating Variable)	Positive emotions
	Negative emotions
Achievement Motivation (Mediated Change)	Motivation to succeed
	Motivation to avoid failure
Academic achievement (dependent variable)	Learning performance
	Ability to learn
	Objective results

In this study, critical thinking ability is the independent variable, academic achievement is the dependent variable, academic emotion is the mediator variable, and achievement motivation is the mediator variable. The study model is shown in Figure 1.

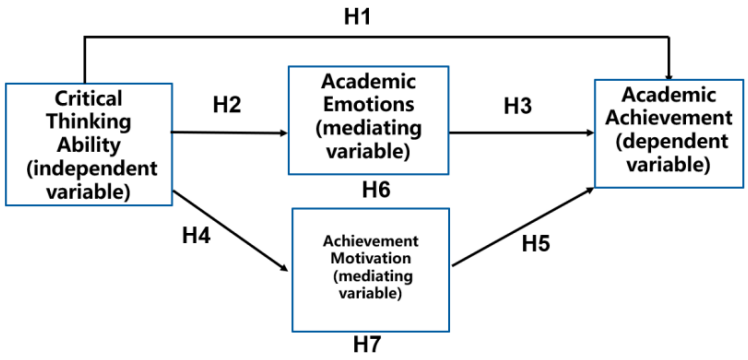

Figure 1 Research Model

3.2 Research Hypothesis

The research hypothesis of this study aims to investigate the relationship among college students' critical thinking ability, academic emotions, academic achievement, and achievement motivation. Based on the previous research on this topic, the following seven hypotheses are put forward:

H1: Critical thinking ability has a significant positive impact on academic achievement.

H2: Critical thinking ability has a significant impact on academic emotions.

H3: Academic emotion has a significant impact on academic achievement.

H4: Critical thinking ability has a significant impact on achievement motivation.

H5: Achievement motivation has a significant impact on academic achievement.

H6: Academic emotion plays a mediating role between critical thinking and academic achievement

H7: Achievement motivation plays a mediating role between critical thinking and academic achievement.

3.3 Research Participants

The formal subjects of this study are undergraduates and junior college students in China, and the random sampling method is used. From July 2024 to August 2024, questionnaires were sent out in the form of online questionnaires, and 1785 questionnaires were finally collected. After the obvious tendency to answer and more than 20% of the missing answers were excluded as invalid questionnaires, 1778 valid questionnaires were collected, and the effective recovery rate was 99.61%. The sample sources of the respondents are relatively wide, covering all provinces and autonomous regions except Taiwan, Hong Kong and Macao.

In the course of the survey, the investigators first introduced the process and purpose of the survey in detail on the online questionnaire platform, emphasizing the principle of confidentiality of the survey. The results of the survey are only for research and will not have any adverse impact on the respondents. It is hoped that the subjects can answer these questions truthfully. The demographic variables involved in this study include gender, grade, professional category, province and region where the school is located, etc. See <Table 2> for the distribution of demographic classification variables of the formal respondents.

Table 2. Demographic factors of formal respondents (N = 1778)

Variables	Category	Number of people (N)	Percentage (%)
Gender	Male	517	29.1
	Female	1261	70.9
Grade	First year of college	767	43.1
	Sophomore year of college	637	35.8
	Junior year of college	264	14.8
	Senior year of college	110	6.2
Age	17 years and below	5	.3
	18 years old	138	7.8
	19 years old	649	36.5
	20 years old	579	32.6
	21 years old	256	14.4
	22 years and above	149	8.5

Professional category	Humanities (including arts and sports)	861	48.4
	Science and engineering	917	51.6

3.4 Research Tools

This study used four scales in the empirical investigation: Critical Thinking Scale, Academic Emotion Scale, Academic Achievement Scale and Achievement Motivation Scale, all of which adopted the mature scale with high reliability and validity, and at the same time made localized adjustment and transformation. In this study, the reliability, exploratory factor analysis, convergent validity and discriminant validity of the four scales were tested. The data of empirical investigation were input and processed by SPSS 27.0 and AMOS 26.0.

1) Critical Thinking Scale

In this study, the measurement tool used to measure and evaluate college students' critical thinking ability is the Chinese version of the California Critical Thinking Disposition Inventory (CTDI-CV) compiled by scholars Pan & Pan et al. (2002). They translated and adapted the original version of the scale to apply to the assessment of Chinese students' critical thinking ability and critical thinking disposition. There are 20 items in the scale, including 5 items of open-mindedness, 5 items of analytical ability, 5 items of systematic ability and 5 items of self-confidence in critical thinking. A five-point Likert scale was used for each rating, ranging from 1 (complete nonconformance) to 5 (complete conformance). The Cronbach's alpha coefficient of the overall scale of critical thinking ability was. 894, and the reliability was good. The results of exploratory factor analysis showed that KMO = .799, higher than .7; Bartlett's sphericity test chi-square = 6061.185, its significance level is less than .001 ($p < .001$), which is suitable for factor analysis. Four factors are extracted after rotation by maximum variance method, and the cumulative variance explanation rate is 73.603%. The structural validity of the critical thinking scale is good. Confirmatory factor analysis (CFA) was conducted on the formal survey data of the critical thinking scale to evaluate the construct validity of the measurement tool by testing the fitting model. The CFA results of the critical thinking scale showed that $\chi^2/DF = 4.923$, GFI = .974, NFI = .968, RMR = .023, RMSEA=.047. The χ^2/DF ratio is 4.923, which is within the acceptable range due to the large sample size. The values of NFI, GFI, PGFI, PCFI, were all greater than.9, the values of SRMR were less than.1, and the values of PNFI were close to.9. The fit of the critical thinking scale performed well. Each index reached or exceeded the commonly accepted criteria of fit, the fit between the model and the actual data was good, and the critical thinking scale had good validity in measuring different dimensions of professional identity. At the same time, the convergent validity and discriminant validity of the critical thinking scale were tested. The average variance variance (AVE) of the self-confidence latent variables of open thinking, analytical ability, systematic ability and critical thinking were close to or greater than. 5, and the combined reliability (CR) was greater than. 7, indicating that the convergent validity of the scale was good. Therefore, the confirmatory analysis model of the critical thinking scale used in this study is reasonable and can be used for further analysis and research.

2) Academic Achievement Scale

The measurement tool used to measure and evaluate the academic achievement of college students is the Academic Achievement Scale for College Students, which is revised by Wang Yanfei, Li Yunjian and Huang

(2011) on the basis of the Employee Organizational Performance Scale and combined with the characteristics of college students. The researcher of this subject quoted this scale directly. There are 10 items in the scale, including 2 items of learning performance dimension, 3 items of learning ability dimension and 5 items of objective achievement dimension. The Cronbach's alpha coefficient of the overall academic achievement scale is 0.843, which means that the reliability is good. The results of exploratory factor analysis showed that KMO was .826, higher than .7; The chi-square of Bartlett's sphericity test is 779.158, and its significance level is less than .001 ($p < .001$), which means that the achievement motivation scale is suitable for factor analysis. After rotating by the maximum variance method, three factors are extracted, and the cumulative variance explanation rate is 76.573%, which means that the structural validity of the achievement motivation scale is good. Confirmatory factor analysis (CFA) was conducted on the formal survey data of the academic achievement scale, and the construct validity of the measurement tool was evaluated by testing the fitting model. The results of CFA on academic achievement showed that $\chi^2/DF = 4.894$, GFI = .987, NFI = .986, RMR = .033, RMSEA=.047. The χ^2/DF ratio is 4.894, which is within the acceptable range. The values of NFI, GFI, PGFI, PNFI, were all greater than. 9, the value of SRMR was less than. 1, and the value of PCFI was close to. 6. The fit of the academic achievement scale was good, the fit between the model and the actual data was good, and the academic achievement scale had good validity in measuring different dimensions of professional identity. Therefore, the confirmatory analysis model of the academic achievement scale adopted in this study is reasonable and can be used for further analysis and research. At the same time, the convergent validity and discriminant validity of the Academic Achievement Scale were tested. The average variance (AVE) of the latent variables of the three dimensions of learning performance, learning ability and objective achievement were greater than. 5, and the combined reliability (CR) was greater than. 7, indicating that the convergent validity of the scale was good. This shows that the scale can accurately measure the characteristics of different dimensions of college students' academic achievement, and provides a solid foundation for further research and application.

3) Academic Emotion Scale

The Academic Emotion Inventory (AEQ) developed by Pekrun et al. (2002) is used to measure and evaluate the academic emotions of college students. According to the characteristics of the subjects, the researcher adjusted the dimensions of the scale and the items of each dimension in order to be more suitable for measuring the academic emotions of the subjects. There were 24 items in the scale, including 7 items of positive emotion and 17 items of negative emotion. The Cronbach's alpha coefficient of the overall scale of academic emotions is .915, which means that the reliability is good. Exploratory factor analysis showed that KMO was .813, higher than .7; The chi-square of Bartlett's sphericity test is 9647.260, and its significance level is less than .001 ($p < .001$), which means that achievement motivation is suitable for factor analysis. After rotating by the maximum variance method, two factors are extracted, and the cumulative variance explanation rate is 77.265%, which shows that the structural validity of achievement motivation is good. Confirmatory factor analysis (CFA) was conducted on the formal survey data of the Academic Emotion Scale to evaluate the construct validity of the measurement tool by testing the fitting model. The results of CFA showed that $\chi^2/DF = 23.652$, GFI = .882, NFI = .935, RMR = .211, RMSEA=.113. The χ^2/DF ratio is 23.652, which is within the acceptable range. The values of NFI and GFI were more than.8, the values of PGFI and PNFI were more than.5, and the values of SRMR were less than.1. The fit of the Academic Emotions Scale was good, and all

the indicators reached or exceeded the commonly accepted criteria of fit. The fit between the model and the actual data was good, and the Academic Emotions Scale had good validity in measuring different dimensions of professional identity. At the same time, the convergent validity and discriminant validity of the Academic Emotion Scale were tested. The results showed that the average variance (AVE) of the latent variables of the two dimensions of positive and negative emotions was greater than. 5, and the combined reliability (CR) was greater than. 7, indicating that the convergent validity of the scale was good. The AVE square root values of positive and negative emotions were much higher than maximum of the absolute value of the correlation coefficient between factors, which indicated that they had good discriminant validity in the learning emotion scale, which meant that the two potential variables were relatively independent and unique in measuring positive and negative emotions, and verified the validity of the scale in different dimensions. It can be seen from the above table that the discriminant validity of each dimension of positive emotion and negative emotion of academic emotion is good.

4) Achievement Motivation Scale

The achievement motivation scale developed by Chinese scholar Ye Renmin and Norwegian scholar Hegtvet (1988) is used to measure and evaluate the achievement motivation of college students. The researcher of this subject directly quoted this scale. As shown in Table 23, there are 24 items in the scale, including 11 motivation dimensions of pursuing success and 13 motivation dimensions of avoiding failure. The Cronbach's alpha coefficient of the overall scale of achievement motivation is .928, which means that the reliability is good. The results of exploratory factor analysis showed that KMO was .876, higher than .7; Bartlett's sphericity test chi-square = 1976.517, its significance level is less than .001 ($p < .001$), which means that achievement motivation is suitable for factor analysis. After rotating by the maximum variance method, two factors are extracted, and the cumulative variance explanation rate is 63.181%, which means that the structural validity of achievement motivation is good. Confirmatory factor analysis (CFA) was conducted on the formal survey data of the Achievement Motivation Scale to evaluate the construct validity of the measurement tool by testing the fitting model. The results of CFA on achievement motivation showed that $\chi^2/DF = 4.826$, GFI = .961, NFI = .969, RMR = .056, RMSEA=.101. The χ^2/DF ratio is 4.826, which is within the acceptable range. The values of NFI and GFI were greater than. 9, the values of PGFI, PNFI and PCFI were greater than. 5, and the value of SRMR was less than. 1. The fit of the Achievement Motivation Scale performed well. Each index reached or exceeded the commonly accepted criteria of fit, the fit between the model and the actual data was good, and the Achievement Motivation Scale had good validity in measuring different dimensions of professional identity. At the same time, the convergent validity and discriminant validity of the Achievement Motivation Scale were tested. The average variance (AVE) of the latent variables of the two dimensions of the motivation to pursue success and the motivation to escape failure were greater than. 5, and the combined reliability (CR) were greater than. 7. The convergent validity of the scale was good. The AVE square root values of the motivation to pursue success and the motivation to escape failure were much higher than maximum value of the absolute value of the correlation coefficient between the factors, indicating that they have good discriminant validity in the achievement motivation scale. The two potential variables are relatively independent and unique in measuring the motivation to pursue success and the motivation to escape failure, which verifies the validity of the scale in different dimensions. It can be seen from the above table that the discriminant validity of each dimension of pursuing success and avoiding failure of achievement motivation is good.

Table 3. Summary of reliability and validity analysis of the scale

Scale	Cronbach's alpha coefficient	KMO value	Bartlett's test for sphericity		
			Approximate chi-square	df	Sig
Critical Thinking Scale	**.894**	.799	6061.185	190	.000
Academic Achievement Scale	**.843**	.826	779.158	45	.000
Academic Emotion Scale	**.915**	.813	9647.260	276	.000
Achievement Motivation Scale	**.928**	.876	1976.517	276	.000

4. Research Results

4.1 Descriptive Statistical Analysis

Table 4. Descriptive statistical analysis of measurement scale data (N = 1778)

	Min	Max	M	SD	SEM	Ske	Kur
Critical thinking ability	2.35	5.00	4.28	.53	.01317	-.878	.444
Open mind	2.60	5.00	4.52	.51	.01622	-1.246	1.168
Analytical ability	2.20	5.00	4.45	.61	.01571	-1.297	1.126
Systematic ability	2.00	5.00	4.16	.79	.01534	-.878	-.213
Critical thinking and self-confidence	1.60	5.00	4.00	.87	.01807	-.582	-.736
Academic mood	1.80	5.00	3.83	.77	.01716	-.490	-.642
Positive emotions	1.00	5.00	3.82	1.06	.02083	-.685	-.460
Negative emotions	1.25	5.00	4.03	.97	.01935	-.796	-.478
Achievement motivation	1.25	5.00	3.64	1.06	.01963	-.441	-.960
Motivation to succeed	1.00	5.00	2.59	.72	.01479	.143	-.149
Motivation to avoid failure	1.00	5.00	3.28	1.24	.01767	-.473	-.735
Academic achievement	1.00	5.00	2.30	.88	.01969	.334	-.631
Learning performance	1.50	5.00	3.75	.77	.01313	-0.467	-0.530
Ability to learn	1.18	5.00	3.76	.91	.01632	-.457	-.528
Objective results	1.00	5.00	3.75	.91	.01806	-.487	-.822

It can be seen from Table 4 that the skewness distribution of the measurement scale data is between -.878 and .334, the kurtosis distribution is between -.960 and 1.168, and there is no abnormal value in the mean value of each variable. According to the research results of Kline (1998), when the absolute value of bias is less than 3 and the absolute value of kurtosis is less than 10, the normality is considered acceptable. It shows that the sample data obey the normal distribution and have an ideal statistical form, which can be used for further test and analysis. It can be seen from the above table that the variables of critical thinking ability, open thinking, analytical ability, systematic ability, critical thinking self-confidence, academic achievement, academic

performance, learning ability, objective achievement, academic emotion, positive emotion, negative emotion, achievement motivation, pursuit of success and avoidance of failure are all approximately normal distribution.

Since the scale used in this study is a 5-point scale, 3 is the median. It can be seen from Table 4 that the overall average values of the four variables are 4.28, 3.83, 3.64 and 2.30 respectively, which indicates that the critical thinking ability, academic emotion, academic achievement and achievement motivation of college students are at a medium level.

From the perspective of each dimension, the average score of open minds is the highest (M = 4.52), and the average score of motivation to pursue success is the lowest (M = 2.59), which is lower than middle critical value 3. Among the four dimensions of critical thinking ability, the average score of open thinking is the highest (M = 4.52), and the average score of systematic ability is the lowest (M = 4.16). Among the two dimensions of academic emotion, the average score of negative emotion (M = 4.03) is higher than that of positive emotion (M = 3.82). Among the two dimensions of achievement motivation, the average score of the motivation of avoiding failure (M = 3.28) is higher than that of the motivation of pursuing success (M = 2.59); among the three dimensions of academic achievement, the average score of learning ability is the highest (M = 3.76), and the average score of academic performance and objective achievement is the lowest (M = 3.75).

It can be seen that college students who enter the adult stage gradually mature with their psychological development, and their cognition is more rational. Therefore, they are generally more positive and positive in open thinking, analytical ability, systematic ability and critical thinking self-confidence, and the positive performance of academic emotions also occupies the mainstream. However, in the achievement motivation dimension, the motivation to avoid failure is more serious. In the academic achievement dimension, it shows the importance of learning ability, rather than sticking to the objective test results.

4.2 Correlation Analysis

In order to explore the correlation among the four variables of college students' critical thinking ability, academic achievement, academic emotion and achievement motivation, this study uses Pearson correlation analysis to analyze the correlation between the four variables of college students' critical thinking ability, academic achievement, academic emotion and achievement motivation and each dimension. The analysis results are shown in <Table 5.>

Table 5. Pearson correlation analysis among the four variables

Variable name	Critical thinking ability	Academic achievement	Academic mood	Achievement motivation
Critical thinking ability	1			
Academic achievement	.603**	1		
Academic mood	-.207**	-.283**	1	
Achievement motivation	.513**	.648**	-.229**	1

Note: * * p < 0.01

It can be seen from< Table 5> that there is a significant positive correlation between critical thinking ability and academic achievement, with a correlation coefficient of 0.603 ($p < .01$), a significant negative correlation between critical thinking ability and academic emotion, with a correlation coefficient of -.207 ($p < .01$), and a significant positive correlation between critical thinking ability and achievement motivation, with a correlation coefficient of 0.513 ($p < .01$). There is a significant negative correlation between academic achievement and academic emotion, the correlation coefficient is -0.283 ($p < .01$), and there is a significant positive correlation between academic achievement and achievement motivation, the correlation coefficient is 0.648 ($p < .01$). There is a significant negative correlation between academic emotion and achievement motivation, and the correlation coefficient is -.229 ($p < .01$).

The relationship described above indicates that critical thinking ability, academic achievement, academic emotion and achievement motivation are interrelated and influential in the educational environment. Improving students' critical thinking ability and achievement motivation can help to improve their academic emotions and academic achievement. The influencing, mediating, and moderating relationships between these variables will be further studied and discussed in the following sections.

4.3 Regression Analysis

Table 6 Multiple regression analysis of college students' critical thinking ability, academic emotion, academic achievement and achievement motivation

Model	Unnormalized coefficient		Normalization factor	P	VIF (Variance inflation factor)	D-W (Durbin Watson) Statistics)	Adjusted R2	F
	B	Standard error	Beta					
Critical thinking ability	.875	.028	.603	.000	1.849	1.990	0.364	1014.688
Academic mood	-.301	.028	-.283	.000	2.246		0.080	154.273
Achievement motivation	.203	.035	.155	.000	1.479		0.437	460.785

Dependent variable: academic achievement

It can be seen from Table 6 that the adjusted R 2 = .364. Critical thinking ability, academic emotion and achievement motivation can explain 36.4% of the changes in learning achievement. This was a moderately strong relationship, indicating that the independent variables (critical thinking, academic emotions, and achievement motivation) together explained a significant portion of the variation in academic achievement. The F test in the model has F = 460.785, p <.0001, VIF (Variance Inflation Factor) < 5, and 1 < VIF < 5 is acceptable multicollinearity, that is, there is no serious multicollinearity between the predictor variables, that is, there is no strong linear relationship between the independent variables. The D-W (Dubin-Watson statistic) value = 1.990 is near the number 2, i.e., DW ≈ 2, indicating no significant autocorrelation between the residuals. It can be seen that the three indicators in the independent variables do not have the problem of collinearity and at least one of them will have an impact on the learning achievement of college students, and the regression model fits well.

Specific analysis shows that the standardized coefficients of three independent variables: critical thinking ability, academic emotion and achievement motivation in the regression equation are: critical thinking ability (β = .364): has the greatest positive impact on academic achievement. Academic Emotion (β = -.283): Negative effect on academic achievement. Achievement motivation (β = .155): It has a positive impact on academic achievement, but the impact is less than critical thinking ability. The regression coefficient of critical thinking ability and achievement motivation is positive, and the regression coefficient of academic emotion is negative. Therefore, the independent variable critical thinking ability and achievement motivation positively affect the dependent variable academic achievement, while the independent variable academic emotion (positive emotion + negative emotion) negatively affects the dependent variable academic achievement. The standardized coefficient shows that critical thinking ability has the greatest impact on college students' academic achievement, followed by achievement motivation; academic emotion (positive emotion + negative emotion) has the least negative impact. Therefore, the critical thinking ability of college students has the highest explanation rate for academic achievement among the three independent variables (Beta = .671).

4.4 Mediating effect test

1) Analysis of the mediating effect of academic emotion

SPSS27.0 and Amos26.0 were used to test the mediating effect in the research model.

See <Table 7> and <Table 8>.

Table 7. Test of mediating effect of academic emotion

Item	Symbol	Meaning	Effect value effect	95% CI		SE value of standard error	Z-value/t-value	P-value	Conclusion
				Lower limit	Upper limit				
Critical Thinking = > Academic Emotions = > Academic achievement	a*b	Indirect effects	.023	.038	.003	.010	-2.254	.024	Part Mediating effect
Critical Thinking = > Academic mood	a	X=>M	.471	.424	0.518	.024	19.482	.000	
Academic Emotions = > Academic achievement	b	M=>Y	.049	.094	.004	.023	-2.133	.033	
Critical Thinking = > Academic achievement	c'	Direct effect	.873	.823	.924	.026	33.869	.000	
Critical Thinking = > Academic achievement	c	Total effect	.850	.804	.896	.023	36.290	.000	

Table 8. Summary of mediating effects of academic emotions

	Academic achievement	Academic mood	Academic achievement
Critical thinking ability	.603***	-.207***	.569***
Academic mood			-.165***
R^2	.364	.043	.390
F	1014.688***	79.436***	566.604***

Note: * * * p < 0.001

It can be seen from Table 8 that critical thinking ability can significantly positively predict academic achievement (β = .603, p < .001), which can explain 36.4% of the variance. Critical thinking ability was a significant negative predictor of academic emotions (β = -.207, p < .001), accounting for 4.3% of the variance. When critical thinking ability and academic emotion were included in the equation, critical thinking ability could significantly positively predict academic achievement (β = .569, p < .001), and academic emotion could significantly negatively predict academic achievement (β = -.165, p < .001), which could explain 39.0% of the variance. And β = .569 < β = .603, which means that academic emotion plays a partial mediating role between critical thinking ability and academic achievement.

2) The mediating effect of achievement motivation

SPSS27.0 and Amos26.0 were used to test the mediating effect in the research model, and the test results are shown in <Table 9> and <Table 10>.

Table 9 Mediating Effect Test of Achievement Motivation

Item	Symbol	Meaning	Effect value effect	95% CI		SE value of standard error	P-value	Conclusion
				Lower limit	Upper limit			
Critical Thinking => Achievement Motivation => Academic achievement	a*b	Indirect effects	.110	.046	.225	.069	.005**	Part Mediating effect
Critical Thinking => Achievement motivation	a	X=>M	.886	.500	.821	.028	.000**	
Achievement Motivation => Academic achievement	b	M=>Y	.125	.486	.758	.036	.033*	
Critical Thinking => Academic achievement	c’	Direct effect	.867	.784	.863	.047	.000**	
Critical Thinking => Academic achievement	c	Total effect	.977	.804	.896	.023	.000**	

* p<0.05 ** p<0.01

Table 10. Summary of Mediating Effect of Achievement Motivation

Item	Inspection conclusion	c	a*b	C'	Calculation formula of effect proportion	Effect Proportion
		Total effect	Intermediary Effect	Direct effect		
Critical Thinking Trait => Achievement Motivation > Academic Achievement	Mediating effect	.977	.110	.867	| a * b / c' |	12.687%

The effect value of the mediating path (critical thinking trait-> achievement motivation-> academic achievement) is .110, indicating that achievement motivation plays a partial mediating role between critical thinking trait and academic achievement. The mediating effect was significant (p = .005 < .01). Direct effect: The trait of critical thinking ability had a direct effect on academic achievement, and the effect value was 0.867, which was significant (p = .000 <.01). The total effect is .977, which indicates the total effect of critical thinking trait on academic achievement through direct and indirect paths. Proportion of effect: The mediating effect accounted for 12.687% of the direct effect, indicating that most of the effect came from the direct effect, while the mediating effect was not significant, but still significant. Overall, critical thinking ability has a significant direct impact on academic achievement, and has a partial mediating effect through achievement motivation. Although the mediating effect accounts for a small proportion, it is still a significant path.

4.5 Structural Equation Modeling

1) Fitting of structural equation model

The fitting indicators of structural equation model and structural equation model are shown in <Table 11> and [Figure 2].

Table 11. Initial Model Fit Index

Common indicators	χ^2	df	^{2}/df	GFI	RMSEA	RMR
Criteria for judgment	-	-	<5	>.9	<.10	<.05
Initial model	59324.746	2917	6.338	.952	.104	. 035
Other indicators	TLI	CFI	AGFI	IFI	SRMR	NFI
Criteria for judgment	>.9	>.9	>.9	>.9	<.1	>.9
Initial model	.455	.471	.210	.471	.186	.458

By analyzing the model fitting index, it is found that χ 2 /DF = 6.338, exceeding the commonly used standard of 5, which may imply that the fit between the model and the data needs to be improved. GFI = .952, exceeding.9, indicating a relatively good overall fit of the model. RMSEA = .104, which is slightly higher than 0.1, suggesting that the root mean square error of the model is better.

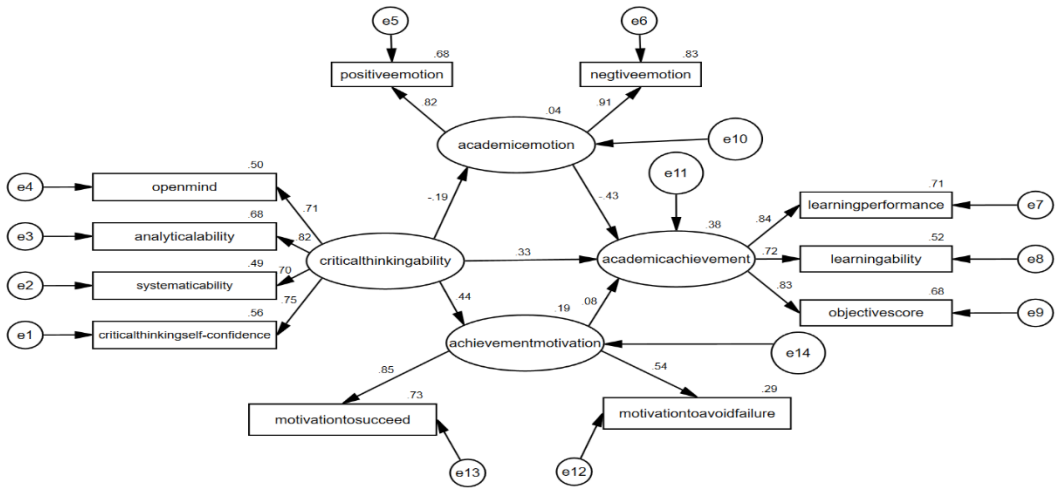

Figure 2. Structural Equation Model

4.6 Hypothesis Testing

The research hypothesis of this study aims to investigate the relationship among college students' critical thinking ability, academic emotions, academic achievement, and achievement motivation. A total of 8 hypotheses are proposed based on the relevant previous studies of this topic, and the research hypotheses are verified according to the research results, as shown in <Table 12>.

Table 12. Study Hypothesis Testing

Research hypothesis	Inspection results
H1: Critical thinking ability has a significant impact on academic achievement.	Accepted
H2: Critical thinking ability has a significant impact on academic emotions.	Accepted
H3: Academic emotion has a significant impact on academic achievement.	Accepted
H4: Critical thinking ability has a significant impact on achievement motivation.	Accepted
H5: Achievement motivation has a significant impact on academic achievement.	Accepted
H6: Academic emotion plays a mediating role between critical thinking and academic achievement	Accepted
H7: Achievement motivation plays a mediating role between critical thinking and academic achievement.	Accepted
H8: Achievement motivation plays a moderating role between academic emotion and academic achievement.	Accepted

V. Analysis and Discussion

5.1 Research Summary

On the basis of previous research and analysis, this study defines the core concepts of critical thinking

ability, academic emotion, achievement motivation and academic achievement of Chinese college students, and explores the dimensional composition of the core concepts. That is, critical thinking ability includes four dimensions: open thinking, analytical ability, systematic ability and self-confidence of critical thinking; academic emotion includes two dimensions: positive emotion and negative emotion; achievement motivation includes two dimensions: motivation to pursue success and motivation to avoid failure; Academic achievement includes three dimensions: learning performance, learning ability and objective achievement. According to the characteristics of the subjects, all the dimensions and items of the four scales, namely, the Critical Thinking Scale, the Academic Emotion Scale, the Achievement Motivation Scale and the Academic Achievement Scale, were adjusted. Through exploratory factor analysis and confirmatory factor analysis, four dimensions of college students' critical thinking ability, two dimensions of academic emotions, two dimensions of achievement motivation and three dimensions of academic achievement are determined. The reliability and validity of the four scales were tested. At the same time, 1778 college students from all over the country were investigated to construct the research model of Chinese college students' critical thinking ability, academic emotion, achievement motivation and the mechanism of academic achievement.

5.2 Research Findings

The results show that the comprehensive performance of critical thinking ability, academic emotion, achievement motivation and academic achievement of Chinese college students is above average. In the aspect of correlation analysis, this study uses Pearson correlation analysis to analyze the correlation between the four variables of college students' critical thinking ability, academic achievement, academic emotion and achievement motivation and each dimension. There is a correlation between all the variables involved. There is a moderate positive correlation between critical thinking ability and academic emotion, a weak positive correlation between academic achievement and academic emotion, and a moderate positive correlation between academic achievement and achievement motivation. There is a strong positive correlation between academic emotions and achievement motivation.

The critical thinking ability of college students has a significant positive impact on academic achievement (H1); College students' critical thinking ability has a significant impact on academic emotion (H2); academic emotion has a significant impact on academic achievement (H3); college students' critical thinking ability has a significant impact on academic achievement (H4); achievement motivation has a significant impact on academic achievement (H5); Academic emotion plays a mediating role between critical thinking ability and academic achievement (H6); achievement motivation plays a mediating role between critical thinking ability and academic achievement (H7). After testing, the above eight assumptions are all valid.

Based on the results of the study, this paper makes a profound and comprehensive reflection, and puts forward effective strategies to improve college students' critical thinking ability and level, strategies and methods to improve college students' academic achievements, and effective strategies to reduce college students' negative academic emotions. It provides theoretical support and practical scientific basis for maintaining and promoting the development and improvement of Chinese college students' critical thinking ability.

6. Conclusion and Prospect

6.1 Research conclusions

Firstly, this paper constructs a theoretical research model of college students' critical thinking ability, academic emotion, achievement motivation and academic achievement, and introduces academic emotion as a mediating variable into the study of the relationship between academic emotion and achievement motivation, which makes up for the shortcomings of previous studies on the logical relationship between the four variables.

Secondly, it explores the connotation, dimensions and correlation of the four core concepts of college students' critical thinking ability, academic emotion, achievement motivation and academic achievement, which can provide reference for the follow-up study.

Thirdly, through the method of quantitative research, this paper deeply studies and verifies the complex relationship between college students 'critical thinking ability, academic emotions, achievement motivation and academic achievement, and verifies that college students' critical thinking ability has a significant positive impact on academic achievement. College students' critical thinking ability has a significant positive impact on academic emotions; Positive academic emotions have a significant positive impact on academic achievement, while negative academic emotions have a significant positive impact on academic achievement. Academic emotion and achievement motivation play a mediating role between critical thinking ability and academic achievement of college students. By clarifying the relationship between these four variables, this follow-up study on critical thinking ability and academic achievement improvement has laid a theoretical and empirical foundation.

6.2 Prospect of Research

In the field of "the relationship and influence among college students' critical thinking ability, academic emotion, academic achievement and achievement motivation", future research can focus on the following five potential issues to explore the complex relationship and influence mechanism among these variables.

First, the measurement and influence of multi-dimensional critical thinking ability is an important research direction. At present, most studies have a single understanding of critical thinking ability. In the future, we can explore how different dimensions of critical thinking ability, such as logical reasoning, critical thinking and creative thinking, affect academic emotions and academic achievement respectively. In addition, the development and validation of multi-dimensional measurement tools for critical thinking is also an important task for future research, which will help to understand the impact of critical thinking on academic performance more comprehensively.

Secondly, the dynamic changes and regulation of academic emotions are worthy of further study. Although some studies have explored the influence of academic emotions, there is still insufficient attention to its dynamic changes in the learning process and its interaction with critical thinking ability and achievement motivation. Future research could use a longitudinal study design to examine how academic emotions change over time and analyze their moderating effects in different learning situations. In addition, exploring the interaction

between academic emotions and other psychological factors (such as self-efficacy, anxiety level, etc.) Will provide a deeper perspective for understanding students' emotional experience.

Third, the mediating role of achievement motivation between critical thinking and academic emotions is a potential research topic. The existing literature has shown the importance of achievement motivation to academic achievement, but the specific mechanism between critical thinking ability and academic emotion has not been fully explored. Future research can use structural equation modeling and other methods to systematically test the mediating effect of achievement motivation on the influence of critical thinking ability on academic emotions, so as to enrich the theoretical model.

Fourthly, the influence of cultural and social background on college students' critical thinking ability, academic emotion and achievement motivation should also be an important research direction. College students from different cultural backgrounds may show different critical thinking skills and emotional States. Therefore, cross-cultural comparative study can reveal the role of cultural factors in this series of relationships. Especially in the context of globalization, how to understand the learning experience and performance of students in different cultural backgrounds will have an important impact on educational practice and policy formulation.

Fifth, empirical research on educational interventions is also an important area for future research. The intervention strategies on how to effectively improve college students' critical thinking ability, regulate academic emotions and promote academic achievement still need to be empirically verified. By designing and implementing specific educational programs and evaluating their impact on students' critical thinking ability, academic mood and academic achievement, practical guidance will be provided for educational practice.

To sum up, in the future research on the relationship and influence among college students' critical thinking ability, academic emotion, academic achievement and achievement motivation, we need to pay attention to multi-dimensional measurement, dynamic change, cross-cultural comparison and educational intervention, in order to provide more rich perspectives and insights for the theoretical development and practical application in this field.

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