Asian Journal of Education and Social Studies

Volume 50, Issue 8, Page 51-65, 2024; Article no.AJESS.119711
ISSN: 2581-6268

A Study of the Effects of Mathematical Culture on Academic Achievement: The Mediating Role of Non-intellectual Factors

Siyu Liu [a] and Shasha Zheng [a*]

[a] *School of Mathematics and Statistics, Shandong Normal University, Jinan, Shandong, China.*

Authors' contributions

This work was carried out in collaboration between both authors. All authors contributed to the study conception and design. Material preparation and analysis were performed by author SL, data collection was performed by authors SL and SZ. The first draft of the manuscript was written by Author SL and all authors commented on previous versions of the manuscript. Both authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/ajess/2024/v50i81506

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/119711

Original Research Article

Received: 12/05/2024
Accepted: 14/07/2024
Published: 18/07/2024

ABSTRACT

Academic achievement is an indicator of students' learning effectiveness, and mathematical culture has been widely researched in recent years, but few articles have explored the influence of mathematical culture on academic achievement and the role of non-intellectual factors in it. This paper adopts the method of literature analysis, comprehensively describes the research background of mathematical culture, academic achievement, and non-intellectual factors, and based on "Questionnaire on Non-intellectual Characteristics of Mathematics Learning for High School Students", compiles a questionnaire on the influence of non-intellectual factors on academic

---

**Corresponding author: Email: shui925@sina.com;*

Cite as: *Liu, Siyu, and Shasha Zheng. 2024. "A Study of the Effects of Mathematical Culture on Academic Achievement: The Mediating Role of Non-Intellectual Factors". Asian Journal of Education and Social Studies 50 (8):51-65. https://doi.org/10.9734/ajess/2024/v50i81506.*

achievement for college students, explores the influence of mathematical culture on academic achievement, and the role of non-intellectual factors as a mediator. The results found that (1) the effects of mathematical culture and non-intellectual factors on academic achievement are significant. (2) Non-intellectual factors play a mediating role in the influence of mathematical culture on academic achievement and the mediating role is significant. Therefore, in the future teaching, we have to penetrate the mathematical culture to improve the students' performance in mathematics by improving the level of their non-intellectual factors, and according to the suggestions before, during, and after the lesson respectively.

Keywords: Academic achievement; mathematical culture; mediating role; non-intellectual factors.

1. INTRODUCTION

1.1 Origin of Mathematical Culture

Mathematical culture first originated in the 1960s, the American mathematician Wilder first put forward the concept of mathematical culture, in his "Evolution of Mathematical Concepts" and "Mathematics as a System" two books, innovative that mathematics is a kind of cultural system, so in the understanding of mathematics, from the perspective of culture to think about, mathematical education is essentially a mathematical culture of education. Until the 6th International Conference on Mathematics Education (ICME-6) was held in 1988, the theme of the conference was "Mathematics-Education-Society-Culture", after which "mathematical culture" gradually began to become the focus of research and attracted wide attention in the field of mathematics education. After that, "mathematical culture" gradually began to become the focus of research and attracted wide attention in the field of mathematics education [1]. Sun Xiaoli and Deng Donggao of Peking University [2] were the first scholars in China to notice the importance of mathematical culture. In their book “Mathematics and Culture”, they collected the thoughts of thousands of mathematicians on mathematical culture, organized and summarized their explorations and expositions, and based on this, they elaborated on the connotation of mathematical culture from the philosophical point of view, and the focus of the study of mathematical culture was on its impact on mathematics education. At that time, the focus of the research on mathematical culture was on its influence on mathematics education.

1.2 Current Research Focus

The research on mathematical culture involves a wide range of topics, including but not limited to the connotation of mathematical culture, its relationship with primary and secondary mathematics classrooms, mathematics textbooks, the history of mathematics, classroom models, and so on.

Fig. 1 shows the annual fluctuation curve of the number of journal articles retrieved from the China National Knowledge Infrastructure database under the theme of "mathematical culture",, from which it can be seen that in 2010 and the years before that, mathematical culture showed a steady increase in the trend, indicating that mathematical culture is gradually being paid attention to.Until 2011, when the number of articles reached 193, showing a sharp increase in the trend, and the number of articles published has increased to 1.3, showing a sharp increase in the trend. In 2011, the number of articles reached 193, showing a sharp increase in the trend, a new curriculum standard was issued in 2011, which mentioned that mathematical culture is an important part of human culture and emphasized the important role played by mathematical culture in cultivating students' cultural literacy and cultural self-confidence, so mathematical culture became a hot spot for research.

1.3 Problem Discovery

Based on the above search results, it is found that the research on mathematical culture has been relatively mature, indicating that more and more educators have begun to pay attention to the role of mathematical culture in education. Through reading the literature, the author found that the research on the influence of mathematical culture on mathematical achievement has been relatively sufficient, but there are few quantitative studies in this area. Therefore, to have a clearer understanding of the relevant studies, research deficiencies, and gaps involved in mathematical culture, this paper intends to make a comprehensive general summary of the research in this direction and to study the role of the non-intellectual factors as mediators in the relationship between the two.

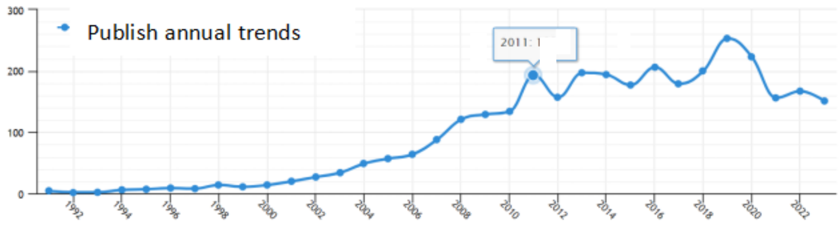

Fig. 1. Changes in the Number of Journal Articles Retrieved With the Theme of "Mathematical Culture"

2. LITERATURE REVIEW

2.1 Mathematical Culture

2.1.1 Culture

Mathematical culture belongs to one of the categories of culture, so if you want to clarify the mathematical culture, you need to first clarify the connotation of culture, the connotation of culture is very rich, different scholars have put forward different definitions of culture, and so far has not formed a unified definition.

British scholar Taylor put forward the definition of culture early in his book "Primitive Culture", and he believed that culture or civilization contains many elements, such as knowledge, belief, art, morality, law, custom, ability, and habit, of which the ability and habit are owned by every member of society [3]. Taylor's definition of culture laid the foundation for the modern concept of culture.Based on the original definition of culture, American scholars Kroeber and Clark analyze and organize the connotation of culture, propose that culture has explicit and implicit behavior, and point out that culture and human beings are mutual, on the one hand, human beings create culture, and on the other hand, culture also guides and determines the life of human beings.

2.1.2 Mathematical culture

Since there is no consensus on the meaning of culture, there is no uniform definition of the meaning of mathematical culture. Some scholars have argued that the elusive nature of culture and learning interactions stems in part from the theoretical perspectives adopted in their research, which often implicitly distinguish between "mathematics" and "culture" [4]. Depending on the direction of the research, different scholars have different emphases on the meaning of mathematical culture.

1. The perspective of conceptual depth

Gu Pei's viewpoint on mathematical culture is viewed from both broad and narrow perspectives. Mathematical culture in the narrow sense mainly takes into account the origin of mathematical disciplines, whereas mathematical culture in the broad sense includes some extraneous categories of mathematical culture on top of the inclusion of mathematical culture in the narrow sense [5].

2. Mathematicians' point of view

Zheng Yuxin gives the connotation of mathematical culture from the point of view of mathematicians and the general public. From the point of view of mathematicians, mathematical culture refers to the unique "way of behavior" of mathematicians. From the general public's point of view, mathematical culture refers to the fact that mathematics has such a significant impact on people in terms of concepts or beliefs that it can be regarded to a large extent as a determining factor of the corresponding holistic societal culture, and in this sense, we can refer to the said holistic culture as "mathematical culture" [6].

3. Mathematical culture and other cultural perspectives

Wilder regarded mathematics as a kind of culture and gave the definition of mathematical culture from the perspective of human culture, that is, mathematical culture is a dynamic system with strong spiritual and material functions with the mathematical scientific system as the core, and with the related cultural fields radiating from mathematical ideas, spirit, knowledge, methods, techniques, theories and so on as the organic components, and regarded mathematical culture as a sub-system of the cultural system, and emphasized that The cultural characteristics of mathematical culture [7].

4. The perspective of the history of mathematics

Wang Xiaoqin and his team from East China Normal University are the leaders in HPM (History and Pedagogy of Mathematics) research. Prof. Wang's “History of Mathematics and Mathematics Education” is a work based on HPM theory to study the principles and examples of combining the history of mathematics and mathematics teaching, and it is a historical landmark of the complete integration of the history of mathematics and mathematics education in China.

Based on the above analysis, there is no uniform definition of what is mathematical culture, not only because the meaning of culture is very complex, but also because the meaning of mathematics has differences and uncertainties. Based on the literature summary, this paper defines mathematical culture as the ideas, spirit, language, mathematical application value, the beauty of mathematics, etc. embodied in the formation process of mathematics, as well as the views and understanding of mathematics formed by the mathematical community in the mathematical activities.

2.2 Non-intellectual Factors

The non-intellectual factor is a concept corresponding to the intellectual factor. The concept of non-intellectual factors was first proposed by the American psychologist Alexander, who, after a large number of tests and analyses, found that the influence of the subjects' interest, will and other elements on the experimental performance could not be ignored, so he proposed the concept of non-intellectual factors relative to intellectual factors in “Concrete Intelligence and Abstract Intelligence” [8].

Weakles also raised this issue in 1940 and systematically elaborated the concept of non-intellectual factors, and since then, the scientific study of non-intellectual factors was officially kicked off [9].

However, in China, the research on non-intellectual factors was almost half a century later than abroad, and it was not until the publication of Zhu Zhixian's article "Ramblings on Thinking Psychology Research" in the early 1980s that non-intellectual factors were introduced into China. But so far, there has not been a unified understanding of non-intellectual factors, and people are still theoretically divided on this concept.

1. The perspective of conceptual depth

For the understanding of non-intellectual factors, most of them are understood from two perspectives: broad and narrow, Yan Guozhai believes that non-intellectual factors in the broad sense refer to all the psychological factors other than intellectual factors that have an impact on human mental activities, and non-intellectual factors in the narrow sense mainly include human motivation, interest, emotion, will and character [10].

2. Inclusive scope perspective

Zhu Yan proposed that non-intellectual factors are relative to intellectual factors and are psychological factors that do not directly participate in cognitive processes. Non-intellectual factors often involve motives, interests, emotions, willpower, personality, needs, goals, ambitions, beliefs, worldviews, and other aspects that are not directly related to cognition [11]. Huang et al. believe that non-intellectual factors refer to psychological factors such as quality, emotion, motivation, and personality that are not directly involved in the cognitive process of the brain, but directly affect people's thoughts, behaviors, and mental processes [12].

Based on the above summary, we find that there is no uniform definition of non-intellectual factors. By reading the literature and the definitions of non-intellectual factors by various scholars, this paper believes that non-intellectual factors are relative to intellectual factors, and within the scope of this study, it is believed that non-intellectual factors include motivation, attitudes, emotional feelings, will and character.

2.3 Academic Achievement

Academic achievement has long been known as a research hotspot in the education sector, is an important indicator of the effectiveness of student learning, and is also an effective way to judge the effectiveness of school parenting. However, so far, there is no universally recognized indicator for measuring academic achievement, and the measurement standards are different in different countries and regions. the PISA test organized by OECD is to measure the ability of 15-year-old students in reading, mathematics, and science; the SAT in the United States is to measure the level of academic ability of high school graduates, and the GRE is a graduate school entrance examination; in mainland China, there are secondary school examinations, college entrance examinations, graduate school entrance examinations, etc., and the test papers and contents of different provinces and cities are still slightly different; in Taiwan, there are "academic tests" and "finger tests". Although academic achievement does not necessarily represent the level of learning ability and is not the only measure, it is still the most recognized and widely used evaluation standard.

The concept of academic achievement itself is not well defined due to its complexity, and different scholars have put forward different understandings and judgment standards, but roughly academic achievement is divided into two parts, i.e., learning ability and learning achievement [13], and since learning achievement is easier to be measured through visualization and quantification and is easy to be compared, this paper uses students' academic performance to measure students' academic achievement.

3. PRESENT STUDY

3.1 The Influence of Mathematical Culture on Non-intellectual Factors

Although the influence of mathematical culture on non-intellectual factors is seldom mentioned specifically, and almost no scholars have published similar articles and put forward ideas, in the research on mathematical culture, we can clearly see that mathematical culture influences various aspects of non-intellectual factors.

1. The influence of mathematical culture on motivation

The study of mathematical culture can promote the enhancement of students' motivation. Mathematics courses are relatively abstract, focusing on theoretical arguments and logical rigor, so it is difficult for students to learn, but if mathematical culture is integrated into the content of the course, it will greatly improve the interest of mathematics, which will in turn improve the students' positive and active attitude [14].

2. The influence of mathematical culture on attitude

Mathematics as a basic subject, abstract, professional, and theoretical logic are its typical characteristics, so it is inevitable for students to lack interest, the integration of mathematical culture into it, can greatly break the students' inherent understanding of mathematics, improve the interest in learning mathematics, and acquire knowledge in the interest.

3. The influence of mathematical culture on emotion

By infiltrating mathematical culture in the classroom, students are like being in ancient times, having spiritual communication with the ancients, feeling a different mathematical experience, and drawing closer to mathematics. At the same time, in the process of learning, they can appreciate the elegance of different mathematicians, and at the same time, students can appreciate the profundity of the excellent traditional Chinese culture, and cultivate the sense of national pride and self-confidence.

4. The influence of mathematical culture on will

The story of mathematicians in mathematical culture is undoubtedly a good example for students to set up a role model image, students can not only understand the source of mathematical development, but also through the excellent qualities of the mathematicians, cultivate students' rigorous and tenacious spirit of scientific inquiry.

5. The influence of mathematical culture on personality

Scholars have studied the relationship between culture and student personality. Starting from the experiences of students, they have explored the relationship between interpersonal relationships and culture. By exploring how students experience personalized, respectful, and encouraging interactions with adults in school, they have linked this issue to the personality of students in school [15].

From the above analysis, it can be seen that although there is not enough direct research on the influence of mathematical culture on non-intellectual factors, almost all of the literature mentions the facilitating effect of mathematical culture on non-intellectual factors such as motivation and interest.

3.2 The Influence of Non-intellectual Factors on Academic Achievement

The influence of non-intellectual factors on academic achievement has been very mature, and many kinds of literature have used rigorous investigation methods to illustrate the positive contribution of non-intellectual factors to students' learning, different scholars focus on this direction differently, some from the non-intellectual factors as a whole, and some from the non-intellectual factors contained in a certain trait to start, the following are illustrated in the following different perspectives of the influence of non-intellectual factors on academic achievement. The following is a description of the impact of non-intellectual factors on academic achievement from different perspectives.

1. Non-intellectual factors in general

Many foreign scholars have studied the impact of non-intellectual factors on and academic achievement, many foreign research results prove that non-intellectual factors are the factors that lead to the same intelligence having achievement differences. The famous American psychologist Wechsler has analyzed and studied 40 Nobel Prize winners and found that they are not very outstanding in the student period of their intellectual level, and most of the winners' intelligence is only medium or medium to high level. However, they were able to achieve such excellent results, mostly due to the role of acquired non-intellectual factors, which illustrates the importance of non-intellectual factors in achieving success [9]. By coincidence, the American psychologist Push Meng conducted decades-long research on 1500 overachievers who were carefully selected, and selected 150 of the most and least successful in life achievement for detailed analysis, and found that there is no big difference between the two groups of subjects in terms of intelligence level, but the former performs better in terms of confidence and will, which is precisely the non-intelligence factors we mentioned [16]. Harvard University has also done a similar study and found that among the reasons for a person's success and achievement, the person's expertise only accounts for 15%, while the remaining 85% depends on the person's non-intellectual factors. All of the above shows the pivotal role of non-intellectual factors in human development.

Domestically, the influence of non-intellectual factors on students' academic performance has been mainly studied. Hong Kong scholars studied the effect of cooperative group discussion on mathematics achievement, through the methods of analysis of covariance and hierarchical linear modeling, found that the mathematics achievement of the experimental students improved significantly, and after analysis, it was found that this was due to the improvement of the communication skills of their peers, which, as one of the non-intelligence factors, plays a pivotal role in interpersonal interactions and learning [17].

2. Motivation

Scholars have found that policymakers have been committed to promoting exam based accountability as a tool to address various educational issues, including weak motivation. Therefore, the level of motivation is an important factor in improving student performance [18]. Scholars have also divided motivation into autonomous motivation and controlled motivation, exploring the different effects of autonomous motivation and controlled motivation on the relationship between self-concept and achievement. Considering the different regulatory types and school subjects described by self-determination theory, this study explores the mediating role of learning motivation between self-concept and achievement. The research results show that the influence of students' self-concept on academic achievement is greatly influenced by the mediating effect of autonomous motivation types, while the mediating effect of controlled motivation types is relatively small [19].

But it does not mean that the stronger the motivation is the better, according to Yerkes-Dodson law, there is an optimal level of motivation for any task, too strong or too weak motivation will lead to a reduction in the efficiency of the task completion, there are different optimal motivation for different difficulty tasks, and a lower level of motivation is more conducive to the completion of the task for the more difficult tasks.

3. Attitude

Some scholars have found through research that non-intellectual factors have the greatest influence on mathematical generalization ability in study habits, followed by learning interest. They also studied the relationship between interest in learning mathematics and generalization ability and found that the more interested students are in learning mathematics, the higher their mathematical generalization ability is, and the less interested they are in learning mathematics, the lower their mathematical generalization ability is [20]. This is the internal interest of students in motivating the learning of mathematics, and interest is the best teacher for students to form correct and positive beliefs and concepts about mathematics.

4. Emotional

Scholars from Germany addressed the extent to which and how school-related learner characteristics (e.g., self-concept and interest related to school mathematics) contribute to successful transitions in the field of mathematics by surveying 182 German university students and examining the role of several personal cognitive and affective variables specific to school mathematics, and the results of the study suggest that the preconditions for learning related to school mathematics have a significant impact on students' appropriate adaptation to the learning environment had only a small effect, and that self-concepts and interests related to science-based mathematics were more likely to help students smooth the transition from secondary school to university [21].

5. Will

Learning mathematics requires students to have a certain level of will; mathematics is more abstract and computational, so if students do not have a strong will, it will be difficult to support students to maintain a long-lasting passion for mathematics, no matter how high their intellectual level is or how much interest they have in mathematics.

6. Personality

Scholars have studied the likelihood of non cognitive outcomes, observable academic behavior, and self-reported social and emotional learning skills of students on high school graduation and post secondary education.Academic behaviors are particularly strong predictors for low-achieving students' long-run outcomes [22].

3.3 The Influence of Mathematical Culture on Academic Achievement

The relationship between mathematical culture and academic achievement has also been studied by some scholars, mostly on the influence of mathematical culture on academic achievement, but some scholars have also explored the relationship between the two in two directions. Yang Xudong studied the relationship between Confucian culture and school-based curriculum from the perspective of offering Confucianism and school-based curriculum, and math achievement was positively correlated with the interest in offering Confucianism and mathematical culture school-based curriculum [23]. Using rootedness theory, scholars in Taiwan examined the impact of culture on 13th-grade Atayal students and revealed the factors that affect Atayal students' learning of mathematics in their cultural context through a systems network analysis. The difference between the verbal representational system of the Atayal culture and the lateral representational system of the Chinese culture made it difficult for Atayal students to make the representational shift, but when the instructional system was considered between the tensions, i.e., cultural factors are involved in learning, the Atayal students can be more actively involved in math learning activities, which helps Atayal students learn math in a cultural flow [12].

4. METHODS

4.1 Research Respondents

This paper takes the undergraduate students of the School of Mathematics and Statistics of a university in Shandong Province, China, mainly freshmen and sophomores, who have already begun to study mathematics classes such as mathematical analysis and higher algebra, and distributes questionnaires to them to conduct a survey, and a total of 51 questionnaires have been received, among which 51 questionnaires are valid, with a validity rate of 100%.

4.2 Research Design

The purpose of this study is to investigate the influence of mathematical culture on academic achievement through the survey, and to explore the role of non-intellectual factors in the process of influence, and based on the results of the teaching recommendations. It mainly includes the following questions:

(i)What is the influence of mathematical culture on academic achievement?
(ii)How do non-intellectual factors affect academic achievement?
(iii)What is the role played by non-intellectual factors in the influence of mathematical culture on academic achievement?

4.3 Research Procedure

(i)The use of literature analysis method, reading and combing of related literature, the concept of this paper mathematical culture, non-intellectual factors, etc. to define.
(ii)Adapt the "Questionnaire on Non-intellectual Characteristics of Mathematics Learning for High School Students" prepared by Prof. Wang Guangming's team, formulate a questionnaire suitable for this study, carry out the reliability test, distribute the questionnaires, retrieve the questionnaires, and compile statistical data.
(iii)Using SPSS software to analyze the basic descriptive statistics of mathematics non-intelligence in general and mathematics non-intelligence dimensions respectively, and to conduct correlation and significance tests.
(iv)According to the results of the study, provide appropriate suggestions for teaching.

This study adopted a questionnaire method, based on Professor Wang Guangming's "Survey Questionnaire on Non-intellectual Characteristics of High School Students in Mathematics Learning" from Tianjin Normal University [24]. A survey questionnaire was developed to investigate the impact of non-intellectual factors on academic achievement among college students, and mathematical culture related questions were added to form the questionnaire for this study.

The questionnaire on the influence of non-intellectual factors on the academic achievement of college students was compiled, and the questions related to mathematical culture were added, which together formed a questionnaire suitable for this study. The first part of the questionnaire is about the basic personal information, mainly about the students' learning situation; the second part is about the understanding and attitude of college students towards mathematical culture; the third part is about the development of non-intellectual factors of college students, and the distribution of the questions is shown in the table below (questions in italics are reverse scoring questions). In the process of the survey, we asked the research participants to choose the answers according to the actual situation. The second and third parts were scored by the Likert five-point scale, which was divided into five answers ranging from "very much in line with" to "very much out of line with", corresponding to a score of 5-1, and some of the questions were reverse-scored, while some of the questions were reverse-scored. Some of the questions were reverse-scored, and the reverse scores were counted when the scores were tallied. The questionnaire was distributed online, mainly relying on the Questionnaire Star platform to distribute the questionnaire to the research subjects, and summarized and statistically analyzed based on the background data.

4.4 Results

4.4.1 Reliability and validity test

1.Reliability test

The results under each dimension of the questionnaire were imported into the spss software for the reliability test, and the Cronbach Alpha values were all greater than 0.7, indicating that the questionnaire has good reliability.

Table 1. Arrangement of questionnaire topics

	Quantities	Title number
cultures	11	1-10, 21
locomotive	18	11, 12, 19, 20, 22, 24, 28, 29, 30, 33, 34, 36, 37, 38, 39, 41, 42, 66
posture	11	18, 27, 32, 43, 45, 46, 53, 60, 62, 64, 65
move (emotionally)	11	13, 16, 25, 26, 35, 40, 48, 51, 57, 58, 59
volition	7	14, 15, 44, 47, 54, 61, 63
personalities	8	17, 23, 31, 49, 50, 52, 55, 56,

Table 2. Reliability test results

Reliability statistics			
Dimension	**Cronbach Alpha**	**Cronbach Alpha based on normalized terms**	**Number of terms**
Mathematical Culture	.930	.930	11
Motivation	.907	.908	18
Attitude	.769	.750	11
Emotion	.736	.735	11
Will	.715	.714	7
Personality	.689	.714	8
Non-intellectual factors	.937	.937	55

2. Validity test results

This questionnaire is an adaptation of Professor Wang Guangming's Questionnaire on Non-intellectual Characteristics of Mathematics Learning for High School Students, and the content only adapts the language used in some middle schools to the discourse more applicable to college students, e.g., the textbooks are changed into specialized course books, and the math scores are changed into specialized course scores, etc., so the content validity can be well guaranteed; the structural validity is based on the method of maximum variance, and the KMO values are all greater than 0.6 and the significance are all less than 0.01, indicating that the questionnaire has good validity and can be further tested.

4.4.2 Overall situation of students' mathematical culture

Questionnaires 1-10 and 21 were designed to test college students' knowledge and attitudes toward mathematical culture, of which 21 were repeated questions to verify the reliability of students' answers. The full score of positive scoring for each question is 5 points, and the total score is 55 points, so after correcting the score of the negative scoring questions, the higher the score, the more positive the students' attitudes towards mathematical culture.

By analyzing the results of these 11 questions, it was found that the average score of the students was about 27.71, which was only half of the total score, with the highest score being 48 and the lowest score being 11. There was a big gap between the students' knowledge and attitude towards mathematical culture.

4.4.3 Overall situation of students' non-intellectual factors

Questionnaires 11-20 and 22-66 are entitled to test the situation of non-intellectual factors of college students, with a total of 55 questions, of which 14, 23, 36, 57, and 64 are repetitive questions, which are used to verify the reliability of college students' answers. Divided into five dimensions of motivation, attitude, emotional feelings, will, and character, of which 18 questions on motivation, 11 questions on attitude, 11 questions on emotion, 7 questions on will, and 8 questions on character, each full score is 5 points, the total score of each dimension is 90, 55, 55, 35, 40 points, respectively, and the total score of the topic of non-intelligent factors is 275 points, and the higher the score is after correcting the score of the reverse scoring topic, the higher score indicates that the student's non-intellectual factor situation is more positive.

Table 3. Validity test tesults

KMO and Bartlett's test		
	KMO Number of Sampling Suitability	**Significance**
Mathematical Culture	.847	.000
Motivation	.795	.000
Attitude	.632	.000
Emotion	.640	.000
Will	.678	.000
Personality	.615	.000

Table 4. Overall mathematical culture

Reporting				
Mathematical Culture				
Average value	**Number of cases**	**Standard Deviation**	**Minimum value**	**Maximum values**
27.71	51	8.336	11	48

Table 5. Overall non-intellectual factor situation

Reporting						
	Non-intellectual factor	**Motivation**	**Attitude**	**Emotion**	**Will**	**Personality**
Average value	145.98	46.04	28.88	31.27	18.33	21.45
Number of cases	51	51	51	51	51	51
Standard Deviation	24.049	10.634	4.058	5.173	3.782	3.551
minimum value	88	19	19	19	10	14
maximum values	204	77	36	43	25	29

By analyzing the results of the student's scores, it was found that the student's average score on non-intellectual factors was 145.98, which accounted for about half of the total score, indicating that the overall non-intellectual situation of the students was not optimistic; the average scores on the remaining five dimensions accounted for only about half of the total score. It can be seen that on each dimension, the overall average score of students is about half of the total score, and there is a large gap between the highest and the lowest scores, indicating that the non-intellectual situation of students varies from person to person.

4.4.4 Overall situation of academic achievement

This study mainly investigated freshmen and sophomore undergraduates, and through the analysis of the weighted mean score of the respondents, it was found that there was a large difference between the student's achievements, and in the case of freshmen students, for example, the highest score was 91.46, and the lowest score was 23.15, and the level of academic achievement achieved by different students in mathematics was different.

4.5 Discussion

4.5.1 Regression analysis

1. The influence of mathematical culture on academic achievement

2. Mathematical culture on non-intellectual factors influence, mathematical culture on non-intellectual factors five dimensions influence

Table 6. Results of regression analysis of mathematics culture and academic achievement

ANOVA[a]						
Mold		**Square sum (e.g. equation of squares)**	**(Number of) degrees of freedom (physics)**	**Mean square**	**F**	**Significance**
1	regression (statistics)	196.523	1	196.523	.868	.356[b]
	residual	11093.809	49	226.404		
	(grand) total	11290.333	50			
a. Dependent variable: achievement						
b. Predictor variables: (constants), mathematical culture						

Table 7. Mathematical culture and non-intellectual factors regression analysis results

Dependent Variable	Non-intellectual Factors	Motivation	Attitude	Emotion	Will	Personality
Significance	.000	.000	.012	.000	.027	.202

Table 8. Results of regression analysis of non-intellectual factors and academic achievement

Dependent Variable	Non-intellectual Factors	Motivation	Attitude	Emotion	Will	Personality
Significance	.000	.000	.001	.015	.002	.048

The results of the regression analysis show that the influence of mathematical culture on non-intellectual factors is very significant, showing a significant effect on all dimensions except the personality dimension, which has no significant relationship.

3. The influence of non-intellectual factors on academic achievement, five dimensions of academic achievement

The results of the regression analysis show that the effect of non-intellectual factors on academic achievement is significant, with all dimensions showing significant effects.

4.5.2 Mediating role of non-intellectual factors

In this paper, Professor Wen Zhonglin of South China Normal University's mediating role test procedure [25] was used to test the mediating role of non-intellectual factors between mathematics culture and mathematics achievement, and the mediating variables schematic diagram and test procedure are as follows:

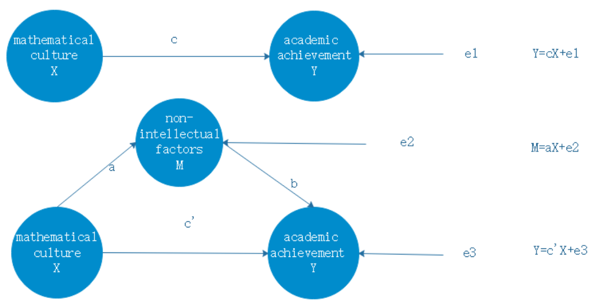

Fig. 2. Schematic diagram of mediating variables

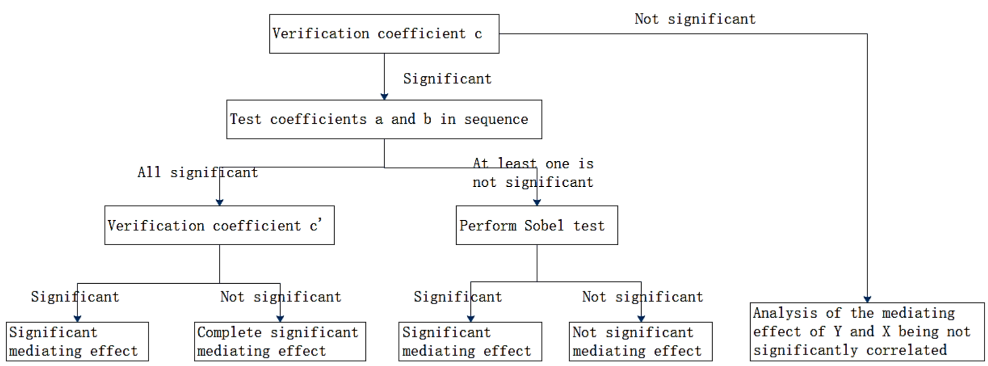

Fig. 3. Mediating role test procedure

1. Culture and Achievement

Table 9. Results of regression analysis of mathematics culture and academic achievement

ANOVA[a]						
Mold		**Square sum (e.g. equation of squares)**	**(Number of) degrees of freedom (physics)**	**Mean square**	**F**	**Significance**
1	regression (statistics)	196.523	1	196.523	.868	.356[b]
	residual	11093.809	49	226.404		
	(grand) total	11290.333	50			

a. Dependent variable: achievement
b. Predictor variables: (constants), mathematical culture

2. Culture and Non-intellectual

Table 10. Results of regression analysis of mathematical culture and non-intellectual factors

ANOVA[a]						
Mold		**Square sum (e.g. equation of squares)**	**(Number of) degrees of freedom (physics)**	**Mean square**	**F**	**Significance**
1	regression (statistics)	7379.613	1	7379.613	16.789	.000[b]
	residual	21537.367	49	439.538		
	(grand) total	28916.980	50			

a. Dependent variable: non-intellectual factors
b. Predictor variables: (constants), mathematical culture

3. Culture、Non-intellectual and Achievement

Table 11. Results of regression analysis of mathematical culture and non-intellectual factors with academic achievement

ANOVA[a]						
Mold		**Square sum (e.g. equation of squares)**	**(Number of) degrees of freedom (physics)**	**Mean square**	**F**	**Significance**
1	regression (statistics)	2848.751	2	1424.376	8.099	.001[b]
	residual	8441.581	48	175.866		
	(grand) total	11290.333	50			

a. Dependent variable: achievement
b. Predictor variables: (constants), non-intellectual factors, mathematical culture

Table 12. Four Ways of Integrating the History of Mathematics Into Teaching and Learning

Form	**Descriptive**
Replica	Taking topics from the history of mathematics and applying them directly
Reconstructive	Reconstructing the history of knowledge development
Compliant	Preparation of mathematical topics based on the history of mathematics
Add-on	Introduces math history, background, etc., and removes it without affecting the content of the lesson

5. CONCLUSIONS

1. The results found that the significance is 0.036, indicating that the impact of mathematical culture on academic achievement is significant; non-intellectual factors as a whole and the significance of each factor is less than 0.05, indicating that the impact on academic achievement is also significant.

2. As can be seen from the results, combined with Professor Wen Zhonglin's intermediary role test process, are significant, so the non-intellectual factors play an intermediary role in the influence of mathematical culture on academic achievement, and the intermediary role is significant.

6. RECOMMENDATIONS

Through the analysis of the above results and conclusions, mathematical culture has a significant impact on mathematical academic achievement, and non-intellectual factors also play a significant mediating role in mathematical culture affecting academic achievement, so it is very important to cultivate students' mathematical cultural literacy. The classroom is the main position for students to learn, and teachers should consciously penetrate the mathematical culture in the classroom.

Scholars have summarized four methods of applying mathematical history, replicated, reconstructed, conformed, and additional [26], and the following table shows the specific meanings of these four methods.

6.1 Before Class

Before class, students can be arranged in advance to pre-study tasks, give students relevant courses on mathematical culture cases, or let students consult on their own, which can include some simple problems, and encourage students to solve them alone.

Example: Students majoring in operations research in the initial class, you can first let students check the source of the professional name, what the stories related to operations research in history, and have a certain knowledge base of the professional name itself. The name "operations research" comes from "The Records of the Grand Historian", "The Plan in a Tent, the Decision to Win a thousand li away"; The historical allusions such as "Tian Ji's horse race", "Ding Wei's construction" and "Wei Wei's rescue of Zhao" are vivid embodiments of the idea of operations research [14]. Students learn about the traditional culture while understanding the professional background, which reflects the combination of mathematics and humanities, and also shows that a country's mathematics education can never be separated from its own history and culture.

6.2 During the Class

1. Introduction

Classroom introduction part, in addition to the conventional review of the introduction, we can use the introduction of cases with mathematical culture, through the unique teaching cases, guide students to analyze the problems in the case, and then lead to the content of the course.

Example: Probability theory is a compulsory subject for students majoring in statistics, and it is also one of the optional compulsory courses for students majoring in mathematics, which has a good application to practical problems in life. The Buffon needle-throwing problem is a classic problem in the geometric probability theory, by explaining the process and results of Buffon's experiment, students are guided to find that the final probability result is pi, which then leads to the content of the geometric probability of learning and the Monte Carlo algorithm in the extended content. Let the new knowledge and students have the cognitive structure of the old knowledge to produce links, eliminate the fear of students for the new content, and increase students' interest in learning, with the interesting and vivid experimental process, presenting the ins and outs of mathematical knowledge, to achieve the organic fusion of knowledge transfer and cultural output.

2. Explaining new lessons

In explaining the new lesson, the teacher can intersperse some cases with historical background with the knowledge points, so that students can understand the principles embedded in the cases through the analysis and thinking of the cases, and at the same time increase the interest, it is easier to cultivate the student's interest in learning, which is conducive to helping the students understand the knowledge points, and then enhance the ability to solve practical problems [12].

Example: In the study of "probability theory" mathematical expectations, can be introduced to

Fermat and Bhaskar's study "the distribution of gambling money" problem, first let the students think about how to distribute the gambling money more reasonably, let the students combined with the content of what they have learned, to express their own views and ideas.Then the teacher can introduce the history of Fermat and Bhaskar on this issue of the discussion process, retracing the path of exploration of mathematicians, stimulate the interest of students, complete the mathematical appointment with mathematicians across time and space, feel the charm of mathematical culture.

6.3 After Class

Homework after class is a further consolidation and sublimation of classroom knowledge. Teachers can collect some exercises about mathematical culture, and reorganize suitable questions for students based on historical mathematical problems, so that students can solve problems based on these problem cases, in order to achieve the goal of consolidating knowledge and understanding culture after class.

Example: In a university number theory class, when explaining the properties of integers, we can first introduce the origin of the "cab number" [2]. When Hardy took a cab to visit Ramanujan, who was sick, he complained to him: "The license plate number of the cab I took was 1729, and this number is very uninteresting." Ramanujan replied, "1729 is a very interesting number. Of all the numbers that can be expressed as the sum of two cubes and in two ways, 1729 is the smallest." (i.e. 1729= $1^3 + 12^3 = 9^3 + 10^3$), and later such numbers were called cab numbers. Thus this question can be set up as an after-school homework question, and by simply removing the answer, it can be an excellent example of after-school homework on mathematical culture.

7. LIMITATIONS AND FUTURE DIRECTIONS

This article used literature analysis to comprehensively elaborate on existing research on mathematical culture, academic achievement, and non-intellectual factors. A survey questionnaire was developed to investigate the impact of non-intellectual factors on academic achievement among college students. The survey results showed that mathematical culture and non-intellectual factors have a significant impact on academic achievement, and non-intellectual factors play a significant mediating role in the influence of mathematical culture on academic achievement. However, due to time constraints, the subjects' size is relatively small and concentrated within the same school. In the future, the subjects' range and quantity will be increased to obtain more comprehensive and scientific research results.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

No generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Zhang ZG. Mathematical Culture and Mathematics Education.Corps Education and Research, 1991;(02):26-32.
2. Kang SG. Mathematical culture in primary school curriculum: Connotation characteristics, main content, and learning value. Curriculum, Textbooks, Teaching Methods. 2022;42(03):99-105.
3. Tylor EB. Primitive Culture. Guangxi Normal University Press. 2005;1.
4. Ehrenfeld N, Heyd-Metzuyanim E. Intellective identities in the construction of a hybrid discourse: The case of an ultra-orthodox jewish mathematics classroom. International Journal of Science and Mathematics Education. 2019;4(17): 739-757.
5. Gu P. Exploration and practice of the mathematics culture curriculum at Nankai University over the past decade: A Discussion on the Integration of Science Education and Humanities Education Chinese Higher Education Research. 2011;(09):92-94.
6. Zheng YX. "Mathematical Culture" and mathematics education. Reference for Middle School Mathematics Teaching. 2005;(10):1-3.
7. Wilder RL. Mathematics as a Cultural System. Oxford, UK: Pergamon Press; 1981.
8. Sun WL, Hu AH, Chen YL. On non intellectual factors and college student management. China Adult Education. 2017;(24):58-61.
9. Wechsler D. Cognitive, conative and non-intellective intelligence. AMERICAN Psychologist. 1950;3:78-83.

10. Li ZC, Li WR, Wang TE. Analysis of Non intellectual Factors for winners of the national supreme science and technology award. Education Research. 2015;36(10): 78-89.
11. Wang XQ. HPM: History of mathematics and mathematics education. Beijing: Science Press; 2017.
12. Huang BC, Li JJ, Chen HX. The construction of a factor structure system for non intellectual factors of college students. Heilongjiang Higher Education Research. 2018;(01):94-98.
13. Wu JH, Fu HL, Zhang YH. Meta analysis of the relationship between perceived social support and student academic achievement: The mediating role of learning engagement. Progress in Psychological Science. 2023;31(04): 552-569.
14. Li DH, Li B, Zhang X. Research on the implementation path of integrating ideological and political elements into mathematics courses in universities. Educational Theory and Practice. 2022; 42(03):57-60.
15. Rodriguez LF. Teachers Know You Can Do More -: Understanding how school cultures of success affect urban high school students. Educational Policy. 2008; 8(22):758-780.
16. Zhang YD. Exploration of the development and cultivation of non intellectual factors in college students. China Adult Education. 2010;(10):69-71.
17. Kutnick P, Fung DCL, Mok IAC, et al. Implementing effective group work for mathematical achievement in primary school classrooms in Hong Kong. International Journal of Science and Mathematics Education. 2017;5(15):957-978.
18. Kornhaber M. Appropriate and inappropriate forms of testing, assessment, and accountability. Educational Policy. 2004;1(18):45-70.
19. Delphine Paumier, Julien Chanal. The differentiated mediation effect of academic autonomous and controlled motivation in the relation between self-concept and achievement. Learning and Motivation. 2023;83.
20. Peng NX, Xiang Y, Yao HA. Study on the impact of non intellectual factors on mathematical generalization ability: based on samples from ethnic minority areas in Guizhou. Mathematical Bulletin. 2015; 54(05):13-16.
21. Rach S, Heinze A. The transition from school to university in mathematics: Which influence do school-related variables have. International Journal of Science and Mathematics Education. 2017;7(15):1343-1363.
22. Liu J, Kuhfeld M, Lee M. Noncognitive factors and student long-run success: Comparing the predictive validity of observable academic behaviors and social-emotional skills. Educational Policy; 2023.
23. Yang XD. The influence of Confucian educational ideas on current mathematics education in middle schools in China.Southwest University; 2020.
24. Wang GM, Song JJ, Wang ZY. Development of a survey questionnaire on non intellectual characteristics of high school mathematics learning.Journal of Mathematics Education. 2015;24(03):17-27.
25. Wen ZL, Zhang L, Hou JT, etc.The mediation effect testing program and its application. Journal of Psychology. 2004;(05):614-620.
26. Zhu Y. My humble opinion on developing students' non intellectual factors in mathematics teaching. High School Mathematics Research. 2023;(01):9-12.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/119711