

## CULTIVATION OF STUDENTS' CORE LITERACY BASED ON THE MATHEMATICAL CULTURE PERSPECTIVE

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**ABSTRACT.** In recent years, the term *core literacy* has been popular in educational circles all over the world, and there are more and more research on core literacy . At the same time, the mathematical culture has also been highly valued on a global scale. The mathematical culture is a part of college students' cultural quality, and then, what is the connection between the mathematical culture and mathematical core literacy? How to improve the mathematical core literacy of contemporary college students? This paper gives the corresponding answers to these two questions.

By illustrating the concrete implementation of the course "Mathematical Culture" offered by Yanbian University, this paper discusses various measures for cultivating students' core qualities in Chinese universities. It must be useful and promote the research on mathematical core literacy for the educators in various countries.

### 1. Introduction

In order to cope with the challenges of globalization, the era of knowledge and the development of science and technology, countries or areas, in combined with their own economic, social and educational development needs, put forward the core literacy oriented toward the 21st century from different angles. May 16, 2013, in China, the major project, '*study on the overall framework of the core literacy of the students in the basic and higher education stages of China*', organized by Lin Chongde, a professor of Beijing Normal University, were launched. It shows that the research of core literacy in China has officially raised the curtain. September 13, 2016, the ministry of education in China promulgated < Core Competencies and Values for Chinese Students' Development > and established the overall framework of core literacy for Chinese students[1]. It puts forward that the core literacy of Chinese students' development is based on the basic principles of science, timesnationality, and takes the cultivation of

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*all-round development of people* as the core, which is mainly divided into three aspects: cultural basis, independent development and social participation. The comprehensive presentation of the attainment is the six major accomplishment: humanistic inside connotation, scientific spirit, learning how to learn, healthy life, responsibility, practice and innovation[2]. The formation of these qualities requires students to learn and apply relevant knowledge and skills in real-life situations, rather than focusing on a single subject topic(Iowa Department of Education, 2010). So when we select and design the content of courses, we should have a subject perspective, and also accumulate the interdisciplinary experience, namely need to carry out effective interdisciplinary content topic learning. This kind of learning also provides students with rich learning experience and experience accumulation, when they enter the job in the future and become a new type of talent who can cooperate with others and collaborate in many fields (Education Scottish, 2010).

## 2. The concept and constitution of Mathematical core literacy

Core literacy integrates the goals and pursuit of three aspects of personal, social, and economic, and is regarded as a *necessary, basic and supporting* quality to be a qualified citizen in 21st century.

In recent years, the training and evaluation of students' core literacy is increasingly attracted worldwide attention, and even become the foundation for education reform in many countries or regions. Facing the rapid changes in society and economy, many international organizations, countries and regions around the world are thinking about how to cultivate future citizens. Because of this, the implementation of the core literacy education has become the common view of the global society, and the basic task and development trend of education in 21st century. But the ultimate accomplishment of core literacy still need to rely on discipline curriculum, That is core literacy and discipline curriculum must establish corresponding and associations, to contribute to the realization of the core literacy. According to Powers, Robert and Blubaugh, William (2005), *In response to the growing need for technological literacy, the University of Northern Mathematics.*(p. 254)[3].

Mathematical core literacy, as an important component of core literacy, has both generality and particularity compared with core literacy.

### 2.1. Concept of Mathematical core literacy

Some people think that the core literacy is another way of saying the overall quality of education, They hold that the literacy education is exactly the quality education, But it is just another way of saying it. This statement is clearly wrong, because core literacy is not equivalent to overall quality. Although the core quality is core with cultivating the people of all-round development, but, in terms of word meaning, literacy is divided into "*core literacy*" and "*noncore literacy*". Core literacy is the most critical literacy that students should possess.

Therefore, core literacy is also called critical literacy. So what is core literacy? Ole Skovsmose(2007) noted that *Mathematical literacy* is far from being a well-defined term[4]. From angle of mathematics, we think that the core literacy is the 'convergence point' of literacy. Literacy is not as specific knowledge and skills, also is not mathematical ability in general. It is a kind of abstract ability higher than mathematical thought, mathematical knowledge and skills. In a common way, mathematical literacy is what is left after the knowledge of mathematics is expelled or forgotten.

According to the mathematics and statistics teaching steering committee of higher education institutions of the ministry of education in China, the basic mathematical literacy is to actively explore and grasp the background and essential literacy of mathematics problems; is to be proficient in using mathematical language to express own mathematical thinking; is to put forward legitimately new ideas, new concepts and methods with a good scientific attitude and innovative spirit; is to explore the way of solving the problem from multiple angles with the rational thinking of mathematics for various questions; is good at simplifying and quantifying the phenomena and processes in the real world and establishing the mathematical models.

Zhang Dianzhou (2009) analysis the core literacy of mathematical from the three aspects: *true, good and beauty*. *true* means understanding the cultural value of rational mathematical civilization, and realizing the rigor and accuracy of mathematical truth; *good* means the basic ability to analyze and solve practical problems with mathematical thought methods, *beauty* means to appreciate the beauty of mathematical wisdom, like mathematics, and love mathematics[5].

Generally, we accept the following definition to the core literacy of mathematics: mathematical core literacy refers to having the basic characteristics of mathematics, having the essential character and key ability adapted to the needs of individual lifelong development and social development. It is a concentrated expression of mathematics curriculum objectives, and is gradually formed in the process of mathematics learning. Mathematical core literacy includes six aspects: mathematical abstraction, logical reasoning, mathematical modeling, intuitive imagination, mathematical calculation and data analysis. More generally, it also includes learning, the application of mathematics, innovation consciousness, and so on. From the perspective of learning evaluation, mathematical core literacy is mainly reflected in the comprehensive application ability of situation and problem, knowledge and skill, thinking and expression, communication and self-reflection.

According to O Publishing (2012), for the PISA (Program for International Student Assessment) test, mathematical literacy is considered to be a kind of personal ability: students can determine and understand the role of mathematics in the society, and conclude mathematical judgment with abundant reason, and use mathematics effectively. As an innovative, caring and thoughtful citizen, this is the necessary mathematical ability to adapt to the current and future life. It's just a good foundation for success (p. 264)[6].

## 2.2. The constitution of Mathematical core literacy

The conference of research results on *the core literacy of Chinese students' development* shows that the core quality is core with cultivating the people of all-round development, including three aspects: cultural basis, independent development, social participation. And the core literacy is characterized by six literacy: humanities background, scientific spirit, learning to learn, healthy living, responsibility, practice innovation. As far as mathematics is concerned, some scholars believe that the core literacy of mathematics consists of seven components: mathematical abstraction, calculation ability, reasoning ability, modeling and data processing, spatial ability, problem solving ability, and mathematical cultural character. These seven components are included in the 3 aspects of core literacy, and is the most critical mathematical literacy a student should have.

## 3. The relationship between mathematical culture and core literacy

As a cultural phenomenon, mathematics has both the commonness of universal culture and the diversity of multiculturalism. The development of mathematics is the result of the interaction between cognition and culture, that is to say, education of mathematics has cultural relevance.

### 3.1. What is mathematical culture?

In a narrow sense, mathematical culture refers to the thought, spirit, method, viewpoint and language of mathematics, as well as their formation and development. In broad sense, besides above connotation, it also includes mathematicians, mathematics history, mathematics beauty, mathematics education, the humanities in the development of mathematics, the connection between mathematics and society, the relationship between mathematics and various cultures, etc.

### 3.2. The characteristics of mathematical culture

Mathematical culture is an important way to spread human thought. As a culture rooted in the fertile soil of human thought, mathematical culture is the crystallization of human wisdom. Because of the high unity and consistency of the mathematical language system in social development, the mathematical language is a high-level form of language. Language is an important symbol system of social development in the process of social operation and development, and has a ability to clear and convey the subjective meaning. Under the conditions of the development of mathematical abstraction and rigor, mathematical language is more systematic, symbolic, and has a high degree of precision.

### 3.3. The influence of mathematical culture on the cultivation of College Students' mathematical core literacy

Whether the liberal or science students, though they have studied mathematics for many years, they still have a superficial understanding of mathematics thought and mathematical spirit, and have a poor understanding of macroscopic understanding and the overall grasp. So, what is the connection between mathematical culture and mathematical literacy? According to the research of psychologists, mathematical culture not only influence students' extraction of mathematical knowledge, but also influence students' cognitive style. In China, mathematical culture courses are set up and expanded in many fields and multi-level universities, and unfailing. This is because mathematical culture conforms to the trend of the times, conforms to the development trend of contemporary literacy education, is an integral part of mathematical literacy education.

Mathematical culture and mathematical literacy permeate each other. By learning mathematical culture, we can realize the spirit of mathematics and understand mathematical thought, learn mathematical thinking, master mathematical methods. And then we can improve the mathematical literacy. Conversely, the process of improving mathematical literacy cannot be separated from the support of mathematical culture. However, in the traditional mathematics teaching in China, the teacher take mathematics only as a tool subject, and ignore the teaching of mathematics culture, let alone the scientific spirit and value of mathematical culture. This is one of the important reasons why most today's students lose confidence in mathematics study, and even hate studying mathematics. Through setting up the courses of mathematical culture for many years and the observation of the students' interest in learning mathematics, I found that mathematical culture not only let students understand the cultural value of mathematics, but also can enhance students' interest in learning mathematics and confidence, even improve the students' mathematical literacy.

#### 4. *Mathematical Culture Course offered in Yanbian university*

It has been more than 20 years since Chinese colleges and universities carried out cultural quality education. In January 1991, the ministry of education approved the construction of 32 national college students' cultural and quality education bases in 53 universities in China, and then added 61 bases in 104 universities, among which Yanbian University was one of them. The cultural quality education plays an important role in innovating education concept, promoting education thinking transformation and innovating education teaching method. To this end, Yanbian University began to set up a number of cross professional elective courses and general education courses in 2005.

Mathematical culture curriculum is developing and expanding in multi-field and multi-level universities, in a variety of forms. The so-called *multi-field* refers to that the undergraduate colleges, vocational colleges, radio and Television University and other colleges and universities have set up mathematical

culture courses. The so-called *multi-level* refers to that many universities, such as **985** colleges and universities, **211** colleges and universities, general and other multi-level colleges and universities, have set up mathematical culture courses. Mathematical culture in Yanbian University is one of the general elective courses for all majors of the whole school.

#### 4.1. The purpose of setting up the course

In China, most students study mathematics very hard in high school, basically in order to improve the mathematics scores, do the tactics that inscribe the sea so as to enter the prestigious school. Only a few students learn mathematics because they like mathematics. For most students, when it comes to '*mathematics*' what arise in their minds immediately are the words like difficult, abstract, boring and so on.

The development of mathematics education cannot be separated from the mathematical literacy. The value of mathematical literacy has been generally recognized by society, but in the education practice and mathematics curriculum resources, students' mathematical literacy is still relatively missing. After many years of teaching in Yanbian University and the careful observation of students, I mainly found the following problems: (1) students don't really understand what is mathematics and mathematical literacy, don't realize the value of mathematics and mathematical science spirit; (2) in the eyes of most students, mathematics is a tool subject that serve other subjects; (3) most students can't appreciate the beauty of mathematics. (4) students find that mathematics is not only abstract, but also difficult to understand, so their interests in mathematics is difficult to improve.

In order to promote the integration of science education and humanistic education, to promote the course construction of blending arts and sciences, and to solve the above-mentioned problems, in 2010, I started to set up the mathematical culture course for all the students of Yanbian University.

#### 4.2. Main content of teaching

1. what is mathematics and mathematical culture: this part mainly introduces what is mathematics, the characteristics of mathematics, the brief history about the development of mathematics, and the three crises of mathematics. It introduces what is the mathematical culture and the charm of mathematics. 2. Mathematical culture in mathematics problems: this part takes the golden section, Königsberg seven Bridges problem, the length of the coastline, Fibonacci rabbit problem, Goldbach's conjecture and Hanoi problem as the carrier, to let students understand mathematics spirit, thoughts and methods, experience the mathematical culture. 3. The mathematics culture in mathematics allusions: this part mainly proceeds from the allusions related to mathematics in Chinese history, such as Han Xin count soldiers and the Chinese remainder theorem, and so on. By analyzing and interpreting allusions, arouse students' interests in learning mathematics, so that most of the students can really master the

essence of mathematics thought mentioned in the course. 4. The mathematical culture in some mathematical views: it contains mathematical views such as *abstract, symmetry, analogy, transformation* and *invariance*, and uses them to solve practical problems. 5. Mathematical paradox: introducing some famous mathematical paradoxes and the function of these paradoxes in the development of mathematics. 6. The mathematical culture of probability theory and mathematical statistics: through the classical stories and mathematical titles of probability and statistics to introduce the difference between probability statistics and basic mathematics, and feel the mathematical culture. 7. Dealing with some problems in the civil service examination and the recruitment examination of foreign companies. By solving these problems, find and excavate the students' mathematical literacy. 8. The classroom teaching is interspersed with game part and students' publication.

Since the course period is only 32 class hours, the above contents can not be completely taught. The students who have selected courses come from different colleges and majors. There are the students from science and engineering profession, from art, sports, law, medicine and other profession. According to the different students' majors in each semester, the suitable part of the teaching content is selected.

### **4.3. Pay attention to the teaching process and cultivate mathematical core literacy from all respects**

As for the students in Yanbian University, like most students from other places, most students, especially for those who are not majoring in mathematics, will find it difficult, abstract and boring when they mention mathematics. Therefore, students are mainly lacking in the ability to solve practical problems with mathematical ideas and the ability to innovate in mathematics, can not appreciate the mathematics from the perspective of beauty.

Aiming at the above problems, in the teaching of mathematical culture, I try to talk about some famous mathematicians' mathematical ideas, and the discovery process of famous theorems. What's more, We should associate practical problems with mathematical thought. In order to arouse the students' interest and enthusiasm, make more students participate in the class, I will give the students an interesting math game topic before each class. That is to say, a problem situation will be created for students in a class.

Creating the problem situation is not a teaching method that can improve the students' mathematical core literacy directly. Instead, its function is formed gradually. Even though it is an indispensable way to improve students' mathematical core literacy. An active classroom leads to a successful teaching, it can not only reduce students' fear and boring feeling for mathematics, but also can allow students to experience by themselves, and have high enthusiasm, full of vigor and vitality, let students experience success and arouse their thirst for knowledge, so as to take the initiative to explore, and form their own methods of mathematics learning.

One of the important teaching goals of "mathematical culture" is how to train students' innovative ability through mathematics culture class. Consciousness of innovation is a kind of ability that high school students should have, but nowadays most college students still lack such consciousness, it is what our teachers need to pay attention to in teaching. Some people say that the mathematical culture reflects the 'old' knowledge, the innovation consciousness reflects the 'new' knowledge, how to combine the 'new' with the 'old'? It can be understood that the process of creating new knowledge will inevitably form a certain mathematical culture. Only when we really understand the "old" culture, can we create new things. If there is no old knowledge brought by the mathematical culture, how can we create new culture? In teaching practice, teachers should first enhance students' awareness of innovation. Students' innovation ability can be improved only when the awareness of innovation is enhanced. Mathematical culture contains the rich history of mathematics, with the development of people's innovation level, as teacher explaining the solutions to some classical problems with students, they will use classical solutions as a support to highlight new solutions, so as to motivate students to explore actively. In addition, we should interact more with students, ask more questions, and cultivate students' ability to question and challenge.

#### 4.4. Assessment methods and assessment analysis

Due to the purpose and content of teaching, the course is not suitable for the written test, so the combination of report and class publishing is adopted. According to the teaching content and professional characteristics, students need to complete a paper about the influence of mathematical culture and mathematical literacy on his or her professional learning.

Mathematics and education, mathematics and culture, mathematics and history, mathematics and philosophy, mathematics and sociology, mathematics and high technology, all will derive some new growth points of subjects. Take the combination of mathematics and economics as an example, the students of economic management institute write his understanding in the class paper: Mathematics and economics can be said that they are inseparable, so that it won't be able to study economy today if you do not understand mathematics. As for the students from the college of humanities and sociology, they analyze the mathematical influence on philosophy and thinking formation from the philosophical thinking in Mathematical Culture, such as abstract thinking, logical thinking, image thinking and direct thinking.

### 5. Conclusion

M. Klein (1962) said: 'mathematics is not only a method, an art or a kind of language, but the main is that mathematics is a knowledge system containing rich content, its content is very useful for natural scientists, social scientists, philosophers, logicians and artists. What's more, it also affects the politicians'



and theologians' theory. It satisfies the curiosity of the universe and the meditation on the wonderful music, sometimes it may even be imperceptible but unquestionably affecting the process of modern history." In fact, in modern empirical science, the acceptance of mathematical methods has increasingly become the main criterion for the success or the failure.'[7]

Mathematical literacy is rooted in a good atmosphere of mathematical culture, mathematics knowledge should be carried out under the concept of mathematical culture. We need to cultivate the students' mathematics core literacy as the goal, the charm of mathematics should be shown incisively and vividly in front of students, let students obtain the preliminary perception for mathematical culture. Mathematical culture enables students to understand the interest of mathematics and appreciate the beauty of mathematics. In mathematical culture course, in addition to basic ability, teachers should also have deep emotion, love and care for students. Teachers should recognize students' individual differences, and no longer use the same scale, the same uniform standards and the same model to measure all students.

The classroom of mathematics culture is not a classroom full of mathematical history. Instead, it inspires students to learn mathematics by guiding mathematical stories, and guides students to follow the goal of mathematics culture course. Of course, the importance of mathematics culture should also have a *degree*, excessive emphasis on mathematical culture, ignoring other mathematical literacy, then the development of the students will be imbalanced.

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