

## RESEARCH ON THE INNOVATION EDUCATION OF UNIVERSITY MATHEMATIC CLASSROOM TEACHING

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### ABSTRACT

Cultivating a batch of innovative talents is the lofty education goal of colleges and universities. The main ways of university mathematics innovation education are classroom innovation education and undergraduate innovation practice. This paper first describes the mental process of mathematical innovation, and then discusses the four core elements of mathematical innovation, as well as the four important links of innovation education in college mathematics classroom teaching. Finally, the importance of mathematical innovation practice is discussed. It aims to cultivate outstanding and innovative talents for social development.

**KEYWORDS:** Innovation, Mathematical intuition, Divergent thinking, Aesthetic education

### 1 INTRODUCTION

In the new era of mass entrepreneurship and innovation, innovation is an eternal topic. At present, colleges and universities actively promote independent innovation and collaborative development. In the book of Professor Xu, he discusses the aesthetic consciousness, abstract thinking, mathematical intuition, creative thinking, mathematical methodology and mathematical teaching reform Etc.. How to use effective teaching methods to make students actively learning is proposed for the teaching of college mathematics (Zhao, 2018 ). Cui expounds six basic qualities or "genes" that creative talents should possess and introduces the goal and mode of training innovative talents in MIT (Cui 2014). Then, four enlightenment points to the cultivation of innovative talents in colleges and universities in China are put forward. From the perspective of systems engineering, Xia expounds the favorable environment and effective mechanism for the growth of innovative talents (Xia 2018). The rational knowledge and intelligent structure of creative talents should be established from the view of modern science and technology system. Innovative talents should be guided to master successful wisdom and innovative thinking by using marxist philosophy. The book of Wu (2012) addressed the beauty of simplicity, kind and vivid markov chain, matrix calculation, even interesting cosine function and so on. Gu introduces the beauty of mathematics in the course of mathematics culture to guide students comprehending the charm in Nankai university (Gu 2016). For the purpose of cultivating innovative talents, Zhu presents a new path of "four- step" innovative talents training (Zhu 2018).

Since 1992, China has held the mathematical modeling contest for college students, which has yielded fruitful results and improved students' innovative ability and level of solving practical problems with mathematical knowledge. However, at present, many students in colleges and universities are hesitation and confused. Some students are content merely to pass examinations.

How to implement innovation education inside and outside the mathematics classroom in colleges and universities to cultivate high-quality innovative talents needed by the society is a problem that we urgently need to study and solve. This paper expounds the mental process of mathematical innovation, focuses on the core elements of mathematical innovation and mathematical classroom innovation education, and finally emphasize the importance of mathematical modeling competitions and other innovative practices.

## **2. The Mental Process of Mathematical Innovation**

According to the modern view of creation and invention, the human brain's thinking activities, generally working for 2-4 hours continuously, will produce the so-called "heating period" and "brain storm" [1]. When you're engrossed in your work for more than an hour, your active brain goes into a heat wave. Then mental activities such as images, associations, conjectures and hypotheses will quickly spring up in the mind and set off a "brain storm". For two hours or so, new ideas and the thought about how to solve a problem may emerge. The essence of mathematical innovation is "selection", that is, in the endless combination of mathematical things, choosing the useful combination and discarding the useless combination, so as to achieve new results. For this, the erudite and prolific Poincare vividly called the mathematical ideas or concepts existing in the human brain "idea atoms". They look like a bunch of atoms hanging from a nail in the wall. The atoms can be combined with each other in endless ways. But only some beautiful combination of choices can produce extremely useful new ideas or concepts. A study on the prolific mathematicians and physicists indicated that three things as follows must be kept in mind when innovating.

### **Have A Clear Goal.**

The more specific goal and the stronger purpose of the work, the easier to form the connection of thinking movement. For example, if you wish to solve a mathematical problem, or if you need to make a mathematical discovery, the diverges thought in the mind consisting of the association, the conjecture, the hypothesis, the analogy and so on, can carry out around this work to solve the question and achieve the goal.

### **Consciously Actively Carry Out Mathematical Research Work**

In order to produce "inspiration" or "insight", it is necessary to consciously actively carry out mathematical research work for mathematician. It turns out that most of the "inspiration" or "insight" comes at the end of a conscious brain storm, but sometimes it comes from an "unconscious process" in the brain, such as relaxing or sleeping after a long period of conscious work. Descartes' first thoughts on analytic geometry, for example, began in the early hours of the morning when he woke up in bed.

### **Conduct Convergent Thinking.**

"Insight" comes from non-logical divergent thinking, which helps mathematical researchers form a reasonable assumption or conjecture. For the acquired assumptions or guesses, the conscious arduous

reasonable logical thinking, also known as "convergence thinking", must be carried on, and the strict mathematics demonstration must be conducted too. This requires that creative mathematicians also be good at convergent thinking. Therefore, mathematical innovation often begins with loose divergent thinking and ends with strict logical analysis thinking.

### 3. The Four Core Elements of Mathematical Innovation

The so-called innovation is the activity that people, as the subject of activities, engage in to generate new ideas and new things [1]. Any creation of new concepts, new theorems, new models and new methods in mathematics can be called mathematical innovation or invention. Research shows that mathematical innovation has the following four core elements.

#### Mathematical Intuition – Aesthetic Feeling

Mathematics intuition is a kind of intuition about the mathematical order existed in the brain. The mathematician Abel believed that the nature of mathematical intuition is the "consciousness" of beauty, or called "beauty feeling". It is the intuitive consciousness between mathematical things with hidden harmonious relations. The stronger consciousness of this kind of beauty, the stronger intuition to find and identify hidden micro harmonious relations. Therefore, Poincare, the great French mathematician, said that "the people who can make mathematical discoveries are those who have the sense of mathematical order, harmony, symmetry, orderliness and mysterious beauty, and only for these people". So mathematical intuition, aesthetic feeling, is an important factor in mathematical innovation.

#### Divergent Thinking

Divergent thinking is a non-logical thinking form based on feeling or intuition. It is a thinking form to obtain reasonable argumentation or conjecture. It is an unstrict thinking mode or method, including association, imagination, simulation, analogy and intuitive reasoning (plausible reasoning), etc. Mathematical innovation often begins with loose divergent thinking, which plays an important role in innovation. Therefore, divergent thinking is also called creative thinking.

#### Amount of Knowledge

Scientific research shows that the innovation ability of scientists can be expressed by the following formula [1]:

#### **Creative Ability = Amount of Knowledge \* Divergent Thinking Ability**

The greater the amount of knowledge, the wider the range of association, analogy and imagination, and the greater the opportunities come into being for new ideas and methods. As we all know, prolific mathematicians are also physicists and astronomers, such as Archimedes, Newton, Euler, etc., who not only have a wide range of knowledge, but also involve in many innovative fields. It is hard to imagine that a scholar with a narrow scope of knowledge can make great inventions.

#### Innovative Spirit

The road for innovation is bumpy and tortuous. Innovators will encounter many setbacks or even failures. Therefore, innovative talents should not only have the desire to innovate [2], but also, most importantly, have the spirit of innovation. They should dare to try and explore the unknown things. Even if the failure, they can quickly rally. If succeed, they don't be complacent, but continue to explore and strive for new breakthroughs. Just like Edison and Madame Curie, they relentlessly pursue ideals and knowledge, dare to think and work, do not believe and follow blindly. They challenge authority and have the courage to innovate.

#### **4. Classroom Innovation Education in Mathematics Teaching**

The fundamental purpose of higher education is to cultivate young talents with innovative consciousness and ability. Classroom innovation education is one of the important ways for universities to cultivate outstanding innovative talents. The so-called classroom innovation education is that teachers stimulate the innovative desire and innovative spirit of college students in the classroom through a variety of ways and means. It also means that teachers can improve the interest in learning for the students, and can broad their scope of knowledge through the revelation of the mathematics beautiful material, displays the teaching art. Therefore, the students are willing to challenge and innovate. In the following subsections, four important links are proposed in the classroom innovation education for mathematics teachers.

#### **Pay Attention to the Guidance of Divergent Thinking**

Divergent thinking is the main factor leading to invention and creation. Therefore, teachers should consciously guide and cultivate students' divergent thinking in classroom teaching. For example, in order to prove the Chebyshev inequality in probability theory

$$P\{X - E(X) \geq \varepsilon\} \leq D(X)/\varepsilon^2 \quad (1)$$

The teachers can first ask students to clarify the known and proven (the meaning of both sides of the inequality). They fully associate the definition of variance and the meaning of probability on the left side of the inequality (1). Then, the students can be guided to compare the known and verified information with intuitive reasoning. Finally, they find the opportunity to enlarge the inequality and prove the conclusion. In this way, students can not only understand and master the application process of divergent thinking, but also realize the beauty of mathematical proof methods. Many complex problem problems in university mathematics, such as the proof of the properties of the coefficient  $\rho$ (rho), will be a easily solved for students by using association, analogy, guess and other methods.

#### **Reveal the Beauty of Mathematics**

"Where there is mathematics, there is beauty," Pollock has long asserted [4]. University mathematics, like elementary mathematics, originates from the infinite, vast and colorful real world. Therefore, university mathematics has beauty in form, content, method, structure and other aspects, which is

called "mathematical beauty". Such as beauty of simplicity, beauty of symmetry, beauty of unity, beauty of strangeness, beauty of method, beauty of structure, beauty of

speculation, beauty of symbol and formula, and so on. For example, concise beauty is the concise for the expression form and structure of the theoretical system. It is not the simple for mathematical content itself. In integral science, for example, Leibniz chose the integral symbol " ∫ " from the aesthetic point of view, which is the first letter "s" to be lengthen from the Latin word "summa" (meaning "summation"). This symbol contains the meaning of summation. Even it has beautiful gesture and curve. So mathematicians compare it to "beautiful girl", and praise it to this day. In the theory of probability, Law of joint distribution of two-dimensional discrete random variables are recorded as  $P_{ij}$ ,

which means  $P\{X = x_i, Y = y_j\}$ . The marginal distribution laws of  $X$  and  $Y$ , are denoted as

$$P_i = P\{X = x_i\} = P\{X = x_i, Y < \infty\}$$

$$P_j = P\{Y = y_j\} = P\{X < \infty, Y = y_j\}$$

where the symbol "•" means that  $X$  and  $Y$  can take any possible value. They are concise, meaningful and beautiful. Not only that, the joint probability density function of two-dimensional continuous random variable is denoted as  $f(x, y)$ . the marginal probability density functions of  $X$  and  $Y$  are denoted as

$$f_X(x) = \int_{-\infty}^{+\infty} f(x, y) dy; \quad f_Y(y) = \int_{-\infty}^{+\infty} f(x, y) dx$$

All of them above reflect the beauty of symbols.

Mathematical beauty is a kind of rational beauty hidden behind the perceptual beauty. It is abstract, rigorous and implicit, which requires mathematics teachers to continuously excavate and appreciate it in class, so as to continuously improve students' feeling ability and aesthetic level of mathematical beauty.

### The Beauty of Teaching Art

Teaching is an art. Every classroom teaching with strong attraction and appeal can always reflect superb teaching art. The so-called teaching art refers to the exquisite teaching skills and techniques that teachers follow the teaching rules in the teaching process, creatively organize teaching in their own unique ways and methods. And they combine knowledge with aesthetics, enable students to learn in a pleasant and efficient way. When preparing the lesson, the teachers should clear up the knowledge structure and pay attention to the points, and excavate the beauty of mathematics in the

mathematics teaching material. It is needed to adopt aesthetic methods and aesthetic means to divide and combine textbooks for teachers. They should add, delete or adjust content of courses to make teaching plans exquisite. In the course of teaching, they should design fascinating mathematical problems, seek for beautiful ways of solving problems, and adopt flexible and diverse teaching methods. So that students can enjoy more beauty and stimulate enthusiasm themselves for learning.

### **Pay Attention to the Teaching of Mathematical Modeling**

The so-called mathematical modeling is the process of determining the variable parameters, establishing the mathematical model, solving and returning to the actual problem to check its correctness repeatedly through the abstraction of the actual problem. The establishment of mathematical model is actually a process of discovery and innovation by using association, analogy and imagination of divergent thinking. For example, the thought of calculus for Newton and Leibniz's, and the thought of hypothesis testing in mathematical statistics are also the processes of mathematical modeling. Therefore, in the classroom, the process in which teachers vividly introduce the modeling ideas and methods in the knowledge background to students, is the display and reproduction of mathematical innovative thinking. It can improve college students' ability to analyze and solve practical problems and comprehensively apply mathematical knowledge, and lay a solid foundation for independent innovation.

### **5. Advocate Innovative Practices**

People's innovation ability can be rapidly improved through repeated innovation practices on the basis of acquiring a large amount of knowledge. Mathematical modeling activities and competitions for college students are undoubtedly the best practice carrier to cultivate innovation ability, and another important way to successfully realize innovation education. The participation of students in mathematical modeling activities and competitions can make students deeply feel that they have learned a little and known a little. It can also encourage students to expand the scope of knowledge, rapidly increase the amount of knowledge. It can especially improve their abilities in many aspects, such as the abilities of data access, data collection and self-learning, the abilities to analyze, judge and solve practical problems, the divergent thinking abilities of imagination, insight, association and so on. Under the guidance of the tutors, the students can experience the practice of modeling and innovation, and then embark on the road of scientific research and innovation faster and better.

### **6. CONCLUSION**

The mathematics teachers, who guide the student to appreciate mathematics beauty in the classroom and enjoy the teaching art beauty, can prompt the students left and right hemispheres coordinated development. The beauty of mathematics is inner beauty and the art of teaching is formal beauty. That can also strengthens there cerebrum memory, the esthetic power and the creativity. The teachers who pay attention to and implement the innovation education inside and outside the classroom, attach importance to the application of mathematics, classroom aesthetic education and modeling innovation practice, must be able to effectively stimulate students' strong interest in mathematics and

interdisciplinary science and cultivate a large number of innovative elite talents. Therefore, mathematics esthetic education and the innovation education come true.

## **BIBLIOGRAPHY**

- [1] Lizhi Xu, Xu Lizhi on Mathematical Methodology [M], Shandong education press. 2001.
- [2] Wenling Zhao, Hongkui Li. How to give vitality to college mathematics curriculum in classroom teaching
- [3] Li Cui, Jing Chu. The "gene" observation and cultivation of innovative talents [J]. Education Exploration. 2014(1): 156-157.
- [4] Li Xia, Ming Zeng. Innovative education thought of Qian Xuesen [J]. The quest, 2018 (1): 120-122.
- [5] Jun Wu, 2012《beauty of mathematics》[M] People's posts and telecommunications press.
- [6] Pei Gu, The mathematics culture course of Nan-kai university from the Angle of aesthetic education. Teaching in Chinese universities, 2016(6): 12-15.
- [7] Changjiang Zhu, Ai Guo, Lihong Yang, "Four-step" college mathematics teaching reform aimed at cultivating innovative talents in science and engineering [J]. Teaching in Chinese universities, 2018(3):33-36.