Mathematics Classroom Teaching and Creative Thinking Education

Lidong Wang[1,2], Wenshu Zhou[2], Jianhua Liang[2] *

[1] Zhuhai College of Jilin University, Zhuhai, 519041, China

[2] School of Science, Dalian Minzu University, Dalian, 116600, China

* The Corresponding author

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Abstract. Creative education is the education whose fundamental value-orientation is to cultivate the creative spirit and ability of students. Classroom teaching is an important way of fostering students' creative thinking ability. In this article, we discussed the question of how we can implement creative thinking methods in higher mathematics teaching, analyzed current problems of practicing creative thinking methods in higher mathematics classrooms, and put forward relevant solutions. This article, hopefully, will contribute to improving students' creative ability as well as enhancing their creative awareness.

1. Introduction

Why do students go to school? How do schools cultivate students? These are the fundamental questions in education and teaching. However, in reality, very few people give thought to these questions. Most teachers believe that teaching is simply to give out knowledge and skills, and most students consider learning as acquiring knowledge and skills. They seem to forget the distinction between humans and animals.

What makes man rule the world? The ability of thinking. It is the very characteristic that distinguishes man from beast. By thinking, by analogies and abstractions, men create tools: we make high-speed rails that run faster than tigers and leopards; we design air crafts that fly higher than birds; we build speedboats and submarines that dive deeper than fish. All examples above demonstrate that human development is about training in thinking, while animals grow by training of skills in speed and strength. Therefore, education needs to guide students into the world of thinking during their learning of professional knowledge, and schools should organize education and teaching systems with students' thinking as the main line. We can compare a person's way of thinking to a computer processor. One with processor of low-performance can only solve basic problems; regardless that he has much knowledge or high degrees. He will not be able to handle complex advanced problems.

In other words, high qualification is not equal to high intelligence. High intelligence is a high-dimensional form of thinking rather than plain storage of knowledge[1-3]. Unfortunately, until today, many of our teachers have not truly realized what the key purpose of education is. As a result, we see in our society lots of people with a lot of knowledge and little understanding, high marks and low ability. The main reason for that, is that our education lacks scientific talent-cultivation methods, thus produced so many people with defective and ineffective ways of thinking.

In this article, we mainly were inspired by the profound innovations in education brought by big data and artificial intelligence and reflected on the topic of how to develop students' innovative thinking ability in classroom teaching.

Mathematics, as one most subject we study during education, has always enjoyed the reputation of "gymnastics of mind". Mathematical research results are all "products" of innovation and creativity[4-7]. So math education, especially higher mathematics teaching, ought to function in cultivating students in methods of creative thinking[8]. To examine this topic, we probed into the questions of how we can improve students' innovative thinking ability in higher mathematics classrooms.

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2. Analysis of the Gap between Expectations for Human Thinking Ability Development and Current Situation of Higher Mathematics Classroom Teaching

The core mission of human ability development is to correctly understand the drawbacks existing in conventional classroom teaching from the perspective of cognition, which is significant for us in reforming methods and fixing problems in teaching. The "problems", by nature, are the gap between our hopes and expectations and reality. So in order to solve the problems, we must be clear about the present situation of classroom teaching.

2.1. Teaching objectives too simplistic

We all know that to achieve anything, we must first have an accurate and reasonable location of objectives, and then, according to that, determine relevant plans and measures of implementation. The decision of teaching objectives is multilevel, consisting of different aspects of cognition, thinking, operating skills, emotion, culture and so on.

On the other hand, for the moment, most teaching programmes are flawed at the design of teaching objectives. Generally, the majority of teachers set teaching goals only in concern of course contents and knowledge points, and in the same way prepare teaching programmes and materials. Interactive exchange of information in the classroom is missing (objective reasons can be: class size too big, hours too limited), let alone other aspects in teaching objective designing such as sufficient emotional communication, cognitive and thinking methods, innovative awareness and creative spirit and capability.

2.2. Book knowledge-oriented

The traditional position of higher mathematics courses is public foundation course, seen as the tool of majors in science & engineering or economics & management. Besides, the course hours have been constantly trimmed down. As a consequence, in class teachers can only elaborate on a few essential knowledge points, which is not much different from retelling textbook contents. There is no explanation of reasons behind theorems, nor how thoughts are applied to practical problem solving.

On the other side, students learn by memorizing mechanically what is taught, without comprehending the meaning of mathematical thoughts. They feel faced with cold and stiff laws and rules. They cannot help, as time passes, getting tired of the dry and tedious learning, and gradually lose their passion for pursuing higher knowledge. One research tried to find out the most useless course considered by university students, and the answer received from many was higher mathematics. This is nothing but failure of our math education. It fails both in setting the goals of higher mathematics courses and the implementation of teaching programme requirements and methods.

2.3. Teacher-oriented

A teacher-oriented class is characterized in the way that, the teacher speaks, students listen; the teacher asks, students answer; the teacher assigns tasks, and students get infused and "spoon-fed" with knowledge. In short, teaching overweighs learning. Students only learn as much as the teacher requires, which has become the fixed mode of classroom teaching. Nevertheless, when students take in knowledge so passively for long, they inevitably lose their enthusiasm and initiative in study and can only repeat what the teachers say. What is worse, the formation of students' self-consciousness, creativity and individuality is seriously undermined. This way of teaching only emphasizes infusing knowledge into students, leaving no space at all for fostering their creative awareness, creative spirit, creative knowledge, creative thinking and creative ability.

2.4 Textbook-oriented

We all know that now classroom teaching works this way teachers schedule textbook contents into calendar in line with the teaching plan, then make course PPTs and finish all teaching tasks as scheduled. At universities, teaching objectives are regarded as completed once teacher's work is done. Teaching inspections only reflect teaching, if teachers have progressed according to course schedule, not students' learning. Apart from that, foundation courses for graduate programmes are exam-oriented, deep and difficult.

Little attention paid to thinking methods, narrow definition of correctness, no transformative,

lateral or divergent thinking, no associations, comparisons or skill transfers, even no clear understanding of how math concepts were generated or fundamental meanings of properties. Those are all very harmful factors for the development of creative talents.

Above all, speaking from the angle of cognition, current higher mathematics classroom emphasizes teaching students "what" - knowledge itself, ignores "how"- the examination of the reasons behind, and ignores the perceptual side of knowledge. That leads to the phenomenon that in higher mathematics classes, teaching has become purely theoretical and abstract, and this does little help to students in comprehending and grasping mathematical concepts, equations, properties and theorems. In fact, teachers should educate students in thinking from the viewpoint of the question inventors. Teaching should resemble the question inventors' exploration, showing a complete process of the raising, analysis and solving of a question, a process of transforming contradictions and thinking creatively.

Conclusion: There is a large gap between our expectations and current mathematics classroom teaching, no matter in fulfilling the core mission of human education, or meeting the demand for innovative talents created by today's rapid advance of science and technology. This gap is an urgent issue we will solve in education and teaching.

3. Measures to Cultivate Students' Creative Thinking Ability in Higher Mathematics Classroom Teaching

At the present age, the importance of knowledge is self-evident. Knowledge is "what" - spiritual achievements of humans; thinking is "how"- reasons behind knowledge, the outcome of the human mind. Human beings cannot create knowledge of high level or solutions to problems without intelligent thinking.

So when it comes to university study, if we only memorize the "what" and not investigate the "how", we will not be able to master the keys to solving problems. We will only solve few repetitive simple questions with the "what" in memory, and get totally lost in front of complicated issues. Therefore, the core mission of university education is not to simply transmit knowledge. More important than that is to equip students' minds with the advanced way of thinking and only by doing this can we improve their creativity as well as capability of solving complex questions.

3.1. Give more attention to students' innovative thinking ability development in teaching objectives

What are the teaching objectives of higher mathematics education? The answer should be determined in line with the goals of talent cultivation.

Main aspects of talent cultivation involve:

1) Moral education (core value education)
2) Physical quality education (formative education, to form habits of physical exercise)
3) Psychological quality education (confidence education)
4) Creative thinking method education (education to enhance human core abilities)
5) Professional skills and quality education (need education)
6) Scientific and cultural quality education (education of basic knowledge and correct attitude and methods)

In all, we wish to educate people who are capable of making substantial contributions to society. If we view talent cultivation as a systematic project, the six aspects above then make six elements of this system, complementing and influencing each other. The relationships among the six elements are just as that of the different sides constituting a six-dimensional continuum in the six-dimensional space, with each of its side affecting the continuum significantly. Similarly, the changes of each element would bring great impact on the whole system. Considering that, our courses ought to be designed in light of the six aspects, and higher mathematics courses designed to accomplish goals from 1 to 6.

The central element of a person's development is thinking, particularly innovative thinking. For long, classroom teaching has been to deliver knowledge, and teachers' primary task has been to help students move knowledge into head like ants. Whoever moves more knowledge is more

learned. The student learns just to cope with situations that already happened and happen repeatedly. This “knowledge storage” pattern of talent education is entirely detached from the cultivation of people’s essential abilities, and will not adapt to the new era, where actual conditions can change in a matter of seconds. This then requires that we locate education on developing students’ innovative thinking ability, and achieve transitions from traditional teaching objectives of merely teaching students knowledge, to objectives of improving their creative awareness and innovative thinking ability. It also requires us to pay attention to fostering the creative thinking ability of students when passing on professional knowledge to them in classroom, to handling real-life problems with the thinking methods of developing mathematical theorems as well as expanding and updating knowledge; to integrate teaching students professional knowledge and cultivating their innovative thinking ability organically, and let the knowledge and thinking methods of students form the balance of creativity.

3.2. Strengthen foster of students’ capability of knowledge association and integration in classroom teaching

Psychologists have always been trying to figure out the unique traits possessed by those who stand out from the crowd in creativity. MIT, the university which ranked top 1 worldwide in 2018, once conducted the most profound research on this question. They interviewed over 3000 company executives within 6 years, and yielded the conclusion that the greatest distinction between innovators and rule-obeying professionals is “the ability of association and integration”. In other words, the ability to relate questions or things in different fields that seem totally irrelevant.

Steve Jobs also mentioned 20 years ago, that “Creativity is the ability of integrating things”. That is to say, creativity is not detached from reality, nor ability that comes from nowhere, but the discovery of ways to improve the reality on the basis of it. The prime precondition of innovation is to integrate existing achievements of the past. In calculus, the main research object is the function, the main factor of function is the corresponding relation, and the main way of establishing corresponding relations among things is association. Mathematical theorem developments themselves are innovations supported by human ability of association and integration.

The concept of limit was initially integrated and yielded with two in-equations with absolute values. When combined with actual problems, it was integrated into concepts of continuous function, differential function, and definite integral and so on. And these concepts were then integrated again and produced new theorems such as differential mean value theorem, L'Hospital's rule and mean value theorem of integration.

This shows that mathematical theorems were created by processing numbers into absolute value in-equations, concepts of function limit, continuous function, differential function, integral function, as well as theorems: intermediate value theorem, differential mean value theorem, integral mean value theorem and so on. When this way of thinking is practiced in enterprise development, raw materials are processed and integrated into new products, which enhances the value of raw materials enormously. A good example is the copper business of the managing director of McCall Corporation. He processed copper into doorknobs, drums and Olympic bronze medals, making copper that was originally sold at 1 pound 35 cents 3500 dollars of sales price.

It is hard to estimate the huge value of the creative products of processed real numbers and functions in higher mathematics. However, in math teaching, this invaluable way of thinking is often weakened by our narrow emphasize on professional knowledge. We can see from the cases above, that the solving of a problem is not purely up to knowledge itself but the flexible mastery of knowledge, the integration and process of knowledge. More specially, to combine things and create new features, like: biscuit + calcium tablet = calcium biscuit, calcium tablet + milk = calcium milk, whisky + vodka + grape wine + champagne = cocktail. Integrative and creative thinking is so powerful, that it boosts the value of ordinary things, and that is what we call “$1+1>2$”.

3.3. Let mathematical problem-solving methods function in exploring creative objectives and directions

It has become the value orientation of the education today to cultivate creative talents. Since our university education is classroom-based, to foster students’ creativeness, we must reflect thoroughly

about the contents as well as methods of current classroom teaching, determine to implement innovative thinking methods and ideas in classrooms, and bring things into practice.

In the development history of mathematical sciences, driven by the need to solve new problems, many creative thinking methods came into shape. Such as systematic thinking method, analogical reasoning method, abstract thinking method, divergent thinking method, development thinking method, associative thinking method, additive thinking method, different thinking and reverse thinking. In classroom, teachers can start from students' receptivity, use diverse approaches synthetically, excavate and refine the thinking methods embodied in textbooks. At the same time, let students fully understand the applications of mathematical thinking methods in real life by designing practical problems that are relevant to course contents, like the application of reverse thinking. For example, the story of a Jewish businessman smartly renting a safe. Positive thinking: to keep valuable objects → to rent a safe → need a lot of money; reverse thinking: little money → use safe at bank → keep valuable objects. By educating students this way, we will enable them to discover questions in mathematics → solve questions → discover new advanced questions → solve advanced questions.

Furthermore, for them to transfer mathematical thinking methods, discover problems in real life → solve problems → discover new advanced problems in real life → solve advanced problems again. Students will thus be inspired in thinking differently and creatively.

4. Conclusion

Universities undertake of cultivating students' creative spirit. The teaching of higher mathematics has a basic and leading position in the cultivation of creative thinking. In this paper, we combine the practice of higher mathematics teaching and analyze the main problems in higher mathematics teaching, on this basis, we put forward countermeasure of cultivate thinking and improve the teaching mode to improve students' ability as well as enhance their awareness in innovation and creativity.

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