

An Empirical Research on How Advanced Mathematics Promotes Students' Critical Thinking Led by Three-teaching Concept in New Engineering Education

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Abstract: Nowadays, the enrollment scale of China's colleges and universities, students' overall ability, teachers' quality and professional academic level all influence college students' enthusiasm, initiative and learning efficiency, which greatly affects the quality of talent cultivation in most colleges and universities. As for the traditional large-sized teaching model of advanced mathematics, student-centered teaching reforms in colleges and universities have been extensively explored. In addition to the traditional lecture-based teaching model, research-based teaching models, hybrid teaching models, and flipped classroom teaching models are typical teaching reforms. Based on the current situation and problems in advanced mathematics teaching in colleges and universities, this paper puts forward the "three-teaching" concept of teaching how to think, teaching how to experience, and teaching how to express in response to the problem, and uses the "three-teaching" concept to lead the situation-problem teaching and enable students to be driven by problems.

Keywords: Critical Thinking; Three-teaching Concept; New Engineering Education; Advanced Mathematics

1. Introduction

As the mother of science, the prosperity of mathematics often determines the progress or decline of the society. The fundamental problem of education is to cultivate people. How to cultivate people and for whom to cultivate people are the core of education. International and domestic situations require that our country's current education should strengthen ideological education and value

guidance. It should combine mathematics teaching with "three-teaching" concept (teaching how to think, teaching how to experience, and teaching how to express), promote the development of their thinking ability, and realize how to cultivate people. Teachers should make full use of the ideological teaching resources in different disciplines to cultivate qualified talents.

2. Theoretical Basis and Significance of Research on Teaching Models Guided by the Three-teaching Concept

2.1 Current Status of Advanced Mathematics Teaching Reform in Colleges and Universities

Due to various reasons such as enrollment scale, students' source, teachers' capability and professional academic level, college students are not motivated enough to learn at current stage, and their learning efficiency is relatively low, which has greatly affected the application-oriented undergraduate program. The quality of talent cultivation in colleges and universities means that the students they cultivate cannot well meet the society's requirements for talents, which in turn affects the employment rate of college graduates.

Mathematics, as one main engineering subject, is the basic course for various majors and it is a powerful tool for cultivating students' ability to apply mathematical knowledge to solve practical problems. It is also a core compulsory course for most first-year students. Currently, it is still mainly taught in large-sized classes. Student-centered teaching reforms in colleges and universities have been widely explored, including traditional lecture-based teaching models, research-based teaching models (interactive, discussion-based, research-based,

case-based, etc.), hybrid teaching models, and flipped classroom teaching. After comparing these teaching models, the problems mainly focus on the following four aspects.

2.1.1 Lecture-based teaching

The main advantage of lecture-based teaching is concise and efficient. Teachers' teaching can make profound and abstract knowledge concrete and allow students to avoid unnecessary work. However, it reduces students' independent thinking and it is not conducive to students' innovative ability.

2.1.2 Research-based teaching

Research-based teaching is mostly based on the course design and organization of famous teachers from famous universities, and it is difficult for some teachers to imitate and copy their teaching contents directly. Even in classes taught by famous teachers from famous colleges and universities, students' participation is set in a specific link, and the teacher is still the commander of the class. Integrating lecture-based and research-discussion teaching method means that half of the classroom time is allocated to teachers for teaching and half to students for discussion. However, there are some difficulties in time control, especially in large-sized classes. Factors such as the theoretical contents of the course and the level of students' learning abilities may affect the time and quality of lectures and discussions.

2.1.3 Hybrid teaching model

The hybrid teaching model is more effective in key colleges and universities, but students in ordinary undergraduate colleges have poor self-learning ability. Teaching resources are often used by the students as a tool to prepare for the exams, which has limited the effect on in-depth learning and knowledge construction.

2.1.4 Flipped classroom teaching

Due to the abstract concepts of many basic mathematical knowledge, students lack a deep understanding and understanding of the new information they have just encountered although they have studied MOOC videos and relevant materials on the Internet [1]. Faced with the questions prepared by the teacher, they are unable to have effective discussions, which results in the poor effect of flipping classroom teaching mode.

2.2 Theoretical Basis and Significance of the "Three-teaching" Concept Teaching Model

The main theoretical basis of the teaching model led by the "three-teaching" concept is the learning theory and teaching theory of constructivism. Situation creation, negotiation conversation and information resource provision are exactly the basic attributes or basic elements required by the constructivist learning theory [2-5]. Constructivist learning theory and learning environment emphasize student-centeredness, requiring students to transform from passive recipients of external stimulation and objects of knowledge infusion to subjects of information processing and active constructors of knowledge meaning. The theory of constructivism requires teachers to change their roles from imparters of knowledge to facilitators for students to actively construct meaning. It requires teachers to adopt new educational ideas and teaching models in the teaching process and completely abandon the teacher-based teaching theory. Traditional educational ideas and teaching models that emphasize knowledge transfer and treat students as objects of knowledge instillation [6-9]. It is conducive to the improvement of students' critical thinking ability, active exploration and discovery, and is conducive to the cultivation of creative talents. Figure 1 shows the difference between critical thinking teaching and non-critical thinking teaching. However, because this teaching model emphasizes students' learning, it often ignores the leading role of teachers, the emotional communication between teachers and students and the important role of emotional factors in the learning process. In addition, due to the absence of the leading role of teachers, when students have too much freedom in independent learning, they can easily deviate from the requirements of teaching objectives. Figure 2 shows the differences between teacher-centered and student-centered teaching principles. between the two teaching modes.

The above-mentioned advantages and disadvantages of the student-centered teaching model are specific embodiments of the advantages and disadvantages of the constructivist theory itself. We must be clearly aware of this in the process of applying and promoting the constructivist theory. How can we maximize our strengths and avoid weaknesses? This is the main research focus of this topic. With the vigorous development of

network technology and the advent of the big data era, there are two types of common big data in education [10-11]. One is teaching big data generated in education and teaching, such as the number of times that students ask questions, the number of times that teachers answer questions, and the frequency of questions in classroom teaching. Another is a category of big data for education and teaching evaluation, such as big data generated by students using mobile phones or computers to complete online exams and their homework after teaching.

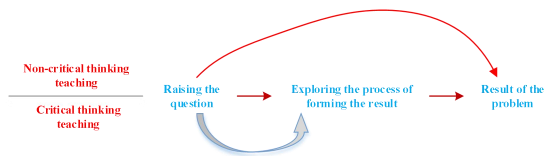


Figure 1. Difference between Critical and Non-critical Thinking

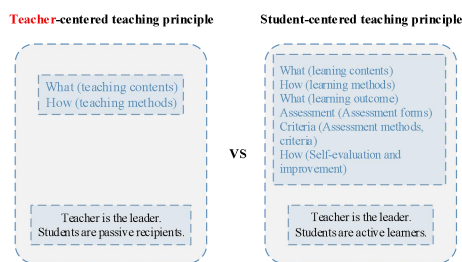


Figure 2. Differences between Teacher-centered and Student-centered Teaching Principle

These big data have profoundly affected the development of the education and brought new challenges to the development of teaching concepts, teaching models, teaching methods and teaching evaluation. How to effectively use educational big data to improve the quality of teaching in colleges and universities is an urgent problem that needs to be solved, and it also puts forward higher requirements for teachers' capability. Figure 3 is an illustration of the integration of critical thinking skills into learning assessment.

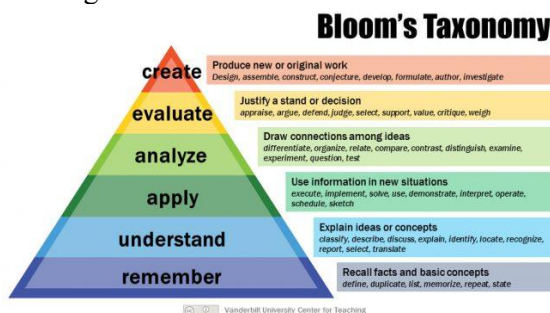


Figure 3. Bloom's Taxonomy

3. Practical Innovation of Teaching Model Guided by “Three-teaching” Concept

3.1 Innovation in Teaching Model: Formation of RMI Thinking Paradigm Based on Problem Situations

“Situation-problem” teaching in advanced mathematics stimulates students' longing for knowledge through the creation of mathematical situations, allowing them to discover, raise and solve mathematical problems through observation and exploration of existing situations under the guidance of teachers, and then gain understanding of mathematical situations. cognition. This forms the RMI (Relational Mapping Inversion Principle) thinking paradigm based on problem situations: mapping mathematical situations into mathematical problems, inverting the obtained mathematical conclusions back, and deepening the mathematical understanding of the existing situations. Figure 4 show the RMI thinking paradigm concerning “situation-problem” teaching in mathematics.

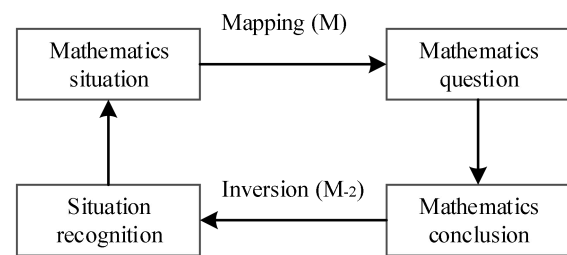


Figure 4. RMI Thinking Paradigm Based on Mathematics “Situation-problem” Teaching

3.2 Innovation in Teaching Concepts

The educational concept of “teaching how to think, teaching how to experience, and teaching how to express” is implemented in college classrooms, and the role and methods of the “three-teaching” concept in cultivating core competencies are conducted in-depth research. Teaching how to think is to let students learn to “think about mathematics” in “situation-problem” teaching and cultivate their thinking skills. Teaching how to experience is to let students learn to “do mathematics” in the exploration of problem situations and accumulate core competencies. Teaching how to express is to let students “talk about mathematics” in inquiry learning and enhance communication skills. Theoretical

research shows that “three-teaching” concept is a high-level summary of the essential attributes of classroom teaching. Practical tests show that the “three-teaching” concept has good effects in improving teaching quality and cultivating students’ competencies.

3.3 Case Studies

Combined with the characteristics of mathematics courses, we cultivate the core values and the awareness of serving the society. It integrates mathematics teaching and cultivates talents with both ability and political integrity in line with China’s development strategy. During the teaching process, moral education and knowledge teaching are integrated. With the help of key knowledge, mathematical history, allusions and other relevant elements in traditional Chinese culture, knowledge teaching is combined with value guidance and patriotic education to guide students to behave correctly, learn knowledge, and establish moral principles. This principle runs through the entire process of education and teaching, achieving full-course education and all-round education.

Here is one example of the Advanced Mathematics course taught for one ISEC (International Scholarly Exchange Curriculum) class majoring in computer science and technology. One class was used as the experimental class for this research object, and another class was used as the comparison class. Through classroom teaching, online teaching, online examination system, MOOC platform and WeChat platform etc., teachers collected and analyzed data, and compared the results of the final examination. Through observing their performance in National College Student Mathematics Competition and the results of students’ participation and performance in other scientific and innovative competitions, we launched a practical teaching exploration of the new “situation-problem” teaching model under the guidance of the “three-teaching” concept. The teaching effect of the Advanced Mathematics course is outstanding and achieved excellent results in many aspects. The experts of the university unanimously believe that the teachers’ overall performance are full of energy, which effectively mobilizes students’ enthusiasm for learning. The students’ classroom performance is also very good, and the experts’ comments on the teachers’ overall

teaching effect are very positive. The teaching quality was highly evaluated, and the students’ learning output effect was obvious, and their scores were significantly better than those in the comparison classes. It can be seen that the practical use of “three-teaching” concept in classes and combination of “situation-problem” teaching with advanced mathematics teaching can effectively mobilize the teaching atmosphere, enhance the students’ creative thinking ability and improve the learning effects.

4. Conclusions

Leading the “situation-problem” teaching with the “three-teaching” concept, the essence is to be driven by questions, so that students can not only stimulate problem awareness and activate mathematical thinking in the expression and communication of problem exploration, but also improve the logic, profoundness and creativity. The study shows that this is an innovative teaching path that is in line with the characteristics of the mathematics discipline.

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