

Practice and Exploration on the Reform of Advanced Mathematics Teaching in Different Levels

Xinhong Liu^a, Yuan Feng^{b,*}, Chunxia Wu^c

Beijing Institute of Petrochemical Technology, Beijing, 102617, China

^aliuxinhong@bipt.edu.cn, ^bfengyuan@bipt.edu.cn, ^cwuchunxia@bipt.edu.cn

**Corresponding author*

Keywords: Advanced Mathematics, Layered teaching, Reform and innovation

Abstract: Based on the different levels and needs of students, the teaching reform of Advanced Mathematics should be carried out in different levels. Make full use of modern educational technology, reconstruct the learning environment, and build an information system for Advanced Mathematics teaching. Integrate the new teaching mode, improve students' participation in learning, and realize the internalization of knowledge. Establish a multi-level, diversified and dynamic assessment mechanism and evaluation system to fully mobilize students' learning enthusiasm. With the help of teaching, mathematical competition and modeling platforms, students' mathematical modeling ability is cultivated and their ability to analyze and solve problems is improved. Through the scientific analysis of the learning effect of stratified students, the necessity and feasibility of stratification are proved.

1. The Inevitability of Layered Teaching

Advanced Mathematics is an important basic course for students majoring in science and Engineering in Colleges and universities in China. It is also a basic subject for postgraduate examinations of science, engineering and economics and management. Advanced Mathematics not only lays a foundation for students' learning and research of subsequent courses, but also cultivates students' scientific literacy such as rigorous logic and clear expression.

At present, China's higher education is transforming from "elite" to "popular". There is a large gap among students in the same class of the same major in the same school, and the cultural foundation of the enrolled students is uneven, especially the foundation of mathematics. Advanced Mathematics is generally a general education course in universities. It is very easy for students with weak foundation to lose interest and motivation in learning, resulting in poor academic performance in Advanced Mathematics. Teachers' classroom teaching organization is difficult, and often laborious and thankless. In addition, students' learning objectives are also different. For example, some students need to have the requirements for further study such as postgraduate entrance examination qualification in the future, and some students will only work in service industries in the future. Their requirements for the content and difficulty of Advanced Mathematics learning are different. The traditional Advanced Mathematics teaching has unified requirements, and the one size fits all teaching model shows great drawbacks. The traditional teaching form will inevitably affect students' enthusiasm, autonomy and creativity in learning, resulting in the phenomenon that some students are

"not satisfied" while others are "not satisfied". The function of university education serving students requires that our teaching must respect the actual situation and objective requirements of students. We should not only ensure that students with poor foundation meet the basic requirements, but also not restrict the development of excellent top-notch talents. According to different students' learning needs, cognitive level, learning ability and their own quality, teachers need to teach pertinently, give full play to each student's strengths, stimulate learning interest and promote the maximum development of all students. At the same time, the outline of the national medium - and long-term education reform and development plan 2010-2020 proposes to establish the concept of everyone becoming a talent, face all students, and promote students' growth and success. Establish the concept of diversified talents, respect individual choices, encourage personality development, and cultivate talents without sticking to one pattern. These will certainly require us to carry out hierarchical teaching reform [1].

2. The Present Situation of Teaching in Different Levels and Classifications

Hierarchical and classified teaching is a personalized teaching model based on students' differences. Teachers divide students into different levels according to their personality characteristics and acceptance ability, and then formulate different training objectives and teaching requirements according to the grouping situation, and adopt a teaching mode that fully promotes the development of students' intelligence with different teaching contents and teaching methods. Through hierarchical and classified teaching, students of each level and professional category can achieve corresponding goals, meet the different needs of each student to the greatest extent, and lay a good foundation for training multi-level and multi category talents.

Foreign countries, such as the United States, also give students fast and slow classes in teaching. In Britain, stratified teaching is implemented in primary and secondary education. This is not discrimination, but compliance with the law of education. Layered teaching is actually a personal teaching form, which is in line with the law of education. At present, from the current situation of domestic higher education, there has been a phenomenon of layered teaching in the education of college students. The college entrance examination itself plays a role of early stratification. 985 and 211 colleges and universities are the first type of colleges and universities. Most of these colleges and universities are research-oriented colleges and universities. They require students to have strong logical reasoning ability, speculative ability, independent learning ability and a strong foundation for primary education. The other one can be called the second type. Such schools have their own unique style and unique educational concept. There are both research-oriented and Application-oriented Institutions. The students of such institutions have a solid foundation, slightly rely on teachers in learning, have certain self-learning ability, and are more inclined to apply in learning. The third category is the second and junior colleges. The training objectives of the colleges and junior colleges are applied talents. Students are required to have strong practical ability, high level of practical operation and certain theoretical basis. In addition to the stratification of students caused by school types, the choice of majors also has obvious classification characteristics. For example, the gender characteristics of many majors are obvious. The proportion of male students in engineering majors such as civil engineering, electrical engineering and computer is very large, while the number of female students in linguistics, law, accounting and management is dominant. These are the framework for the hierarchical classification of colleges and universities in China.

As the second University in Beijing, Beijing Institute of Petrochemical Technology enrolls about 1100 students in engineering every year. The large class of Advanced Mathematics courses and the traditional "step-by-step" form of course content directly affect students' learning interest and teaching effect. The disadvantages of traditional teaching are as follows: the students' rise rate in class

is not high, their ability to calculate is reduced, and the failure rate remains high. Even on the premise of reducing the difficulty of the test questions, there is a strange circle of rising failure rate. According to the course characteristics of Advanced Mathematics, layered teaching is also a suitable teaching method. Advanced Mathematics is a general course in many schools. The course content is closely linked and has strong continuity. Therefore, the course itself has strict basic requirements for students. In many courses, students can work hard after class, but it is difficult to catch up with the class progress only through extracurricular self-study. Grasping the difficulty of teaching is also a headache for many Advanced Mathematics teachers. If teachers only take care of the students with the worst foundation in the class, most students will feel bored in class. Many students just study for exams and lose the essence of education. If the intermediate level students are taken as a reference, some students will not be able to graduate because they fail in mathematics, and some students will lose interest in mathematics because their classes are not challenging, and even affect their further study. From the perspective of educational psychology, learners tend to actively complete the slightly challenging learning goals, and for the goals that are difficult to achieve, they tend to have a mentality of giving up. Similarly, for the learning goals that do not have any challenges, they will have a feeling of boredom. For students of different levels, adopting appropriate teaching objectives will make every student achieve progress on the basis of efforts. Therefore, it is necessary to apply the layered teaching method in the teaching of Advanced Mathematics.

Vygotsky, an educator of the former Soviet Union, put forward the theory of the zone of proximal development, which believed that every student had two levels: the existing level and the potential level. Their public area is called the nearest development zone. Teaching should consider the individual differences between these two levels and transform the potential level of the nearest development zone into the existing level. Continue to create a higher level of the nearest Development Zone, promote students to develop their potential, and continue to achieve development. Layered teaching follows this teaching law. The so-called layered teaching is to re divide the regular classes with the same teaching requirements into new classes of different levels, and determine the teaching contents and teaching objectives of different levels based on the syllabus of a course and according to the content of teaching materials and the individual differences of students' learning ability. Choose teaching methods suitable for students at different levels, design exercises and evaluation methods at different levels, fully mobilize the learning enthusiasm and initiative of students at different levels, so that each student can be fully developed in their own recent development zone, so that all students can make maximum progress on the original basis, and achieve the purpose of improving teaching quality in a large area. This is the real goal and significance of hierarchical teaching, and it is also the true meaning of educational pursuit.

3. Specific Measures for the Reform of Stratified Teaching [2,3]

Taking into account the existing natural stratification characteristics of students, our university divides about 1100 engineering students in the annual undergraduate enrollment into two levels-the reinforcement layer and the foundation layer. There are less than 200 people in the reinforcement layer and more than 900 people in the foundation layer. The teaching objectives are divided into two levels: Reinforcement level and basic level. The goal of strengthening the level is to cultivate pioneering engineering and technical talents and research talents in new engineering disciplines. Pay attention to enlightening thinking and developing ability, cultivate students' high mathematical quality, and focus on cultivating students' awareness and ability of self-study, exploration and creation, so that students at this level have a lasting learning motivation and a conscious habit of studying, can flexibly use the learned knowledge and methods to solve complex problems, and lay a solid foundation for future work. The goal of the basic level is to cultivate new engineering talents. Focus

on stimulating students' learning interest and enthusiasm, guide students to form good learning habits and effective learning methods, and enable students to have a systematic and in-depth grasp and understanding of the basic concepts and research methods in the course. Cultivate students' ability to solve practical problems with mathematics, and become new engineering talents with high quality. All these should conform to the talent training goal of our university - "high level applied talents".

Teaching content is the main carrier to achieve teaching objectives. The reform of teaching content is the key to teaching reform. Strengthen the teaching content at different levels, strive to explain and analyze their mathematical thinking and mathematical thoughts, introduce some modern mathematical thinking methods, strengthen students' mathematical foundation, combine some postgraduate entrance examination questions, cultivate interest, tap potential, and pay attention to cultivating students' theoretical analysis and application ability. The stratification of teaching content requirements points out the direction for specific teaching organizations, such as the stratification of teaching objects, the differentiation of teaching plans, and the selection of teaching methods.

In order to improve students' learning enthusiasm and learning effect, some teaching methods are boldly tried in hierarchical teaching. Based on the cloud class platform, basic courseware, micro class and other resources are put into the cloud class platform for students to use their spare time for self-study at any time. The abundant network resources ensure the students' need for autonomous learning and urge them to consciously study mathematical problems.

The establishment of mathematical models through case teaching in the classroom has greatly increased students' interest in learning mathematics and improved the teaching quality of mathematics classroom. At the same time, mathematics experiments are introduced into Advanced Mathematics classes, and computer knowledge and mathematical software are used to simplify the complex operation process and solve practical problems, so as to improve students' ability to analyze and solve problems.

With the help of the school's mathematics competition, Beijing mathematics competition, National Mathematical Modeling Competition and other platforms, encourage and guide students to participate in colorful mathematics learning activities, lay a good foundation for further study and ensure the realization of teaching objectives.

In addition to cloud like courses, the network platform also includes Maple T.A., MATLAB Grader experimental platform and MATLAB online platform to build a learning mode of "online preview, classroom learning and after-school reinforcement". On the basis of meeting the basic level, a flexible curriculum content system is established. Enlighten thinking, develop ability, and cultivate students' higher mathematical quality. Develop students' self-study ability and continuous learning ability. Based on "micro class" before class, we can realize the autonomy of learning. In class, we can realize the internalization of knowledge under different teaching modes such as flipped class, discussion and cooperation. After class, we can use cloud class platform and micro class resources to strengthen practice and cultivate students' self-study ability and innovation ability

In terms of assessment methods, we use the previous teaching experience and mode for reference, adopt the method of multiple tests and examinations, and test after each section and chapter, so that students can understand their learning status and degree, and teachers can understand their learning situation. After the test, the teacher can explain the content online in detail, so that the students can digest, consolidate and improve the content. Avoid the phenomenon that one exam determines a lifetime, and avoid the fluke mentality of students before the exam, which is conducive to the sustainability of learning.

4. The Innovation of Layered Teaching

4.1. Integrate the new teaching mode, improve students' participation in learning, and realize the internalization of knowledge

The new teaching model consists of three teaching stages: pre class, classroom and post class. Teachers, students and teachers interact closely to complete the teaching process. Before class, according to the teaching content, students learn the courseware and micro class video of relevant knowledge on the cloud class platform, and realize the autonomy of partial knowledge learning on this basis. The classroom focuses on teaching difficulties, communication and discussion to realize the internalization of knowledge. After class, through hierarchical homework, online learning platforms such as cloud class platform are used to form complementarity. This teaching mode is more conducive to students' personal participation in the teaching process, which is consistent with the student-centered teaching concept and the concept of learning mathematics from activities advocated by the learning theory. Only by taking part in and perfecting the construction of knowledge, can students really master and flexibly apply it.

4.2. With the help of teaching, mathematical competition and modeling platforms, students' mathematical modeling ability is cultivated and their ability to analyze and solve problems is improved

The establishment of mathematical model through case teaching has greatly increased students' interest in learning mathematics and improved the teaching quality of mathematics classroom. At the same time, mathematics experiments are introduced into Advanced Mathematics classes, and computer knowledge and mathematical software are used to simplify the complex operation process and solve practical problems, so as to improve students' ability to analyze and solve problems.

Encourage and guide students to participate in a variety of mathematics learning activities, lay a good foundation for further study and ensure the realization of teaching objectives with the help of platforms such as school mathematics competitions and Beijing mathematics competitions. The cooperative learning teaching model can successfully extend the classroom teaching beyond the classroom and realize the actual increase of effective learning time.

4.3. Make full use of modern educational technology, reconstruct the learning environment, build an information system for Advanced Mathematics teaching, and reflect the innovation of teaching mode

Advanced Mathematics curriculum has been facing the problems of large number of students and large class size, so it is very important to build an information-based teaching environment. This course is based on cloud class, micro class video and online evaluation system Maple T. A. and MATLAB Grader, an information system for Advanced Mathematics teaching has been established to realize diversified supply. Domestic and foreign platforms are used in combination with each other to organize course teaching links, promote process evaluation, accurately analyze students' learning situation and teachers' teaching effect, and timely adjust students' learning methods and teachers' teaching methods. Improve the efficiency of teaching feedback and facilitate the timely improvement of teaching effect.

4.4. Establish a multi-level, diversified and dynamic assessment mechanism and evaluation system to fully mobilize students' learning enthusiasm [4-6]

In terms of assessment methods, we should use the previous teaching experience and mode for reference, adopt the method of multiple tests and examinations, and conduct unit tests after each chapter, so that students can understand their learning status and degree, teachers can truly understand students' learning situation, and avoid the phenomenon that homework plagiarism can't reflect students' real learning situation. After the test, teachers can explain in detail online, let students digest, consolidate and improve the content. Avoid the phenomenon that one exam determines a lifetime, and avoid the fluke mentality of students before the exam, which is conducive to the sustainability of learning.

In order to further mobilize students' learning enthusiasm, according to the examination results of the first semester, students at the Reinforcement level and the basic level flow and adjust to form a dynamic learning class.

5. Analysis of Learning Effect

The layered teaching reform reflects the changes of teaching contents, teaching methods and teaching strategies, and also improves the learning effect of students Table 1 below shows the comparison of the average score and excellent rate of the two levels in the midterm and final examinations.

Table 1: Layered test results

	Average score of midterm exam	Excellent rate of midterm exam	Average score of final exam	Excellent rate of final exam
Reinforcement layer	82.06	32%	75.89	18%
Foundation layer	64.46	7%	54.58	5%

From the results of the examination, the students with high scores are concentrated in the reinforcement layer. The gap between the reinforcement layer and the foundation layer is relatively large. The effect of stratification is reasonable and obvious. Most of the students at all levels can basically meet the requirements of this level and ensure the teaching quality.

Table 2: Comparison of chapter measurement

	average	standard deviation	Ratio of 9-10 points	Ratio of 8 points	Ratio of 7 points	Ratio of 6 points	Ratio of 0-5 points
Chapter 1 with pre-test	9	1.5	67%	15%	6%	6%	6%
Chapter 2 with pre-test	8	1.72	36%	14%	26%	12%	12%
Chapter 3 without pre-test	7	2.65	41%	9%	11%	5%	35%

It can be seen from table 2 that when we add the pre-test to the teaching of the reinforcement layer, the students' failure rate in the tests of these chapters is 6% and 12%, while the failure rate in the tests of the chapters without the pre-test is 35%. Obviously, the pre-test is mainly aimed at basic knowledge. Students can learn this knowledge by themselves through online materials. The pre-test can well urge students to learn and help teachers understand students' mastery.

In short, hierarchical teaching recognizes the differences in students' learning ability, respects students' personality development, and realizes students' learning at different levels. Students are divided into different levels, different teaching methods are adopted for different levels, and teaching contents at different levels are formulated, which provides students at different levels with a learning and development path, so that students' development has enough freedom and space. It has practiced the educational idea of teaching students according to their aptitude, and widened a new way to

improve the quality of education and teaching in a large area.

Acknowledgements

The authors gratefully acknowledge the general teaching reform project of Beijing Institute of Petrochemical Technology “Student centered, hierarchical teaching reform and research of Advanced Mathematics course”.

References

- [1] Xiao Yingxiong, Xiao Jianhai, Li Miao, et al. *Research on Hierarchical Teaching of Higher Mathematics in Engineering Colleges - Taking Hubei Engineering College as an example*[J]. *Journal of Hubei Institute of engineering*, 2015 (3): 89-93.
- [2] Zeng Yuxiang, Liu Yuqiong, Huang Yonghui. *Research on the application of hierarchical cooperative learning from the perspective of apos -- taking higher mathematics teaching as an example* [J]. *Heilongjiang Higher Education Research*, 2013, 031 (004): 171-173.
- [3] Kang Wenyan, Gao Qiaoqin, Kang, et al. *Application of micro class in hierarchical teaching of higher mathematics* [J]. *China education technology equipment*, 2017, 02: 130-131.
- [4] Nie Cunyun, Chen Xiaoling, Liu Guanghui, et al. *On the reform of higher mathematics teaching in engineering colleges in the construction of "new engineering course"* [J]. *Journal of Hunan Institute of Engineering (SOCIAL SCIENCE EDITION)*, 2018, 28 (03): 109-113.
- [5] Chen Jing, Qin Hongmei. *Exploration of hierarchical teaching of "higher mathematics" in Higher Vocational Education with the help of SPOC* [J]. *Journal of Yangzhou Institute of education*, 2019, 037 (001): 79-82.
- [6] Zhou Yili, Sun Xihao, Dong Zhiqiang. *Research on Hierarchical Teaching of Higher Mathematics in Applied Undergraduate Universities -- Taking the teaching practice of Wuxi Taihu University as an example* [J]. *University education*, 2020, 000 (001): 34-36.