



# On strengthening the cultivation of application and innovation ability in teaching of Advanced Algebra for mathematics majors

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**Abstract**—Advanced Algebra is one of the three basic courses for mathematics majors. As we all know, innovation ability is very important for the future development of any professional students, especially for the application-oriented students. Although some teachers realized the importance of innovation ability to mathematics majors, and took some measures, the effect was not ideal. This paper first discusses the position and function of Advanced Algebra course. Secondly, it analyzes the problems of application and innovation ability training in the teaching of Advanced Algebra for mathematics majors. Finally, the strategies of application and innovation training in Advanced Algebra teaching for mathematics majors are given.

**Index Terms**—Basic course, innovation ability, mathematics application ability, mathematics major, strategy.

## I. INTRODUCTION

With the further deepening of the reform of mathematics education in colleges and universities, the requirements of the basic mathematics education in middle schools and the society on the knowledge, ability and quality of the required talents are gradually improved, which puts forward new requirements for the teaching of basic courses in mathematics majors. The reform is multi-faceted and multi-level. The requirements of mathematics application and innovation ability of mathematics majors are further improved, which has set off a wave of "strengthening practice teaching and improving application ability" [1-10]. In the face of the rapid development of science and technology, the primary task of higher education is to cultivate high-quality talents with innovative spirit and ability. It is an inevitable trend of the reform of mathematics education to cultivate the ability of mathematics application and innovation of students majoring in mathematics. It is also an inevitable need for the implementation of mathematics quality education in China and an inevitable path for the development of mathematics science and society.

The major of mathematics is an important part of the major set up by the newly established local undergraduate colleges, which generally includes the major of mathematics and applied mathematics, information and computing science,

statistics, financial mathematics, etc.

The ability of application and innovation is inseparable from creative thinking. Creative thinking is the core of mathematics quality education. This ability must not only be cultivated through the teaching of effective knowledge, especially basic knowledge, but also guide students to apply what they have learned, analyze and creatively solve practical problems, and stimulate their creative enthusiasm and interest. Because Advanced Algebra course is far away from the frontier subject, it is difficult for students to put forward new scientific concepts or discover new theories in the process of learning. However, the knowledge they have learned is brand-new for the junior students. In this sense, students' learning process contains creative thinking activities. In teaching, through the improvement of teaching methods, it can inspire students to ask questions with innovative ideas, guide students to feel the joy of creation and success, gradually cultivate students' scientific working attitude, rigorous research spirit and strong sense of enterprise, and improve their creative thinking ability. For example, for the problem "Let  $A$  be a  $n$ -order real square matrix, then  $rank(A'A) = rank(A)$ ", we can guide students to use the theory of linear equations and the theory of quadratic form to prove it respectively. After proving this question, the teacher can ask the question: "If the real square matrix in the above proposition is replaced by the  $n \times m$  matrix in the real number field, is the above conclusion still true?" Furthermore, "If the real number field in the above proposition is replaced by the complex number field, is the conclusion still valid? If not, what conclusion can we get in the complex field?" Teachers don't have to give the results directly, but through inspiring students' positive thinking, and let students explore their own conclusions, give specific proof process..

## II. THE POSITION AND FUNCTION OF ADVANCED ALGEBRA

The most fundamental goal of Local Application-oriented Universities is to train and transport application-oriented talents for the society. The training of



Applied Talents in teaching is inseparable from curriculum construction and teaching reform. However, it is difficult to integrate the application into the basic courses of the subject: how to implement the idea of cultivating applied talents into the daily and abstract theory teaching is an urgent problem to be solved. Advanced Algebra is one of the most important basic courses for mathematics majors, and it is also the basis for students to learn the follow-up courses well. This fact has been generally accepted by mathematics workers, and with the development of science and technology, its application value is gradually reflected. Matrix theory in Advanced Algebra is the most practical part in mathematics. The teaching of this course plays an important role in the cultivation of students' learning ability and application ability in the future. Therefore, the course of Advanced Algebra must and can be reformed with the times.

### III. PROBLEMS AND ANALYSIS OF THE CULTIVATION OF APPLICATION AND INNOVATION ABILITY IN ADVANCED ALGEBRA TEACHING FOR MATHEMATICS MAJORS

#### A. Instructional design

The teaching design is simple and impetuous. It focuses on the calculation of examples or exercises, but ignores the infiltration of mathematical ideas. Teachers spend a lot of time on the derivation and calculation of examples or exercises, and put most of their energy on qualitative analysis. They lack the elaboration of physical laws and mathematical models. For example, for determinants, they often spend a lot of time explaining its definition, properties and calculation, while for others, they do not. In fact, the determinant has been replaced by the matrix theory in the application of Advanced Algebra, and gradually weakened.

#### B. Teaching devices

In terms of teaching means and teaching methods, the teaching means are single, and the traditional routine of "Teacher centered, textbook centered and classroom centered" is still adhered to, which separates knowledge from the fundamental purpose of students' all-round development, and students are passively accepted in the whole teaching process. It is difficult for students to improve their ability of practice and application in concept, theorem, formula and problem solving. Most of the teaching is scripted, lack of ingenious design, lack of applied knowledge subject, lack of combination with modern computer technology, resulting in the disconnection of modern education concept and content, lack of practice and application of knowledge.

#### C. Teaching method

In terms of teaching methods, due to the long-term existence of exam oriented education mode, the tradition of paying attention to classroom teaching and the particularity of

strict logic system of mathematics majors, the "indoctrination" teaching is deeply rooted in teaching practice. In the classroom, the teacher fills the classroom with indoctrination, while the students accept it passively, which results in the fixed mode of "teaching learning" in the teaching practice for a long time. The students lack the ability and motivation to actively think about problems, and they only know the knowledge by rote, but they don't know the reason. As a result, the students' concept and ability to solve practical problems have not been cultivated, which leads to the problems. The results show that the students have a narrow range of mathematical knowledge, blank mathematical thinking, and lack of creativity and application ability.

#### D. Teaching reflection and teaching research

Lack of teaching reflection and teaching research. Some teachers seldom do serious reflection before, during and after teaching, which makes teaching become a mechanical and repetitive process.

#### E. Textbook compilation

In terms of textbook compilation, mathematics majors often choose some "authentic" traditional textbooks, while many excellent mathematics textbooks, including some national award-winning textbooks, are often deleted because of the limited teaching hours. Most of the attention of teachers and students is focused on the process of proof, mathematical concepts and reasoning, and the exercises and examples with application background involved in the teaching are often in the ideal state, which leads to the teaching of mathematics majors is only limited to the discussion of the so-called "pure mathematics", so that students know little about the application of mathematical knowledge.

#### F. Teaching practice

The mastery of professional knowledge of normal students majoring in Mathematics in teaching practice is satisfactory, but they can't meet the needs of middle school mathematics education in the aspects of organizing teaching, teaching skills, innovation ability, using modern teaching means, making high-quality teaching courseware and making relevant teaching aids according to the teaching content. These situations can well reflect that normal students majoring in mathematics still need to further improve their ability in the application of mathematical software, the ability to solve practical problems with the help of computers, the ability to make mathematical courseware, and the ability of hands-on innovation.

### IV. STRATEGIES OF CULTIVATING APPLICATION ABILITY IN ADVANCED ALGEBRA TEACHING FOR MATHEMATICS MAJORS

#### A. Changing the teaching concept is the premise of cultivating the ability of mathematics application

Change the concept of "taking knowledge as the core" into



the concept of "taking application as the core". To adapt to the requirements and ideas of professional certification of the Ministry of education, advocate student-centered and output-oriented. Due to the misleading of exam oriented education, most of the students trained in the past are "inheritance type", while "application type" is less. Teachers constantly advocate to be knowledgeable and strong in memory, but ignore the cultivation of students' application ability. For a long time, many teachers have formed the concept and behavior model with knowledge as the core. In the process of classroom teaching, these teachers consciously or unconsciously focus on the teaching objectives of curriculum knowledge, regardless of the formulation of teaching objectives, the design of teaching methods, or the teaching activities in the classroom, while ignoring the cultivation of students' application ability. In order to cultivate students' mathematics application ability in mathematics teaching, we must abandon the concept of "taking knowledge as the core", establish the concept of "taking application as the core", and take cultivating students' application ability of mathematics knowledge as the core goal of mathematics teaching.

*B. Advocate "Inquiry Teaching" and realizes the transformation from "emphasizing knowledge and theory teaching" to "emphasizing application ability teaching"*

"Inquiry Teaching" is an attempt to reform the current teaching mode of Mathematics Major under the guidance of the theory of cultivating students' mathematical application ability and combining with the characteristics of mathematics major. Under the guidance of teachers, students are the main body of inquiry, and are guided to carry out inquiry activities in the whole process of knowledge occurrence, formation and development, so that students can learn to find problems and ask questions And gradually cultivate their ability to analyze and solve problems. The research and practice of "Inquiry Teaching" has initially realized the transformation from emphasizing knowledge theory teaching to emphasizing application ability teaching.

*C. Flexible use of teaching methods and modern technical means to stimulate students' enthusiasm and interest in learning*

For education, the ultimate goal of teaching is to apply what we have learned. Mathematics, as a research-oriented but boring subject, is a very difficult but boring science. If college students are distracted in class and don't keep up with the teacher's ideas, then the whole class is invalid for students, and it's very difficult for them to understand by themselves after class. Thus forming a vicious circle, not only to combat the enthusiasm of college students for mathematics learning, but also to master the professional knowledge theory is not solid, so that they lag behind in the future employment competition. Therefore, in the classroom, teachers should

flexibly use teaching methods, stimulate the enthusiasm of college students, make the classroom atmosphere of Advanced Algebra become active, so as to enhance students' interest in learning, so as to improve the learning efficiency of mathematics course. In the process of theoretical knowledge transfer, we should also combine with practice, exercise the practical ability of college students, so as to have professional practical ability in the future work.

The promotion of modern teaching means is an entry point to cultivate mathematics application ability. In the information age, people need to get a lot of information from the complex environment, and extract and create new information. The basic task of mathematics teaching is to cultivate the students' ability to solve practical problems and apply mathematical knowledge analysis to provide them with necessary mathematical knowledge.

With the development and progress of society, the complex practical problems in modern society need to be solved by computer, which puts forward higher requirements for students' mathematical application ability. They need to analyze the problem, find the law, and establish a mathematical model. And we should use the computer to cultivate students' mathematical application ability. The computer can not only store data, demonstrate and calculate, but also lead to the innovation of mathematical concepts and methods. Teachers should use modern teaching methods in the teaching process, and students majoring in mathematics must have the ability to skillfully use computers. The advantages of using these methods are that, on the one hand, the use of computer multimedia technology can enable students to master the means and methods of obtaining information and improve their ability to actively acquire knowledge; on the other hand, it can enlighten students' creative thinking, mobilize students' learning enthusiasm and improve students' ability to apply mathematics.

Modern teaching means can speed up the dissemination of information, improve the quality of information, break through and surpass the traditional mode of thinking, and cause deep changes in teaching methods. With the development of the information age, more and more modern teaching methods are integrated into modern teaching, such as TV video, projector, computer and CAD software, online courses, micro class, MOOC and so on. These modern teaching methods have been used in some courses, and the effect is good, but they have not been widely used in Advanced Algebra courses. At present, most of them are still using traditional teaching methods.

According to the teaching content, in the teaching process of Advanced Algebra course for mathematics majors, we should actively use modern teaching methods such as multimedia and micro class, give full play to the advantages of modern teaching methods such as "bright color", "vivid image", "audio-visual synchronization", and try to design some computer-aided teaching software that students feel



fresh, interesting and helpful to understand knowledge. The abstract knowledge is visualized, which can stimulate students' vision, attract students' attention and arouse students' interest in what they have learned. For example, the definition, theorem, nature, graphics and typical examples can be made into multimedia courseware, which can greatly reduce the blackboard writing, not only can reduce the labor intensity of teachers, but also can save time, so as to increase the amount of information in a class; using dynamic pictures and videos to make abstract concepts concrete and intuitive, for example, in the teaching of Advanced Algebra, using quadratic to simplify the second class. It can be realized directly and efficiently with the help of computer and CAI software, which makes the classroom more rich and three-dimensional. College students in understanding to see more intuitive, comprehensive, in order to stimulate students' interest in learning, so as to more comprehensive understanding of difficult applied mathematics problems, therefore, the development of theoretical knowledge and practical ability are strong all-round talents, in the future employment competition for their own solid backing.

In a word, making full use of modern teaching means not only saves time and effort, but also plays an important role in improving the quality of teaching, and strengthens the cultivation of students' mathematical application ability.

*D. Strengthen the construction of curriculum connotation and promote the cultivation of mathematics application ability*

Strengthen the construction of excellent courses and micro courses, and effectively apply them. In terms of course content, it is required that teaching materials should be combined with practice and applied knowledge should be infiltrated into teaching materials. We should actively explore the comprehensive course teaching with mathematics as the main content and learning activities. Among them, the comprehensiveness of curriculum content is not a simple combination of a single discipline, but a combination of basic knowledge and basic methods of multiple disciplines, based on its essential attributes to show the theory and practice of mathematics discipline and enhance the ability of mathematics application [5].

*E. Application-oriented problems should be infiltrated into the classroom teaching interaction*

In classroom teaching, the organic teaching interaction between teachers and students enables students to understand the classroom content and related knowledge through interaction. In such an active atmosphere, it can promote students to understand the relationship between mathematics and other subjects and daily life, and understand the universality of mathematics application, so as to inspire students' interest in learning and thinking enthusiasm. At the same time, it also enables students to understand the process of the generation, formation and application of mathematical

knowledge, and change their learning methods. In this process, teachers need to introduce application-oriented questions to guide students to discuss and think in a certain period of time. The solution ideas and conclusions obtained through personal discussion and thinking can be used for comparative analysis with teachers' solution ideas and conclusions to find out the wrong key or compare the advantages and disadvantages of problem-solving methods. This can not only exercise the ability of solving applied problems, but also strengthen the ability of individuals to apply the learned knowledge to solving mathematical problems, so as to improve the classroom teaching effect, but also mobilize the enthusiasm of students' learning and thinking in varying degrees. Classroom teaching interaction requires teachers to highlight the theme of classroom teaching content as much as possible in classroom teaching design, and create a good interaction space for students. The introduction of applied problems in knowledge selection, difficulty and logical relationship should be suitable for the understanding and acceptance of the students, which is also the application-oriented problems infiltrating into classroom teaching interaction. Problems that cannot be ignored. Only good application-oriented questions infiltrate into effective classroom interaction can produce good teaching effect.

*F. Strengthen the teaching of exercise class, appropriately supplement the application-oriented and multi-solution oriented questions, and cultivate students' divergent thinking*

"Understand in class, can't do exercises" is a common headache for students in learning Advanced Algebra. Students think that Advanced Algebra is more abstract and there seems to be no rules to follow when solving problems. In fact, it is because of the abstract content, so the method of solving problems is flexible. If you want to learn to "seek the root" and get a problem, you can start from the definition and theorem, which will help to eliminate the suspense and solve the problem.

Aiming at the problem that it is difficult to make a problem, in the exercise teaching, we should consciously choose a problem with multiple solutions when choosing a problem. In the process of explanation, more attention should be paid to clear ideas and methods. Through this question, students can master the knowledge before and after, and learn how to think when encountering similar questions. If they can't do it with common methods, they can adjust their thinking. Even if the teacher is familiar with this topic, it's better to show the idea of seeing this topic for the first time to the students without reservation. Although the teacher will occasionally "jam", and this is exactly the time to make students' thinking sparkle, students often have unexpected surprises, put forward a variety of solutions. Sometimes, students can even put forward a variety of methods to solve problems of medium difficulty.

Some "practical problems" should be properly arranged for



students to think and solve after class. In order to solve this problem, students should not only consult the relevant materials, but also jump out of the theoretical circle, stand in different angles, re-examine the relevant knowledge, and promote them to think more deeply about the horizontal and vertical connection of these knowledge. For example, after the teaching of the chapter "system of linear equations", students can be assigned such a topic as homework: "please use the rank of the system of linear equations to judge the position relationship of two lines in the space, and explain its geometric meaning". Students are required to submit a small report, which will receive unexpected results.

The cultivation of application-oriented talents is the need of the development of the times, and it is also the theme of the basic curriculum construction of mathematics major in Local Application-oriented Universities. It also needs to be explored constantly in practice and repeated practice in order to get true knowledge.

*G. The practice of mathematical problems focuses on the infiltration and application of knowledge*

The reform of mathematics teaching in Colleges and universities advocates updating students' thinking mode through teaching, so that students are diligent in thinking. This requires that teachers should not be limited to the knowledge content of teaching materials, but should choose to be attractive to students and highlight the cross application of knowledge between different disciplines. We should combine mathematics knowledge with real life, design and organize teaching, so that mathematics teaching can keep the organic combination of systematization and application of mathematics knowledge. At the same time, teaching design should be guided by application-oriented problems and inquiry learning as the main way to guide students to obtain the results of problems as much as possible through personal discussion or mutual discussion, which is conducive to students' understanding of the process of mathematical concepts and conclusions. For example, when introducing the positive definite quadratic form and positive definite matrix, it can be connected with the extreme value of multivariate function in mathematical analysis, and when introducing the derivative of determinant, it can be connected with the lobita rule in mathematical analysis, which can stimulate students' interest and curiosity, arouse students' attention, and then guide students to analyze and solve problems by using conditions and related concepts and theorems Question. Through a certain practice of application-oriented problems, not only strengthen students' understanding of basic knowledge, definition, concept, nature and theorem, but also broaden students' vision of mathematical problems, guide students to compare and summarize, and promote students to master the knowledge and related problem-solving methods. After a long period of running in, such knowledge infiltration and application can stimulate students' learning in varying degrees Students' various learning abilities.

*H. Integrating the idea of mathematical modeling into Advanced Algebra Teaching*

Mathematical model is the abstraction and Simulation of practical problems. The establishment of mathematical model requires the induction and abstraction of problems and the full play of people's creative thinking. The process of establishing model is also the process of creation. Integrating the idea of mathematical modeling into the teaching of Advanced Algebra can improve students' mathematical literacy and innovation ability. For example, the least square method can be obtained by using the distance between the linear equations and the vector in Euclidean space to the subspace, and the least square method is an effective and specific method to solve practical problems. Teachers should pay attention to the use of mathematical modeling when explaining.

At the same time of imparting basic theory and basic skills, we should strengthen students' ability in analyzing problems, establishing mathematical models and solving practical problems, so as to meet the requirements of the new century for mathematical talents. For example, to provide students with some application of linear equations, matrices, determinants and other small topics to solve practical problems, so that students get the opportunity to practice mathematics. Through the opening of Advanced Algebra experiment course, it provides a simulation training ground for students to apply algebra methods to solve various practical problems. Students according to their own needs, give full play to creativity, use matlab or maple and other software to do algebra practice, not only learn to master the software function, but also improve the learning efficiency.

Practice has proved that mathematical modeling and its competition is the intermediary and bridge between mathematical science and other non Mathematical Sciences, which plays a positive role in promoting students to engage in scientific research activities within their ability in the learning stage and in cultivating students' mathematical application ability.

*I. Integrating mathematics experiment into Advanced Algebra Teaching*

Although many domestic universities have opened various forms of mathematics experiment courses, the overall level and supporting facilities are relatively backward, which can not meet the growing thirst for knowledge of students. For the education of normal universities, it is not a simple teaching mode, but should cultivate and promote the two-way mode of teachers' guidance and students' self creation, focusing on improving students' comprehensive ability to solve problems rather than the mechanical memory of pure theory. From this point of view, mathematics experiment course has an irreplaceable practical role.

Further strengthen the students' application of mathematical application software, and strengthen the experimental course of mathematical software. Further



strengthen the mastery of MATLAB, mathematics, SRSS, SPSS and other mathematical software, design Advanced Algebra experiment course, and let students form a group to discuss the related problems of mathematical modeling.

The teaching method based on mathematical experiment is not only to teach students the ready-made definitions, theorems and methods intuitively, but also to make full use of modern means and technology, choose different mathematical software according to the characteristics of different courses, make the abstract become intuitionistic through the experiment, and guide students to complete the construction process of mathematical theory independently, and observe it through hands-on operation. Observe, analyze, explore, guess and summarize to experience mathematics, feel and understand mathematics, become the master of mathematics learning activities, let students have independent thinking, problem-solving thinking ability and creative problem-solving hands-on and application ability.

This paper introduces mathematical experiment into the teaching of basic courses of mathematics majors. We must accurately grasp the basic course of the subject, in order to lay the foundation for the future complex professional learning. Even for the future engaged in related geometry teaching work is of great help.

In the teaching of Advanced Algebra, we should increase the use of computational software in mathematics experiment course in accordance with the development of the times. In the experimental class, we don't teach students too many and complicated theories, as long as they can operate in practice. We are not limited to the introduction of MATLAB software. What's more important is to teach students how to use MATLAB software around the teaching content, so that students can experience the convenience and efficiency of using mathematical software. For example, the matrix is closely related to each chapter, and the matrix theory is widely related to the computer. The matrix inversion, eigenvalues and eigenvectors, diagonalization of the matrix and so on, which are more troublesome in the actual calculation, become much simpler after the computer work. With the help of computer, our time is saved. We focus on the introduction of matrix theory and important methods. In this way, students can not only learn theoretical knowledge, but also solve problems with modern educational technology. This is a great progress in our reform.

#### *J. Strengthen the reform of assessment methods*

Pay attention to the process assessment, increase the practical and experimental subjects. This measure can urge mathematics teachers to change the traditional teaching concept of "emphasizing theory and neglecting practice", promote and strengthen the case teaching of practical application of background knowledge, enable students to understand and realize the practical application of basic mathematics knowledge, and improve students' enthusiasm and understanding of learning mathematics.

Advanced Algebra is distributed in the first, second and seventh semesters. It is the most important part in the accumulation of basic mathematical knowledge and the training of basic mathematical ability. The main content of this course is completed in the first two semesters. The 47th semester is the summary of the main ideas, methods and skills of Advanced Algebra, including the analysis of a series of typical problems. There are strict requirements for the homework of Advanced Algebra, and there are strict closed book examinations in the first two semesters. In the seventh semester, under the premise of strict requirements, students are given a certain degree of freedom and the opportunity to play their creative ability. The reform of examination and assessment methods is as follows: the usual homework accounts for 20%; the first part of the final examination (judgment questions and blank filling questions, 40 points) implements the closed book examination, the second part (solving questions and proof questions, 60 points) implements the open book examination, and the final examination paper score accounts for 80% of the total score, which has received very good results.

#### V. CONCLUSION

Ability is an important part of quality. It is also a developing process to cultivate students' application ability and innovation ability in the teaching of Advanced Algebra, a basic course of mathematics. It is a long-term and arduous task for the teaching workers of Advanced Algebra that teachers should constantly practice, carry out teaching reform, and strive to cultivate high-quality mathematical talents to adapt to the times. Teachers should actively explore effective ways to cultivate students' mathematical application ability, and make continuous efforts to cultivate students with good moral character, rich knowledge and excellent skills!

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