

Research on Integrating Mathematical Modeling Ideas into Higher Mathematics Teaching

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Abstract: Advanced mathematics is a fundamental discipline with a lot of theoretical and abstract content, which leads to excessively dull course learning and ineffective improvement of students' comprehensive application abilities. Mathematical modeling is a way of applying mathematical knowledge to other disciplines or fields, which helps to enhance mathematical application abilities, cultivate mathematical ideas and concepts. This article analyzes the role of integrating mathematical modeling ideas into higher mathematics teaching, and based on previous research results, proposes a path for integrating mathematical modeling ideas into higher mathematics teaching: integrating mathematical modeling ideas into teaching resources, integrating mathematical modeling ideas into example explanations, combining mathematical knowledge application with mathematical models, encouraging students to actively participate in mathematical modeling competitions, and applying mathematical modeling ideas to theoretical derivation.

Keywords: Mathematical Modeling; Higher Mathematics; Modeling Process; Function; Path

1. Introduction

Mathematics is a discipline that abstracts from real-life problems, retaining only quantitative relationships and spatial forms in the real world, abandoning everything else. With the establishment and development of mathematical theoretical systems, abstraction has gradually increased. In the higher mathematics section, the level of abstraction has reached a considerable level, and the high level of abstraction has also become a cognitive obstacle for students. Advanced mathematics is a fundamental discipline and a compulsory course for multiple professional disciplines. Advanced mathematics contains a wide range of knowledge points and is highly theoretical, making it difficult to learn. The traditional teaching focuses on mathematical formulas, propositions, mathematical theories, and logical reasoning, and does not pay attention to practical ability training related to mathematical knowledge for students both in class and outside of class. This not only hinders the cultivation of students' interest in learning mathematics, but also leads to a lack of applied knowledge and weak application awareness, ultimately resulting in a lack of practical ability in practice.

In fact, mathematics is closely related to many problems in real life. Many seemingly ordinary details of life can be abstracted into a mathematical problem, and this abstract process is called mathematical modeling. Mathematical modeling is based on practical problems, integrating mathematical modeling ideas and organically integrating practical problems with higher mathematics teaching. It can not only stimulate students' interest in learning, but also inspire them to view the world with mathematical thinking[1]. The National Higher Education Mathematics Curriculum Guidance Committee has proposed to strengthen the cultivation and training of students' ability to establish mathematical models and use computers to analyze and handle practical problems. This requires reforming the traditional teaching model of higher mathematics that emphasizes theory, integrating modeling ideas and methods into teaching, and cultivating students' innovation and application abilities.

2. Fundamentals of Mathematical Modeling

2.1 Mathematical Models and Mathematical Modeling

Compared to prototypes, models refer to a form of expression that explains and explains the research object, divided into concrete models and abstract models. Model thinking is very useful in daily life, especially in the fields of technology and construction. When it is necessary to abstract prototypes and solve problems, model thinking is used. A mathematical model refers to using mathematical language to summarize the research object and mathematical structure based on the essential characteristics of things and the quantitative relationships between things. Mathematical modeling, as a crucial step in mathematical modeling, guides students to use mathematical knowledge to abstract practical problems and solve them using mathematical methods. It is not simply applying mathematical formulas to solve mathematical application problems, but analyzing the possible influencing factors of complex and ever-changing practical problems and creatively transforming existing formulas to obtain models.

Mathematical modeling is a more comprehensive and complete problem-solving process that maps objective objects or problem phenomena from non mathematical domains to the mathematical domain, creatively establishes mathematical models, applies mathematical methods to solve practical problems, and returns to the actual situation to test mathematical solutions and judge the rationality of the model. Mathematical modeling is a way of applying mathematical knowledge to other disciplines or fields, which helps to enhance mathematical application abilities, cultivate mathematical ideas and concepts[2].

Mathematical modeling ability refers to the ability to express real-world problems in mathematical form, solve them mathematically, translate the solution results into real-world results, and verify their effectiveness in the process of mathematical modeling. Mathematical modeling ability can be decomposed into three aspects: first, model assumption ability. It has the ability to analyze and identify the main variables in real life, and make reasonable assumptions about the quantitative relationships between variables. Secondly, the ability to build models. It refers to the ability to use mathematical concepts, formulas, and theorems to describe the relationships between variables and derive mathematical solutions. Thirdly, the ability to verify models. It refers to the ability to evaluate and reflect on results, solutions, and mathematical models in the process of mathematical modeling.

2.2 Mathematical Modeling Process

Establishing mathematical models for practical problems, especially those with high levels of abstraction, is a creative labor. There are various practical problems in the real world, and the methods of mathematical modeling are also diverse. It is not possible to establish mathematical models for various practical problems according to a fixed pattern. However, there are still some commonalities in the methods and processes of establishing mathematical models, and mastering these rules will help to complete mathematical modeling tasks. The typical mathematical modeling process consists of 7 steps, as shown in Figure 1.

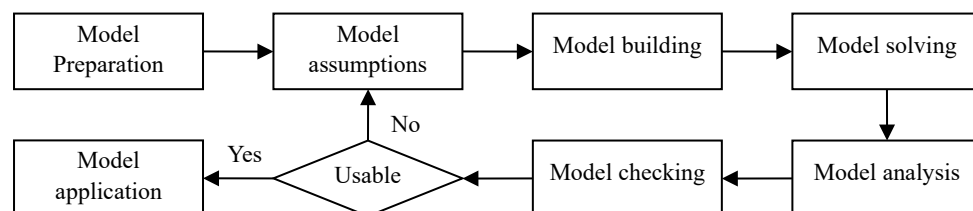


Figure 1: Mathematical modeling process

According to the purpose and requirements of modeling, mathematical analysis is carried out on the numerical results obtained from the model solution, mainly including dependency analysis between variables, stability analysis, sensitivity analysis of system parameters, and error analysis. After the model analysis meets the requirements, it is necessary to go back to the actual problem to verify the model, using actual phenomena and data to test the rationality and applicability of the model, that is, to verify the correctness of the model. If the theoretical values calculated by the model are in good

agreement with the actual values, the model is successful; If the theoretical values differ significantly or partially from the actual values, the model will fail.

3. The Role of Integrating Mathematical Modeling Ideas into Higher Mathematics Teaching

3.1 Stimulate Interest in Learning Advanced Mathematics

The complexity of advanced mathematics knowledge places higher demands on thinking logic and computational abilities, resulting in many students having low interest in learning. Interest is the best teacher, and teachers should be good at stimulating students' interest and guiding them to actively engage in learning activities. Mathematical modeling is a research approach that simulates and extracts from real-life practice. It applies advanced mathematical knowledge in the process of model design and analysis, which is closely related to real-life situations. When guiding students to explore and analyze, it can better stimulate their interest[3]. Modeling and analysis require the use of mathematical software such as Matlab, which imposes certain requirements on students' learning and application abilities, laying a solid foundation for subsequent learning.

3.2 Injecting New Vitality into Higher Mathematics Teaching

Applying mathematical modeling ideas to higher mathematics teaching can effectively improve the problems of traditional teaching methods such as dryness and dullness, inject new vitality into higher mathematics teaching, and enhance teaching efficiency. Teachers develop scientific and reasonable teaching plans based on the actual situation of students learning advanced mathematics, select appropriate practical problems to establish mathematical models, encourage students to think independently, and enable students to deeply understand the true meaning of mathematical models[4]. Teachers focus on cultivating students' interests, stimulating their curiosity, enhancing their initiative and enthusiasm for learning, enabling them to think independently about mathematical problems, and gradually cultivating their ability to establish mathematical models and analyze and solve problems, thereby enhancing their comprehensive literacy.

3.3 Enhance Students' Ability to Solve Practical Problems

Mathematical modeling is a bridge that connects theoretical knowledge with practical problems, and is the prerequisite and foundation for using theoretical knowledge to guide practical activities and solve practical problems. Integrating mathematical modeling ideas into higher mathematics teaching, guiding students to analyze practical problems, discover the mathematical laws contained therein, grasp the essence of the problem, simplify hypotheses, establish relevant mathematical models, and then use tools such as computers to solve the model, and verify the model through practical applications [5]. In teaching, by integrating mathematical modeling ideas and continuously guiding students to independently analyze, consult relevant materials, apply existing knowledge, and provide solutions to practical problems, students can effectively improve their ability to solve practical problems.

3.4 Promoting the Reform and Development of Higher Mathematics Teaching

Advanced mathematics, as a fundamental component of the curriculum system, plays a promoting role in cultivating thinking ability and comprehensive literacy, and has become a key focus of university curriculum construction. The development of science and technology requires more mathematical talents, which has put forward updated and higher requirements for higher mathematics teaching. The traditional higher mathematics curriculum system requires curriculum implementation to pursue theoretical rigor and maintain the independence and integrity of the curriculum[6]. The teaching content mostly stays at the theoretical level, and many students have formed the idea that mathematics has no practical use. By integrating mathematical modeling ideas, mathematics can exist as a tool and change students' understanding of mathematics. Mathematical modeling can promote the reform of higher mathematics teaching and promote the development of higher mathematics teaching.

3.5 Cultivate Students' Computer Application Abilities

For complex practical problems involving many variables, the calculation process is quite complex. It is difficult to obtain the correct answer by relying solely on manual calculation, and it also wastes a

lot of time. Therefore, the mathematical modeling process often uses computers for precise calculation, and a few lines of commands can replace the tedious mathematical calculation process. When students study computer courses, the textbook only provides some programming commands and statements, which is not conducive to cultivating computer programming skills [7]. Mathematical modeling provides students with the opportunity to comprehensively use various commands and learn languages to write programs, improving their programming and model solving abilities.

4. The Path of Integrating Mathematical Modeling Ideas into Higher Mathematics Teaching

4.1 Integrating Mathematical Modeling Ideas into Teaching Resources

Teaching resources refer to the collection of all teaching elements developed and utilized to improve teaching quality and optimize teaching activities, centered around teaching objectives. In the era of big data, teaching resources are showing an explosive growth trend, and the level of educational informatization is constantly improving. Various new forms of teaching resources are constantly emerging. Teachers need to use mathematical modeling as a carrier to integrate relevant teaching resources, so that college students can have a more intuitive and clear understanding of concepts and theorems in higher mathematics, and present abstract knowledge in a concrete and intuitive manner. Fully utilize MOOC, Cloud and Rain Classroom, Mathematical Modeling Network, and multimedia technology to integrate teaching resources and establish a "one-stop" learning mode[8]. Students choose corresponding learning methods according to their own needs, effectively helping them achieve self-directed learning, enabling them to understand advanced mathematical knowledge through their own abilities, and effectively enhancing their enthusiasm for mathematical modeling. In the process of teaching design, interactive, exploratory, autonomous, and experiential methods are adopted to carry out heuristic teaching, stimulate students' desires, strengthen comprehensive abilities, broaden channels for acquiring mathematical knowledge, and achieve mathematical teaching objectives.

4.2 Integrating Mathematical Modeling Ideas into Example Explanation

Example teaching is an important component of mathematics teaching, which is an effective supplement to textbook knowledge. It can enable students to apply their learned mathematical knowledge to solve problems and achieve the goal of consolidating their knowledge. At the same time, example teaching is also an important way for students to learn mathematics, which directly affects the cultivation of mathematical problem-solving ability and mathematical thinking ability. The example problem combines important formulas and classic problem-solving ideas, and students must study the example problem seriously in order to better grasp mathematical knowledge. Applying mathematical modeling ideas to example analysis is the process of combining formulas with practical problems, deepening the understanding of mathematical knowledge, understanding the mathematical principles and knowledge contained in formulas, and improving thinking and logical thinking abilities through problem analysis and in-depth research on problem-solving methods. In addition, application problems in mathematical exercises are also the simplest type of mathematical modeling problems. Although processed and simplified, they are still mathematical problems with practical background and significance. It is necessary to establish a connection between mathematics and practice, provide a platform for applying mathematical knowledge and methods, and provide ideas for practical applications.

4.3 Integrating Mathematical Knowledge Application with Mathematical Models

The application of mathematical knowledge can be to solve practical problems in real life, as well as theoretical or applied problems in the development of mathematics. As long as these problems are easy for students to understand and can be solved using the knowledge they have learned, teachers can combine the learned content, select appropriate problems, guide students to analyze, and enable students to experience the process of establishing models to solve problems, deepening their understanding of mathematical knowledge, Train the ability to apply mathematical knowledge. For example, when learning derivatives, the application of derivatives in economics can be combined. Regarding the knowledge point of "analyzing total returns using demand elasticity", mathematical modeling can achieve twice the result with half the effort [9]. The teacher first raises the question "Can price reduction increase revenue in market competition?" and asks students to analyze the factors that affect revenue, establish a model between revenue and demand elasticity, use the monotonicity of

functions to analyze conclusions, and truly feel the application of mathematical modeling, calculus knowledge to solve economic problems, and abstract mathematical knowledge.

4.4 Encourage Students to Actively Participate in Mathematical Modeling Competitions

Mathematical modeling competitions have long been an important component of mathematics education in China, and are of great significance in promoting mathematics education and enhancing mathematical literacy. The holding of the National Mathematical Modeling Competition not only stimulates students' enthusiasm and interest in learning mathematics, but also improves their mathematical thinking ability and problem-solving ability, cultivates innovative spirit and practical ability, develops comprehensive qualities, and plays an important role in promoting the cultivation of innovative talents. Competition questions generally come from practical problems that have been appropriately simplified and processed in fields such as engineering technology and management science. Participants are not required to master in-depth specialized knowledge in advance, only to have studied advanced mathematics courses. The questions have greater flexibility for participants to unleash their creative abilities. Participants are required to solve practical problems within the specified time and use mathematical methods for modeling and analysis, which not only tests their theoretical knowledge mastery ability, but also requires practical problem-solving ability and innovative thinking. It is necessary to encourage students to actively participate in mathematical modeling competitions, provide more practical opportunities for students, and build a scientific and reasonable platform for mathematical knowledge communication and exchange, so that students can combine theoretical knowledge with practice and effectively improve their mathematical learning abilities.

4.5 Applying Mathematical Modeling Ideas to Theoretical Derivation

Integrating mathematical modeling ideas into theoretical learning can help students improve their understanding of theoretical knowledge, especially theoretical knowledge closely related to practical problems such as limits, differentials, definite integrals, or ordinary differential equations. In the process of theoretical derivation, students need to deeply understand the thinking mode and problem-solving ideas of mathematical modeling in order to ensure the rigor and accuracy of the derivation process. Integrating mathematical modeling ideas into the theoretical derivation process can encourage students to understand other related knowledge points from multiple perspectives, form awareness of analyzing the connections between each knowledge point, and improve their logical and transformational thinking abilities. In addition, to construct a mathematical modeling thinking system and apply mathematical modeling ideas in the theoretical derivation process, it is necessary to effectively integrate various basic theoretical knowledge, design top-level ideas, reform teaching methods, and fully enhance student classroom participation.

5. Conclusions

Integrating mathematical modeling ideas into higher mathematics teaching can not only stimulate students' interest in learning higher mathematics, help them effectively understand the properties and theorems in higher mathematics, but also cultivate their awareness of applying mathematics and improve their ability to solve practical problems. The integration of mathematical modeling ideas into higher mathematics teaching is a gradual process. Teachers need to coordinate and plan the infiltration of mathematical modeling ideas, select models that are similar to the teaching content or related to the profession, and are suitable for students' cognitive foundations. The integration of mathematical modeling ideas into teaching should guide students to think, solve, and verify outside of class. Integrating mathematical modeling ideas into higher mathematics teaching is an effective method for cultivating innovative talents. This is a long-term teaching research work that requires not only further research on teaching content and process, but also continuous exploration from aspects such as curriculum system and teaching form.

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