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Reflections and Practice on the Integration of Applied Undergraduate Mathematical Modeling Thought and Mathematics Teaching

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Abstract: *This article starts with the current development status of mathematics teaching and mathematical modeling in application-oriented undergraduate colleges, analyzes the existing problems, and considers and practices the integration perspective and methods of mathematical modeling and university mathematics teaching, as well as the objectives of mathematical modeling and university mathematics curriculum construction. Specific aspects and measures for the development of curriculum construction are proposed.*

Keywords: *Mathematical Modeling, College Mathematics Teaching, Innovative Practice, Integration, Applied Undergraduate*

1. Current status of applied undergraduate mathematics teaching and mathematical modeling development

Applied undergraduate institutions comply with the high requirements and standards of the country for talent cultivation in higher education institutions, with a focus on cultivating innovative and applied talents at all levels and types. In applied undergraduate programs, the integration of mathematical modeling and basic mathematics teaching is still in the early and middle stages, and there are many unresolved issues. Firstly, there is a conflict between the logical and abstract nature of the subject itself and students' knowledge foundation and learning habits. The knowledge system of university mathematics courses often has high logical difficulty and abstraction, while the basic knowledge of applied undergraduate students is relatively weak and they do not have good learning habits. Taking the second type of line integral I taught in Advanced Mathematics as an example, 68 students were surveyed with questionnaires during the teaching, and the statistics of data related to basic knowledge are shown in Figure 1. From this, it can be seen that about 50% of students have weak basic knowledge, and their forgetting speed and rate of learning content are high. Combined with daily teaching, it can be found that a considerable proportion of students have low interest in learning mathematics courses, poor initiative and consciousness in learning, lack the habit of "reviewing old knowledge to learn new things", and a lack of strong desire for knowledge. Resolving the conflict between the two can achieve better teaching outcomes.

Secondly, the development speed of mathematical modeling in applied undergraduate colleges is relatively slow. Mathematical modeling has a history of about 40 years as a university course in China, but its development history is relatively short in applied undergraduate programs, with a certain lag. Students lack sufficient understanding of mathematical model establishment and application. We randomly selected 140 students from first and second year university students who taught for a questionnaire survey, and found that about 38% of them had no experience with mathematical modeling at all, about 48% of them had heard of mathematical modeling, about 12% of them had superficial knowledge, and only 2% of them had in-depth learning in modeling. Most students who participate in modeling competitions only focus on learning relevant knowledge during the competition period and do not mention it after the competition. Therefore, the construction of mathematical modeling in applied undergraduate colleges still requires a long-term process.[1]

Thirdly, the integration of mathematical modeling and mathematical teaching still lacks comprehensive planning and construction. Many universities have made explorations and research on the integration of mathematics and models in various aspects [2] [3] [4] [5]. In application-oriented undergraduate colleges, mathematics teaching is also constantly exploring how to better integrate models with teaching [6] [7]. However, this process is often relatively scattered and lacks systematic

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planning, and a large number of adjustments and reforms still need to be made based on teaching and training objectives.

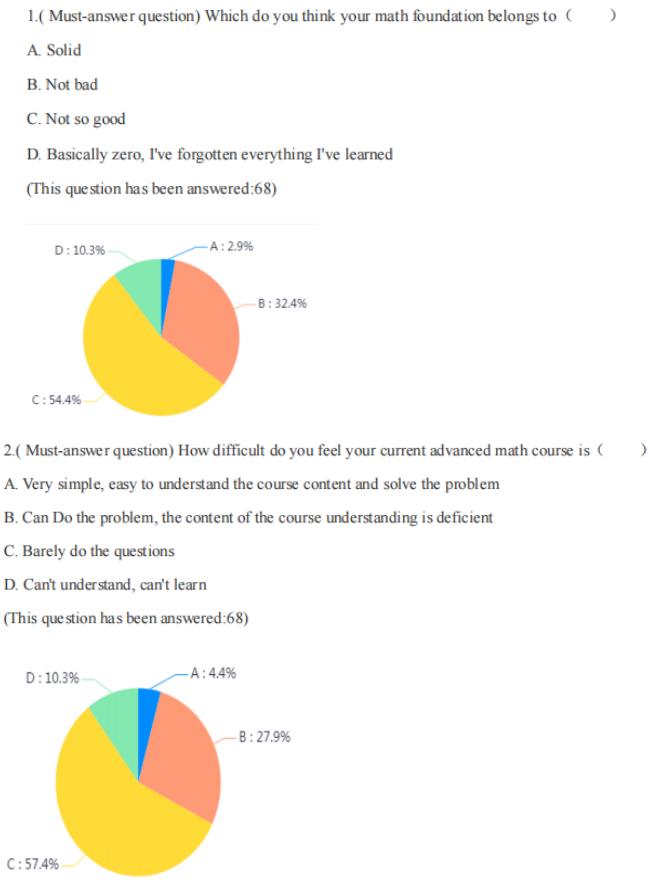

Figure 1: Statistics on Students' Mathematical Foundations

Based on the above cognition, combined with our teaching reform process, we will consider and practice the integration of mathematical modeling ideas and mathematical teaching from the following points.

2. Integration of mathematical modeling and mathematical teaching content

Many concepts and methods of Higher Mathematics, linear algebra and other courses come from practical problems. The integration of teaching content with mathematical modeling must grasp the combination point of curriculum characteristics and practical problems and integrate them reasonably.

In terms of integrating mathematical modeling with the teaching content of "Advanced Mathematics", we focus on two points. The first is to reduce the abstraction of concepts, use vivid and easily understandable examples to make mathematical concepts more intuitive, and reduce students' resistance to mathematics, in order to promote students' restoration of learning interest and confidence. For example, we combine the concept of "limit" with finding the area of a curved triangle to give students an intuitive impression of "limit" and help them understand its meaning; By combining the concept of "derivative" with the calculation of instantaneous velocity in variable speed linear motion, students can understand that "derivative" is actually the "rate of change", and combine it with the tangent slope of the curve to give "derivative" a geometric interpretation. The second is to pay attention to practical applications, such as the Taylor formula that students find difficult to understand, which actually provides a polynomial structure for approximate calculations. To deepen my understanding, I will briefly introduce a Bernstein polynomial that is similar to Taylor's formula during my teaching:

$$B_n(f;x)=\sum_{v=0}^{n} f(\tfrac{v}{n})B_{v,n}(x)=\sum_{v=0}^{n} f(\tfrac{v}{n})C_n^v x^v(1-x)^{n-v}$$

And demonstrate to students the polynomial obtained by replacing the independent variable x with

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a continuous polyline $h(x)$

$$B_n(f;h(x))=\sum_{v=0}^{n} f(\tfrac{v}{n})C_n^v h^v(x)[1-h(x)]^{n-v}$$

The renderings used for surface design [8] make the Taylor formula vivid and improve students' acceptance of it.

Linear algebra has a high degree of abstraction, but it has many applications. Therefore, when combining with models, we should not only fit the course content, but also pay attention to the relationship with the real background. For example, when introducing the basic matrix operation, we simplified the background of a large area of frost disaster in southern China in a certain year into a model, explained the matrix addition and subtraction, matrix multiplication and other operations through the calculation of the amount of materials distributed to three different cities and their costs, and reasonably explained the reasons and methods for the matrix operation. For another example, in the part of explaining the quadratic form, the quadratic form transformation standard form is associated with the quadratic surface in Advanced Mathematics to enrich the content and application of students.

3. Methods and methods of integrating mathematical modeling with mathematics curriculum teaching

3.1. Based on mathematics classroom teaching, pay attention to the introduction and analysis of mathematical models in daily teaching, and guide in-depth learning after class

Classroom teaching is the best battlefield for the integration of mathematical modeling ideas and mathematical teaching. After years of teaching practice, combined with the development and changes of students' learning ability, acceptance ability, and learning needs, we have gradually explored the teaching method of weakening theoretical deduction and "introducing by example, leading by example" in the teaching process. Introduce concepts through interesting mathematical examples, then set questions around examples to stimulate students' interest in learning, and gradually teach solving methods layer by layer; we should pay attention to the relevant points emerging in the facts, such as the relevant verification results and inference results of the vaccine effect introduced in the teaching of relevant courses during the COVID-19 epidemic, endow the model with vitality, and enhance students' interest and ability to relate to reality.

In order to achieve better teaching results, we gradually implement methods such as setting up post class Q&A, distributing questions that match the teaching progress and have a certain degree of improvement, and proposing analysis and discussion of mathematical models related to the course content, based on classroom teaching, in order to promote students to think more, think more, and practice more.

3.2. Promoting the integration of mathematical modeling and teaching with job search and academic examination as attraction and competition as motivation

From the perspective of the characteristics of application-oriented undergraduate students, for most students, relying solely on course learning objectives to drive students to complete mathematics courses is far from enough. When students realize that the charm of mathematical modeling is not only about expanding their horizons and improving their abilities, but also that awards in modeling competitions are an important stepping stone for exams or job hunting, they will start with their own academic planning, independently understand and learn modeling knowledge, and actively participate in the learning of mathematical modeling and various competitions. The process of participating in mathematical modeling competitions is also a process that quickly promotes students' in-depth learning and application. For example, in the 2013 National Mathematical Modeling Competition titled "The Impact of Lane Occupation on Urban Road Capacity", our award-winning team used a multiple linear regression model to fit equations for variables such as vehicle queue length, actual traffic capacity of accident cross-section, and accident duration in their answers, fully integrated learning with application. This process makes students aware of the importance of mathematical models and mathematical learning to greatly enhance their motivation and enthusiasm for subsequent learning.

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3.3. Configuring online self-learning materials to enhance offline teaching effectiveness and enhance students' comprehensive abilities

Due to the limitations of teaching time and content in the course teaching process, it is difficult to achieve the learning goals of students with different needs solely through classroom teaching. Therefore, we use online resource models to provide ideological and cultural, problem-solving, and example solving materials for course learning through courseware or micro videos, enabling students to supplement their learning anytime and anywhere. We should record online modeling courses and module learning videos, provide excellent modeling materials with online resources, and help students systematically learn mathematical modeling knowledge, in order to enrich their knowledge system, and improve their mathematical application ability and comprehensive quality.

4. The construction goal of integrating mathematical modeling ideas with university mathematics curriculum teaching

4.1. Strengthening the construction of high-quality mathematics courses and mathematical modeling courses, so that mathematical modeling and university mathematics teaching can be mutually supportive, and enhance students' theoretical and practical abilities

In application-oriented undergraduate colleges, to achieve better integrated teaching effect, on the one hand, for various courses such as Advanced Mathematics and linear algebra, we should adjust the teaching and construction objectives of the courses according to the specific situation of students, strengthen the cooperation between online and offline teaching, and create high-quality mathematical courses suitable for students. On the other hand, it is also necessary to continue to do a good job in the construction of mathematical modeling courses, gradually establish and improve mathematical modeling courses by offering offline general courses, in oder to provide practical environments such as laboratories, conducting modeling competition sandonline learning materials. These two aspects complement each other in order to create more learning opportunities for students, so that they can not only consolidate their foundation but also effectively improve their application abilities.

4.2. Strengthening the construction of teaching staff and mathematical modeling team

The construction and development of university mathematics courses not only need to focus on course content and teaching, but also need to build a matched teaching team. We adhere to the principle of "leading the new with the old, and developing together", gradually cultivating an excellent teaching team from various aspects such as teaching professional ability, scientific research ability, and innovative practical ability, as a strong support for the long-term development of the curriculum.

At the same time, it is necessary to cultivate and build a tiered team of mathematical modeling students. From the beginning of student enrollment, students are guided to establish and solve mathematical models through the combination of mathematical models and courses such as "Advanced Mathematics". By promoting mathematical modeling competitions and offering general courses, students can understand and master the basic knowledge and framework of mathematical modeling. By sharing the experience of participating in mathematical modeling with senior students, we can lead new students to participate in mathematical modeling learning and practice, cultivate teamwork spirit and organizational coordination ability, and stimulate students' enthusiasm for participating in the competition. Finally, we can encourage and organize students to form teams to participate in various mathematical modeling competitions, and enhance students' innovative and practical abilities and literacy through teamwork and competition as a tool.

5. Conclusion

In the teaching and construction of mathematics courses in application-oriented undergraduate colleges, reform and innovation are the fundamental driving force for the development of curriculum construction. Starting from the goal of talent cultivation, the integration and development of mathematical modeling methods and mathematics course teaching can better consolidate students' theoretical knowledge, improve their quality, and cultivate comprehensive talents with comprehensive knowledge, innovative spirit, and practical ability that meet the needs of national development.

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