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The Construction of a Mathematical Modeling Curriculum System Oriented by New Engineering Talents

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Abstract: This article provides an overview of the research progress on mathematical modeling courses both domestically and internationally, and points out the main problems that currently exist. Propose to no longer include competition results in the evaluation criteria, and establish its own training model based on the actual situation of the school. With the assistance of teachers, establish cross disciplinary projects. Teach students to apply knowledge to new problems, allowing more students to achieve more lasting results. The role and significance of research projects in promoting teaching work and improving teaching quality, and the specific research objects and contents. The main research subjects are students from most majors in science and engineering at our university. The main value lies in the exploration and practical work done in the field of new engineering education to cultivate students' mathematical literacy and numerical calculation ability.

Keywords: Mathematical Modeling Courses; New Engineering Disciplines; Interdisciplinary Teamwork.

1. Introduction

After over 30 years of development, nearly all higher education institutions have introduced various forms of mathematical modeling courses, paving an effective path for cultivating students' abilities to analyze and solve practical problems using mathematical methods. Activities such as mathematical modeling, mathematical experiments, and the organization of mathematical modeling competitions have established a bridge connecting mathematics with the external world, significantly enhancing students' mathematical literacy and ability to apply mathematics. This represents a successful attempt to reform the mathematics teaching system and content [1,2].

Mathematical modeling has breathed new life into the quality education of mathematics. However, it poses significant challenges due to the extensive and profound scope of the teaching content. This covers various disciplines ranging from traditional fields like mechanics and physics to chemistry, biology, economics, finance, information technology, materials science, environmental studies, energy, high-tech, and even social fields [3-6]. The abilities in mathematical analysis, calculation, information retrieval, and writing models must be well-coordinated among all stakeholders. The advantage lies in cultivating students' comprehensive abilities. Nevertheless, the depth and breadth of the content prove too challenging for some ordinary undergraduate students. The ever-changing and diverse forms of models lead to fluctuating performance in major competitions, causing students to feel discouraged and lack motivation.

2. Specific Implementation Plan

2.1. Relative Breadth and Depth in Content

Our current situation is that, aside from a very small number of students, most students lack the interest and patience to complete successive comprehensive model trainings. At the beginning of the school year, there are only a hundred students attending classes, leaving less than half of them in the mid-term stage, and less than a quarter in the final stage. The students who take elective courses in mathematical modeling at our school mainly come from five major categories: physics and communication, mechanical engineering, computer science, and mathematics. Therefore, the reform of our curriculum system only needs to have relative breadth and depth in content. If the topic selection is too broad, students will give up when faced with difficulties. If the model leans towards basics and is relatively simple, then although students can easily get started, the fragmented knowledge they learn cannot be systematized. Most of our examples come from modeling cases in previous years, but they should be consistent with some of the professional backgrounds in the above categories, so that students have a familiar impression of the model, rather than being confused at the beginning and losing confidence in modeling. With models that have a certain degree of relative breadth and depth, we aim to cultivate their mathematical analysis ability, computational ability, as well as their ability to search for materials and write scientific papers, creating a good learning atmosphere.

2.2. Interdisciplinary and Integrated Characteristic Courses are Offered

If the orientation of new engineering talents is shifting from a focus on single-subject knowledge to interdisciplinary teamwork [3,4], our modeling serves as a bridge. Through scientific training in modeling cases, we aim to strengthen their foundations while teaching them how to integrate multidisciplinary knowledge to tackle successive challenging problems, thereby building their confidence. This enables them to face new challenges fearlessly. Upon the completion of the course, we offer distinctive interdisciplinary courses, collaboratively developed across colleges and universities, emphasizing the cultivation of innovative practical abilities. Our ongoing guidance and mentorship in modeling literacy is

not only our duty but also a reflection of our value. Competition results will no longer be a factor in our evaluation criteria.

acknowledgment section. Note that the acknowledgment section is placed at the end of the paper before the reference section.

3. Significance of This Research Project in Teaching Quality

Focusing on the science and engineering disciplines at our university, we aim to explore a new educational model suitable for teaching mathematical modeling. By integrating professional backgrounds, we aim to enhance students' interest in learning. Interdisciplinary teams are trained to collaborate, and through scientific training in case modeling, students strengthen their foundations while mastering the integration of multidisciplinary knowledge to solve successive problems. This training equips them with the ability to scientifically analyze and calculate problems, fostering the motivation to think independently in their respective professional fields, ultimately empowering future engineers with both ability and confidence.

Upon course completion, we offer interdisciplinary and integrated courses [6,7], collaboratively developed by multiple colleges, emphasizing the cultivation of innovative practical abilities. We establish long-term student-centered collaborations, guiding engineering students from our university's three departments in their engineering training, mathematical modeling, and numerical calculations involved in graduation projects. We encourage Mathematics Department students to actively participate in engineering competitions and training, applying mathematical knowledge and methods to practical engineering problems, broadening their horizons, providing resources for selecting graduation thesis materials, and enhancing the quality of graduation theses.

This research aims to explore and establish a teaching system for the course of "Mathematical Modeling", providing a valuable reference for the teaching reform of other mathematical courses, particularly for the construction of the data science discipline that our department is currently planning. The data science major necessitates that our science teachers expand towards the direction of engineering training.

4. Specific Research Subjects and Content

Research subjects: Most science and engineering students at Jianghan University. Research content: We primarily focus on reforming the following three aspects:

4.1. The Teaching Content Should Possess Relative Breadth and Depth

There is a problem model about reasonable pricing in the real estate market. A student from East China Normal University said that in order to solve the pricing problem in the real estate market, the three of them worked together and almost ran through half of the real estate agencies in Shanghai. This experience will be unforgettable for them for a lifetime. If our students come from majors such as management and economics at our school, this is a good example for us. Our students can also learn from their methods and travel to real estate agencies throughout Wuhan to collect information, analyze and model. But almost all of our students come from the three colleges of Mathematics and Computer Science, Physics and Communication, and Mechanical Engineering, so this type of model is not very helpful to us. Our teaching content should focus on models in engineering applications.

The static analysis of mooring systems is a typical mechanical engineering problem, which utilizes the principles of force balance and moment balance in engineering mechanics to establish a catenary model and solve it using optimization methods[7,8]. Examining their knowledge of mechanics reflects the breadth of modeling. Mathematics and computer science students may not be able to start at the beginning stage, but they can understand through the teacher's analysis. Computer science students are also strong in programming and solving problems during the calculation stage. Mathematics students actively participate and learn to understand engineering problems, allowing them to see how to apply mathematical knowledge to solve engineering problems, and even try to model on their own. Our model is not proficient in every major, but at least some students are familiar with it. Even if other students don't understand, they can discuss it in this team. If they are willing to learn, they can eventually understand it. If the scope of the model is too narrow, it is not conducive to opening up their horizons and unleashing their creativity. Therefore, it is appropriate to choose a model with relative breadth.

Any problem involving the rate of change can be modeled using corresponding differential equations, so explaining such models is an important content[9]. We will start with predicting population growth, from exponential growth models to logistic models, to explain the problem clearly. Then we will talk about the "SARS transmission" virus model, emphasizing the analytical ability of the model. We will choose from simple univariate differential equation models to complex multivariate differential equation system models, fully reflecting the analytical ability of the problem. The use of visualization drawing skills is the content that this model should master. There is also a prediction model for China's population growth in the 2007 National Games, focusing on such factors as regionality and population structure. Therefore, a population migration model is established, corresponding to an algebraic iteration model. If we only talk about the model for predicting population growth, then we can only talk about fragmented knowledge in class. Only by explaining the multivariate equation system model can students' thinking be opened up. In the evolution of time, comprehensive analysis of multiple factors such as healthy population, infected individuals, etc. The mechanism of the model is not complicated, and the difficulty lies in patient and meticulous analysis; Algebraic iterative models test their ability to analyze various important factors that determine population, such as the ratio of urban and rural population, gender ratio, and the structure of different age groups. The above are all models related to population forecasting, but the perspective of analyzing the problem is different, resulting in different types of models. This is exactly the depth that students need to achieve in modeling.

Each discipline has its own depth and breadth, and there are many optimization methods. When using software, basic knowledge is essential, but only simple programming skills are enough. Depth is not enough. After learning the principles of gradient descent, genetic algorithm, or swarm ant algorithm for 2 hours, computer students can be responsible for writing algorithm programs, and then each student can use

the software package to test and apply the optimization calculations used in previous models. The BP network in artificial neural networks is widely used for predictive analysis and has not been used in modeling competitions in recent years. However, in the era of artificial intelligence, algorithms are crucial, and the design of BP networks is based on optimization principles, which can be seen as a specific application of the previous optimization method.

We use case studies to teach and integrate them, which is exactly the breadth and depth of our content requirements.

4.2. Effectively Communication and Expression in Teaching Methods

Due to the fact that the teaching content we have chosen is not too difficult, and our teachers are also experienced teachers who have been trained in the modeling team, it is not difficult to give a good class. Therefore, our teaching focus should be on analyzing different problems, with a particular emphasis on mathematical models, to stimulate their interest in learning mathematical knowledge. In terms of teaching methods, we should avoid the accumulation of fragmented knowledge and consistently incorporate analytical and computational skills, as well as the ability to write scientific papers, into our training objectives.

The teaching process generally involves guiding students to analyze and discuss problems in class, jointly building models, explaining algorithm principles, having a group with strong programming skills guide the whole class to write programs, and finally calculating the results. Finally, each person in the class will write a small paper on this stage of the course.

In teaching, the dissemination of single knowledge should be changed, because engineering problems are often not solved alone, they require teamwork. Effective communication with students, allowing them to express their ideas, becomes crucial for building an excellent team. Establish an equal and easy-going atmosphere with students during class, encourage them to bring mathematical and computational problems in their field to the classroom, even a high math problem, and let them discuss with each other until the problem is solved. Through these activities, students will learn how to get along with others, collaborate as a team, receive assistance from both male and female students, communicate across different majors, and integrate their thoughts.

Although we will learn a lot of knowledge in the classroom, we will encounter many new things we have never seen before in our future studies and work. Learning how to learn, lifelong learning, and always maintaining curiosity are the most fundamental. Can our course really help them like this? As long as we persist, we can gradually achieve good results through subtle influence.

4.3. Emphases on the Continuity of the Curriculum

Although our courses are short-term, as long as we teach them the ability to learn, with the help of the Internet, we can use MOOC and other high-quality course resources for future study and work.

Each discipline has its own comprehensive project topic, as well as various competitions in its own major. There is a large amount of mathematical knowledge to be used in between, and both teachers and students in our mathematics department can participate. There is also interdisciplinary cooperation in the graduation project of senior students. Our applied mathematics students can fully participate in various majors and write high-level articles. In the stage of course development, we emphasize the cultivation of learning ability, and the types of models are inevitably designed relatively few, which can be fully expanded at this stage.

5. Characteristics, Innovation, and Promotional Application Value of This Project

5.1. Features:

Based on the actual situation of our school, establish our own training model and, with the assistance of teachers, establish interdisciplinary projects. Teach students to apply knowledge to new problems, allowing more students to achieve more lasting results.

5.2. Innovation Point:

Has relative depth and breadth in teaching content; Enable students to not give up due to difficulty, broaden their horizons with moderate difficulty, and stimulate their interest in learning. In terms of teaching methods, we truly integrate theoretical knowledge of mathematics with scientific computing, and consistently incorporate analytical and computational skills, as well as the ability to write scientific papers, into our training objectives.

5.3. Application Value and Promotion:

The main research subjects are students from most majors in science and engineering at our university. The main value lies in the exploration and practical work done in the field of new engineering education to cultivate students' mathematical literacy and numerical calculation ability.

6. Conclusion

The characteristics of this project are in the context of the new engineering field, and based on the requirements of the new era for the professional practice ability of college students, it explores the role of subject competitions in cultivating the professional practice ability of engineering students in our university and promoting the professional practice teaching of teachers.

We have utilized and relied on Jianghan University to carry out teaching practice in cultivating the professional practical abilities of college students.

Gradually achieving good results, significant achievements have been made in cultivating students' professional practical abilities, which can provide reference, innovation, and promotion value for practical teaching in related majors.

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