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Advanced Talent Training Mode with Mathematical Modeling Competition as the Starting Point Research and Practice

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Abstract: Under the current social development background with innovation as the core, mathematical modeling, as an important means of interdisciplinary application, has gradually become an important starting point for cultivating innovative and applied talents in higher education. This paper discusses the theoretical basis, implementation path and practical effect of building an advanced talent training mode based on mathematical modeling competition. By integrating mathematical modeling competition into the teaching system, colleges and universities can effectively improve students comprehensive quality, especially their problem solving ability, innovative thinking and teamwork ability. Through case analysis, this paper verifies the positive role of this training mode in improving students practical ability and academic level, and puts forward the direction and suggestions for further improvement.

Keywords: Mathematical Modeling Competition; Talent Cultivation; Advanced Teaching; Innovation Ability; Practical Teaching

1. Introduction

1.1 Research Background and Significance

As a widely recognized platform for cultivating students innovative ability at home and abroad, mathematical modeling competition is not only an extension of the application of mathematics, but also an important means to cultivate students comprehensive ability. With the rapid development of global economy and technology, the societys requirements for college graduates have gradually shifted from traditional subject knowledge to more extensive interdisciplinary application ability and innovative thinking. As a quantitative analysis method based on real problems, mathematical modeling can effectively exercise students logical thinking, problem solving ability and team spirit. Therefore, taking mathematical modeling competition as the starting point to build an advanced talent training mode not only meets the needs of higher education reform, but also provides an important way for the country to cultivate innovative and compound talents.

1.2 Research Purpose and Question Proposal

The purpose of this paper is to analyze the role of mathematical modeling competition in talent cultivation, explore its integration path with the curriculum system of colleges and universities, and build a set of advanced talent cultivation mode that meets the needs of students at different levels. The main issues studied include:
(1) How to effectively integrate mathematical modeling competition into the teaching system of colleges and universities?
(2) How does the advanced talent training mode improve students innovative ability and practical ability?
(3) What are the challenges and solutions faced by this model in actual implementation?

2. Theoretical Basis

2.1 The Educational Value of the Mathematical Modeling Competition

The mathematical modeling competition drives students learning through real problems, requiring students to use mathematical tools and programming means to solve complex practical problems. This process not only enhances students ability to understand and apply theoretical knowledge, but also cultivates their teamwork, innovative thinking and interdisciplinary comprehensive quality[1]. Research shows that students participating in the mathematical modeling competition are more competitive in the graduation job market because they gain practical experience in

handling complex problems and solving practical problems during the competition.

2.2 Theoretical Basis of Advanced Talent Training Mode

The advanced teaching mode emphasizes the cultivation of students ability in stages, and designs learning tasks suitable for their development according to their cognitive level and learning ability. This model is suitable for students with different learning levels, and can improve students academic level and comprehensive quality through gradual promotion[2]. As a practical teaching tool, mathematical modeling competition is very suitable for the application of advanced talent training mode. Students can gradually improve their modeling skills and innovation skills, from entry to advanced competition tasks.

2.3 Theoretical Basis for the Cultivation of Practical Ability and Innovation Ability

Practical ability and innovative ability are the important goals of talent cultivation in modern higher education. Practical ability refers to students ability to use knowledge to solve problems in specific situations, while innovative ability refers to the ability to find problems and put forward novel solutions in practice. The process of the Mathematical Modeling Competition is precisely the ideal platform to develop both competencies, as students need to apply abstract mathematical knowledge to concrete problems and constantly innovate in the process[3].

3. Construction of Advanced Talent Training Model

3.1 Training Objectives

The advanced talent training mode with mathematical modeling competition as the core aims to help students obtain corresponding ability improvement at different stages through gradual teaching and practical training processes, and finally have the comprehensive quality to deal with complex practical problems. The model can be divided into basic level, advanced level and advanced level. The training objectives of each level are aimed at students different development stages, corresponding to specific skills and ability requirements.

3.3.1 Basic Level: Cultivate Students Solid Mathematical Foundation and Modeling Thinking Mathematical Foundation

The core of mathematical modeling is the application of mathematical knowledge. Therefore, in this stage of teaching, it is necessary to ensure that students master the basic mathematical knowledge, such as linear algebra, calculus, probability theory and statistics. This knowledge is not only a basic tool for students to solve modeling problems, but also a basis for complex computation and derivation in subsequent strata. Through the solid mathematical foundation training, students can better understand the theoretical model and methodology in mathematical modeling[4].

Modeling thinking: Mathematical modeling is not only the accumulation of mathematical knowledge, but also emphasizes the thinking process of applying theoretical knowledge to solving practical problems. At the basic level, students need to learn how to abstract mathematical models from real problems, and transform complex problems into computable and analytic mathematical models through simplification, hypothesis and other steps. This process requires students to have a preliminary modeling thinking, that is, how to identify objects that can be modeled from practice and select appropriate mathematical tools for expression.

Programming and computing tools: Modern mathematical modeling is inseparable from the support of computer tools. Students need to master basic programming languages (such as Python, MATLAB) and the use of modeling software, and be able to achieve data processing, model processing and result analysis by writing simple programs. Through an initial mastery of computational tools, students can lay a solid foundation for subsequent modeling practice[5].

3.3.2 Into the Class: to Improve Students Interdisciplinary Knowledge Integration Ability and Innovation Ability

Interdisciplinary knowledge integration: Modern mathematical modeling problems often involve the knowledge of multiple disciplines. For example, in financial modeling, students need to not only master mathematical knowledge, but also have the relevant background in economics and statistics; in biomedical modeling, they need to integrate biological and medical knowledge. Therefore, the hierarchical learning should pay attention to the integration ability of interdisciplinary knowledge, and help students to use the knowledge of different disciplines to

solve complex modeling problems. In this process, students need to have an open learning attitude and strong interdisciplinary understanding ability, and be able to expand the depth and breadth of problem solving through interdisciplinary intersection.

Improvement of complex problem solving ability: At this stage, the problems faced by students will be more complex and challenging. Students need to be able to identify and understand complex real-world problems, build more elaborate mathematical models, and derive scientific solutions through reasonable assumptions, simplification and optimization processes. This process requires students to be able to flexibly apply what they have learned and constantly iterate and optimize models in practical problems[6].

Cultivation of innovative thinking: Innovative ability is the core competitiveness in mathematical modeling competition. In the advanced stage, students should not only be able to use existing mathematical tools to solve problems, but also have innovative thinking and be able to propose new models or improve existing solutions according to the actual needs of problems[7]. The cultivation of innovative thinking needs a lot of practice and exploration, so that students dare to break through the traditional thinking framework and try new methods and ideas.

3.3.3 High-level level: cultivate students scientific research thinking and ability to solve complex practical problems

At the advanced level, the training goal focuses on senior students or students with modeling experience, aiming to help them have scientific research thinking and the ability to solve complex practical problems[8]. The goal of this stage is to provide students with higher-level academic research and practice opportunities, and further enhance their competitiveness in academic and practical applications.

Improvement of scientific research thinking: Scientific research thinking is the focus of high-level training. Students need to have a complete scientific research thinking process of finding problems, putting forward hypotheses, designing experiments and verifying hypotheses. As a research tool, mathematical modeling can help students build models, analyze data and draw conclusions in the process of scientific research. Therefore, students should not only have the ability to use existing models in the advanced stage, but also be able to put forward new mathematical models and theories through innovative research to promote the progress of the discipline.

Systematic solving ability of complex problems: High-level problems are often more complex, requiring students to propose effective solutions in complex situations such as uncertainty and nonlinear systems. The modeling tasks at this stage may involve difficult content such as large-scale data processing and nonlinear optimization. Students need to master high-order mathematical tools and optimization algorithms, and conduct big data analysis and simulation through advanced programming skills. At the same time, students also need to learn to maintain scientific rigor and put forward feasible solutions under various uncertain factors[9].

Improving the competitiveness of academic research and innovative application: High-order training objectives not only focus on the application of mathematical modeling in academic research, but also include its practical operation ability in innovative application. Students need to be able to apply their academic research results to practical problems and improve their competitiveness in enterprises and scientific research institutions. This not only requires students to have a strong practical operation ability, but also need to have a high sense of innovation, to be able to constantly explore new technologies and methods in practice[10].

3.2 Culture Path Design

The advanced talent training mode with mathematical modeling competition as the core is gradually implemented in stages to cultivate students modeling ability, interdisciplinary knowledge integration ability and innovation ability. The path of talent training is divided into entry stage, promotion stage and deepening stage. Each stage provides corresponding learning content and practical requirements for students at different learning levels[11].

3.2.1 Entry stage

For junior students or new to mathematical modeling students, the main task of the entry stage is to lay a solid mathematical foundation, develop modeling thinking, and be familiar with basic programming tools and modeling methods. The specific culture path design of this stage includes the following aspects:

Learning of basic mathematics knowledge:

students need to master the basic knowledge of mathematical modeling, such as linear algebra, calculus, probability and statistics and other subjects. Through this knowledge, students can understand the mathematical tools commonly used in modeling and the theoretical logic behind it. Schools can open "Introduction to mathematical modeling" courses or "applied mathematics foundation" courses to lay a solid foundation for students in mathematics.

Preliminary cultivation of modeling thinking: In the entry stage, we should also pay attention to the inspiration of modeling thinking, and help students to master how to abstract practical problems into mathematical models, and solve them through mathematical tools. The school can introduce the basic process of modeling and the common modeling types and practical cases, so as to help students understand the practical application of modeling.

Learning of programming tools: Modern mathematical modeling is inseparable from the support of programming tools, so students need to learn basic programming languages (such as Python, MATLAB) and related computing tools at this stage. Programming capabilities will help students process data, build models and conduct simulations. Schools can guide students to learn programming skills through courses such as Python Programming Foundation and Introduction to MATLAB.

Practical application cases: In order to enhance the practicality of learning, schools should introduce some simple practical cases, and let students apply their learned mathematical knowledge and programming skills to solve real problems. For example, design some small problems in life, students solve through modeling and computing tools, and then develop their practical ability and practical interest.

3.2.2 Promotion stage

The promotion stage is mainly aimed at middle and senior students, aiming to further improve students modeling ability and innovative thinking through more complex modeling tasks and the integration of interdisciplinary knowledge. Students will conduct deep learning by participating in mathematical modeling competitions in and out of school, project practices, and more complex case analysis. The culture path design at this stage includes the following contents:

Modeling enhancement: In the improvement stage, students need to use more practical projects or competitions, using more complex mathematical tools and modeling methods to solve practical problems. For example, students may encounter more challenging problems such as optimization models, stochastic models, and prediction models. The school can improve the students practical ability by organizing the school mathematical modeling competition and simulating the real competition environment.

Interdisciplinary knowledge integration: As the complexity of problems increases, students need to learn how to integrate knowledge from multiple disciplines to solve problems. For example, to solve an economic modeling problem, students not only need mathematical knowledge, but also need to apply economic principles; Processing an ecosystem model may also require basic knowledge of biology and environmental science. Schools can help students understand the modeling needs in different fields by offering the courses of Interdisciplinary Modeling and Applied Modeling, and guide students to apply the knowledge of different disciplines to modeling.

Cultivation of innovative ability: The promotion stage is not only the strengthening of knowledge and skills, but also the key cultivation period of students innovative ability. At this stage, students need to continuously optimize the scheme in modeling and put forward innovative solutions. For example, for the traditional model of a certain problem, students need to explore how to simplify, optimize or propose more efficient algorithmic solutions. Schools can guide students to put forward innovative schemes and conduct experimental verification through project-driven teaching (PBL) and case analysis[12].

Practical problem modeling practice: At this stage, schools should provide more real case and project practice opportunities to ensure that students can apply what they have learned to practical problems. By simulating real-world problems in a business or society, students will be guided to complete modeling tasks. Such practical projects can not only improve students ability to solve practical problems, but also cultivate their team spirit and project management ability.

3.2.3 Deepening stage

The deepening stage is mainly aimed at senior students or students with rich experience in the field of mathematical modeling, aiming at further improving their scientific research ability

and comprehensive ability to solve complex problems. Students enter the top level of academic research fields or industry applications by participating in high-level competitions, scientific research projects or academic paper writing. The cultivation pathway at this stage includes:

High Level Mathematical Modeling Competitions: By participating in national or international level mathematical modeling competitions such as National College Student Mathematical Modeling Competition (CUMCM), American Mathematical Modeling Competition (MCM/ICM), and others, students will be challenged at a higher level in the context of complex practical problems. This kind of competition requires students to have strong comprehensive qualities, including profound theoretical foundation, skilled modeling skills, innovative thinking and excellent teamwork ability. The school can provide systematic competition training for these outstanding students, and provide full guidance in the competition.

Participation in scientific research projects: In the deepening stage, schools should encourage students to participate in various scientific research projects, especially interdisciplinary scientific research projects, to help them further exercise their ability to solve practical problems in the research process. By collaborating with mentors or participating in corporate projects, students are able to get exposed to the most cutting-edge technologies and theories and apply them to real-world scenarios. For example, by participating in scientific research projects in the fields of intelligent manufacturing, artificial intelligence, financial risk prediction, etc., students will have the opportunity to complete the whole process from model design to application under the guidance of their tutors.

Writing and publishing academic papers: The improvement of academic ability is also an important part of the deepening stage. Through the experience accumulated in scientific research projects, students can organize their research results into academic papers and try to publish them in academic journals. Writing academic papers can not only improve students writing and expression ability, but also further exercise their logical thinking and academic accomplishment.

Specialized academic resources and tutor support: In the deepening stage, the school should provide students with rich academic resources and personalized tutor support, including one-on-one scientific research guidance, professional modeling resource library, laboratory equipment, etc. These supports will help students study complex problems in depth and enhance their competitiveness in academic and practical fields.

3.3 Integration of Resources Inside and Outside the School

When implementing the advanced training mode, schools should integrate resources inside and outside the school and establish diversified support platforms. Specific measures include: when implementing the advanced talent training mode with mathematical modeling competition as the core, the school not only needs to rely on the existing teaching resources, but also needs to integrate all kinds of high-quality resources inside and outside the school to provide students with diversified learning and practice platforms. This process can not only provide students with more practical opportunities, but also help them establish a broader academic and professional horizon. Through the reasonable integration of resources inside and outside the school, the school can provide students with rich learning support and improve the effect of talent cultivation. Specific resource integration measures include the following aspects:

3.3.1 Establish an on-campus mathematical modeling association, and regularly organize training and experience exchange

In order to better promote the learning and practice of mathematical modeling, schools can organize and manage related activities by establishing mathematical modeling associations in schools. Mathematical Modeling Association is not only an exchange platform for students to learn modeling knowledge, but also an important organizational structure to promote the advanced talent training mode. Through the construction of the association, students can get more systematic training and experience sharing with the support of resources inside and outside the school.

Regular training activities: the association can cooperate with mathematics, statistics, computer and other related departments, and invite experts from both inside and outside the school to provide professional training courses for students, covering basic modeling skills, programming tools, case analysis and other

contents. Through regular training, students can gradually improve their ability in the learning process, and complete the learning path from basic to advanced.

Organizing experience exchange and modeling sharing: By organizing experience-sharing meetings or modeling discussion groups, the association can provide a platform for students who have competed to share their competition experience and modeling skills. By sharing their experiences in the competition, model building skills and problem solving ideas, students can not only help other students better understand the modeling process, but also enhance the cooperation spirit and communication ability of the whole team.

Intramural simulation competitions: The association can also hold regular intramural simulation competitions to create practical opportunities for students to participate in the competition. By simulating national or international mathematical modeling competitions, students can adapt to the atmosphere and rules of the competition in advance and accumulate competition experience. At the same time, the simulation competition is also an effective learning feedback mechanism, through which students learning effect is evaluated and they adjust the training program in time.

3.3.2 Invite enterprises or industry experts to participate, and provide practical cases and professional guidance

Mathematical modeling is not limited to academic research, it has a wide demand in enterprises, industry, finance and other practical applications. Therefore, in order to help students to better apply theoretical knowledge to practical problems, schools should actively cooperate with enterprises and industry institutions, and invite enterprise experts to participate in talent training. Specific measures will include:

Introduce practical case teaching: business and industry experts can provide students with modeling cases based on practical work needs. These cases can not only help students understand the real problems encountered in the industry, but also enable them to use academic knowledge in the process of solving problems to improve their practical ability. By participating in real case analysis, students can understand modeling applications in different domains and enhance their ability to understand and apply interdisciplinary knowledge.

Provide corporate tutor guidance: enterprise and industry experts can also act as off-campus tutors to provide directional guidance for students. Especially in the advanced stage of student training, corporate mentors can provide technical support and direction guidance for students research projects or competitions. Through regular communication with students, tutors can help students understand the needs of the industry, and adjust the modeling scheme according to practical problems to ensure that students research has practical application value.

Internship and practice opportunities: The school can arrange students to conduct internship projects related to modeling in enterprises through cooperation with enterprises. By personally participating in enterprise research and development or project management, students can apply their modeling knowledge to practical work and further improve their ability to solve problems. Internships not only allow students to gain practical experience, but also deepen their understanding of the industry, helping them to become more competitive in their career development.

3.3.3 Encourage students to participate in international and national mathematical and modeling competitions to expand their international horizons

In the context of globalization, participating in international academic exchanges and competition is an important way to cultivate students international vision. In order to better stimulate students learning motivation, schools should encourage students to actively participate in the mathematical modeling competitions at home and abroad, and provide relevant support for them.

Participation and support in international competitions: Schools can provide students with the opportunity to participate in internationally renowned mathematical modeling competitions (such as American Mathematical Modeling Competition MCM/ICM, International Mathematical Modeling Competition for College Students, etc.). International competitions not only test students academic ability and innovative thinking, but also help students broaden their horizons and understand the global application of mathematical modeling through communication with international teams. Schools should provide professional training, competition fee funding and follow-up support for students participating in international

competitions to ensure that they can give their full strength.

Promotion of well-known domestic competitions: In addition to international competitions, schools should actively organize students to participate in well-known domestic competitions such as the National Mathematical Modeling Competition for College Students (CUMCM). These competitions provide a broad platform for students to show their abilities, and the experience and achievements accumulated in the competitions are of great help to students future academic and professional development. By setting up a competition reward mechanism, schools can encourage more students to participate, and provide academic development opportunities for the outstanding competitors.

4. Practice and Case Analysis

4.1 Implementation Path

Through the combination of curriculum reform and competition projects, colleges and universities should gradually improve the teaching system of mathematical modeling. Mathematical modeling courses are offered at the introductory stage, and students master basic modeling abilities by combining theory with practice; In the promotion stage, students take competition as the starting point and gradually challenge more complex practical problems; In the deepening stage, students participate in scientific research projects or high-level competitions under the guidance of tutors to further enhance their academic and innovative abilities.

4.2 Typical Cases

By constructing an advanced talent training mode with mathematical modeling competition as the core, a university has achieved excellent results in the national mathematical modeling competition for college students for many years. The school adopts a hierarchical teaching method, offering basic courses of mathematical modeling in the lower grades and modeling project courses in the upper grades. Students get a lot of practical opportunities inside and outside the school. After graduation, students not only have solid subject knowledge, but also have strong innovation ability and practical experience, which is widely recognized by enterprises.

4.3 Implementation Effect Evaluation

Through three years of implementation, this model has significantly improved students comprehensive quality and practical ability, especially in the mathematical modeling competition. Students scientific research quality and innovation ability have been effectively cultivated, and graduates competitiveness in the job market has been significantly enhanced.

5. Existing Problems and Improvement Suggestions

5.1 Existing Problems

Although the application of advanced talent training mode in mathematical modeling competition has achieved initial results, it still faces the following challenges in the actual implementation process:

1. Lack of teachers: the relative lack of professional guidance teacher resources is difficult to meet the diversified needs of students;
2. Unbalanced enthusiasm of students participation: some students have low participation due to lack of basic knowledge or interest;
3. Limited resource support: especially in small and medium-sized universities, insufficient investment in resources limits students learning and practice opportunities.

5.2 Suggestions for Improvement

1. Improve teachers: Schools should strengthen the construction of mathematical modeling teachers, and improve teachers modeling guidance ability through teacher training and industrial cooperation;
2. Stimulate students interest: Enhance students interest in mathematical modeling by optimizing the course content and introducing more practical cases and competitions;
3. Increase resource input: Schools should increase funds and resources input in mathematical modeling competitions and practical projects, and provide students with more practical training opportunities.

6. Conclusions and Prospects

6.1 Study Conclusion

By studying the role of mathematical modeling competition in talent cultivation in colleges and universities, this paper constructs an advanced

talent cultivation mode with competition as the starting point. This model effectively improves students innovative thinking, practical ability and professional competitiveness by cultivating students mathematical modeling ability and comprehensive quality in stages.

6.2 Future Outlook

In the future, colleges and universities should further deepen the integration of mathematical modeling and curriculum system, expand interdisciplinary application fields, and enhance the role of mathematical modeling competition in the cultivation of innovative talents. At the same time, schools need to strengthen cooperation with enterprises and industries, and constantly optimize the training mode in combination with actual needs, so as to cultivate more innovative talents who meet social needs.

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