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Exploration on the Reform of Probability Theory and Mathematical Statistics Teaching Based on the Construction of First-Class Undergraduate Courses

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Abstract: *Probability theory and mathematical statistics courses are the basic courses in science and engineering. The exploration of probability theory and mathematical statistics teaching reform based on the construction of first-class undergraduate courses is important. This article analyzes the reform of first-class undergraduate courses in probability theory and mathematical statistics from multiple levels such as reform measures, characteristics and innovation, reform results, and continuous reform direction.*

Keywords: *Probability Theory and Mathematical Statistics; First-Class Undergraduate Course Construction; Online and Offline Hybrid Teaching; Curriculum Practice; Teaching Reform*

1. Introduction

Probability theory and mathematical statistics courses are the basic courses of science and engineering. Science and engineering play an important role in the progress of the entire society. Many scholars have proposed some methods of course construction for the course construction of probability theory and mathematical statistics.

Ma Jiaqi[1] discussed the specific measures for the reform of probability theory and mathematical statistics curriculum in applied higher education institutions. Zhang Yanfang[2] analyzes the teaching model that combines online and offline, and combines the first classroom and the second classroom, and promotes the construction of first-class courses. Huang Ganji[3] adopts a fusion teaching method to innovate reform and practice classroom teaching of probability theory and mathematical statistics. Tian Donghong[4] relies on the OBE concept and the MOOC platform of China University, carried out the teaching reform and practice of the course. Wang Kun[5] explored the teaching innovative ideas of probability theory and mathematical statistics courses. Wu Ying[6] has achieved the transformation from a "traditional knowledge transmission type" to a "student-centered ability cultivation type". Liang Yinshuang[7] explores the construction methods of first-class undergraduate courses in probability theory and mathematical statistics under the background of new engineering. Zhou Gang[8] carried out the research and practice of the construction of online and offline first-class courses on "Probability Theory and Mathematical Statistics". Wang Yanping[9] has carried out some exploratory practical innovations in teaching materials, teaching content, teaching plans, teaching methods, teaching methods and assessment methods.Based on the predecessors, this article provides some new models and methods for the construction of probability theory and mathematical statistics courses.

2. Current status of course research

Probability theory and mathematical system are core courses in majors such as mathematics and applied mathematics, computer science and technology, data science and big data technology. The course covers random variables and their distribution, parameter estimation, hypothesis testing and other modules, forming a complete knowledge system of "basic theory-method application-practical innovation".

The probability theory and mathematical statistics courses focus on serving the country's major strategic needs and the six advantageous industries of Sichuan Province (electronics and information, equipment manufacturing, food and textiles, energy and chemicals, advanced materials, medicine and health) and artificial intelligence industry, and build a three-in-one curriculum system of "basic theory-

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application practice-social services". A case library that is closely integrated with the six advantageous industries mainly covers data science and big data model construction in the field of electronic information, national economic statistical analysis, and educational statistical model optimization, forming teaching content with local industrial characteristics.

The learning outcome requirements required for this course. Knowledge objectives: Master core theories such as the probability of random events, random variable distribution, parameter estimation, hypothesis testing, etc., understand basic principles such as the law of large numbers, the central limit theorem, and the Glivenko theorem, and be familiar with all the knowledge points in probability theory and mathematical statistics. Ability Objective: Be able to use SPSS, MATLAB, Python and other tools for data modeling and simulation analysis, and independently complete industrial data analysis reports; have the ability to abstract probability models from practical problems. Literacy objectives: Cultivate rigorous logical thinking and scientific spirit, form a cognitive paradigm of "data-driven decision-making"; strengthen social responsibility, and understand the importance of statistical ethics in data application.

Through the closed-loop design of "Theoretical Teaching - Experimental Training - Social Practice", the course achieves seamless connection between knowledge imparting and social needs, allowing students to transform course knowledge into solving industrial problems, and helps Sichuan Province build a national influential science and technology innovation center.

3. Reform measures for probability theory and mathematical statistics courses

Probability theory and mathematical statistics, as important branches of mathematics, play an indispensable role in modern science and technology, engineering applications and social and economic management. The course actively responds to major national strategic needs, closely focuses on the development trends of the six advantageous industries and artificial intelligence industries in Sichuan Province, and is committed to building a probability theory and mathematical statistics course integrating basic theoretical research, academic cutting-edge exploration and practical application ability cultivation.

3.1 Teaching content optimization

The syllabus of this course is centered on cultivating students' scientific research thinking, innovative awareness and ability to solve complex problems. It systematically covers the basic concepts, basic theories, basic methods of probability theory and mathematical statistics, as well as their applications in engineering, economy, management and other fields. The content of the outline keeps up with the academic frontier, combines the development needs of Sichuan Province's six advantageous industries and artificial intelligence industries, pays attention to the combination of theory and practice, and emphasizes the systematicity and practicality of knowledge.

Lesson plan design focuses on heuristic teaching and inquiry learning, and adopts modular teaching method. Each module revolves around a core theme. Through case analysis, group discussion, practical operation and other forms, students can deeply understand the basic principles and methods of probability theory and mathematical statistics. At the same time, the lesson plan incorporates the latest scientific research results and practical application cases to enhance the timeliness and attractiveness of the course.

3.2 Innovation in teaching methods

Hybrid teaching model: adopts a combination of online teaching and offline teaching, and uses the online platform to provide rich teaching resources and interactive platforms, while maintaining the interactive and targeted nature of offline classrooms.

Case teaching: By introducing a large number of practical cases, students can master theoretical knowledge in the process of analyzing problems and improve their ability to solve problems.

Discussion-based teaching: Encourage students to actively participate in classroom discussions, express their own opinions and opinions, and cultivate students' critical thinking and oral expression skills.

Practical teaching: By organizing experiments, internships, training and other activities, students

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can personally experience the effects of probability statistics methods in actual application, and improve their practical and innovative abilities.

AI-enabled teaching: Combined with the development of the AI era, the essence of AI is statistical analysis and algorithms, empowering teaching with AI, and introducing artificial intelligence technologies such as AIGC, CHATGPT, Power BI and other artificial intelligence technologies and platforms into course construction, and empowering course construction with artificial intelligence practice.

3.3 Cultivation of scientific research thinking

Guide scientific research interests: Focus on cultivating students' scientific research interests in course teaching, and stimulate students' desire to explore by introducing the latest research results and application prospects in the field of probability statistics.

Scientific research method training: Through teaching scientific research methods, literature search skills, etc., and through training in literature reviews, writing of subject papers, etc., we help students master basic scientific research skills and lay a solid foundation for subsequent scientific research work.

Participation in scientific research projects: Encourage students to actively participate in college research projects and national college student mathematics modeling competitions and other activities, and improve their scientific research and innovation capabilities through practical exercise.

3.4 Inspire innovation consciousness

Encourage innovative thinking: In classroom teaching, focus on cultivating students' innovative thinking and divergent thinking, and encourage students to put forward new perspectives and insights.

Innovation Practice Opportunities: By organizing innovation experiments, entrepreneurial practices and other activities, students can provide a platform to demonstrate their innovation abilities.

Creating an innovative atmosphere: Create a positive and upward innovation atmosphere, encourage students to learn and inspire each other, and jointly improve their innovation ability.

3.5 Improve ability to solve complex problems

The construction of this course not only focuses on students' personal growth and development, but also is committed to serving regional economic and social development, industrial upgrading and technological progress. It is specifically reflected in the following aspects.

Serving regional economy: By cultivating compound talents with solid theoretical foundations and practical capabilities in probability statistics, we provide intellectual support for the development of Sichuan Province’s six advantageous industries and artificial intelligence industries. Students can play an important role in electronic information, finance, data analysis and other fields to promote the prosperity and development of the regional economy.

Promoting industrial upgrading: With the rapid development of technologies such as big data and artificial intelligence, the role of probability statistics in industrial upgrading is becoming increasingly prominent. This course will focus on cultivating students' data analysis ability and innovative thinking, and provide new impetus for industrial upgrading.

Promoting technological progress: This course will introduce the latest statistical software and technical tools (such as SPSS, Python, PBI, etc.) to allow students to master cutting-edge technologies such as data mining and machine learning, and provide strong support for technological progress. At the same time, through cooperation with enterprises to carry out scientific research projects and technical services, we will promote the deep integration of industry, education and research, and promote the transformation and application of scientific and technological achievements.

3.6 Information-based and practical teaching

Establish a typical case library covering multiple fields such as electronic information, equipment manufacturing, food and textiles, energy and chemicals, advanced materials, medical and health, digital economy and artificial intelligence. By collecting, sorting and analyzing actual cases, students can understand the application of probability theory and mathematical statistics in different fields, and

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improve students' practical ability and problem-solving ability.

Develop virtual simulation experiment teaching project parameter estimation simulation, hypothesis testing experiment, central limit theorem simulation, etc. Through virtual simulation experiments, students can more intuitively understand the basic principles and methods of probability theory and mathematical statistics, and improve the accuracy and efficiency of experimental operations.

Build a rich digital resource platform, including online courses, teaching videos, e-books, exercise banks, etc. Through the digital resource platform, students can access learning resources anytime, anywhere, and conduct independent learning and interactive communication. At the same time, the digital resource platform also provides teachers with convenient teaching assistance tools, improving teaching efficiency and quality.

3.7 Course assessment and evaluation reform

With the continuous deepening of educational reform, the traditional end-based evaluation method that focuses on knowledge memory and exam-oriented ability has no longer met the needs of modern education. Especially in a course that closely combines theory and practice such as probability theory and mathematical statistics, an evaluation method that can fully reflect students' abilities and qualities is needed. Therefore, it is particularly important to strengthen the reform of formative evaluation oriented towards ability and quality evaluation.Development of a Multi-Dimensional Assessment System: Replacing Exam-Oriented Evaluation with Comprehensive Metrics Incorporating Group Discussions, Lab Reports, and final examinations. Through multi-dimensional and multi-form evaluation, students' learning status and ability level are comprehensively and objectively reflected. We should strengthen process-oriented assessment, focus on students' performance and progress in the learning process, and integrate evaluation throughout the teaching process. By understanding students' learning progress in a timely manner, we can provide targeted guidance and feedback. Under the guidance of the process-oriented assessment framework, we should compile summative reports for process assessment. Additionally, we should introduce authentic project-based learning assessment, integrate course content, and design project tasks with real-world relevance.Through group cooperation, project planning, implementation and summary, students' comprehensive qualities such as team collaboration, problem solving, innovative thinking and practical ability are evaluated.

The construction goal of this course is to improve students' scientific research thinking, innovative awareness and ability to solve complex problems through systematic and comprehensive teaching of probability theory and mathematical statistical knowledge system. The course aims to enable students to comprehensively master the fundamental concepts, theories, and methods of probability theory and mathematical statistics, covering core topics such as random events, probability distributions, random variables, parameter estimation, and hypothesis testing. Additionally, it seeks to cultivate students' ability to analyze and solve practical problems using probabilistic and statistical methods, including skills in data processing, data analysis, and statistical inference.At the same time, through practical teaching and scientific research activities, students' practical ability and innovation ability will be improved. Through the study of this course, students' scientific research thinking, innovation awareness and teamwork spirit can be cultivated, so that students can have a rigorous scientific attitude, keen insight and continuous learning ability.

4. Characteristics and Innovation of Probability Theory and Mathematical Statistics Curriculum Reform

4.1 Course Features

This course not only explains the basic theories of probability theory and mathematical statistics in depth, but also pays attention to the application of theory in practical problems. Through product quality control, students can be guided to use the knowledge they have learned to solve practical problems, so that students can deeply understand the practical value of probability statistics.

The course focuses on cultivating students' mathematical thinking and guiding students to think and analyze problems from the perspective of probability statistics. During the teaching process, students are encouraged to ask questions and explore independently, and through logical reasoning and mathematical modeling, students' innovative consciousness and ability to solve complex problems are cultivated.

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With the development trend of interdisciplinary integration, this course is actively integrating with other disciplines. For example, in combination with computer science, the application of probability statistics in machine learning and data mining is introduced to broaden students' knowledge horizons.

4.2 Teaching reform and innovation points

We should promote blended teaching and fully utilize the online platform to provide rich learning resources. Moreover, in the classroom, we should adopt interactive methods such as case analysis to stimulate students' interest in learning and their initiative. After class, students are guided to inquiry-based learning through college students' scientific research projects, simulation experimental analysis, and subject cutting-edge paper reviews.

We should establish a diversified assessment system by replacing the conventional approach, thereby increasing the weight of formative assessment and comprehensively evaluating students' learning process and outcomes.

To enhance practical teaching, we should design specialized laboratory sessions and implement industry-oriented projects.Through experimental operations and practical project training, students can personally experience the application process of probability statistics methods, and improve students' practical hands-on ability and ability to solve practical problems.

5. Results of the preliminary reform of probability theory and mathematical statistics courses

Against the backdrop of the current major national strategic needs and the booming development of Sichuan Province's six advantageous industries and artificial intelligence industries, probability theory and mathematical statistics, as important branches of mathematics, are increasingly prominent. In order to better adapt to the needs of the times and cultivate high-quality talents with high-level thinking, practical innovation ability and practical problem solving ability, this course has accumulated some reform experience in the early stage.

This course aims to enable students to master the basic concepts, theories and methods of probability theory and mathematical statistics, cultivate students' ability to use probability statistical thinking to solve practical problems, improve students' data analysis, logical reasoning and mathematical modeling literacy, and be able to use software such as SPSS, platforms such as Power BI, and AIGC to conduct data analysis, laying a solid foundation for subsequent professional course learning and future career development.

The course achievement has achieved remarkable results, mainly involving the following three aspects.

Student achievements: Students' knowledge acquisition is becoming more and more solid. They have won many awards in many competitions such as Sichuan Mathematics Modeling Competition, Sichuan Mathematics Competition, Lanqiao Cup National Software and Information Technology Professional Talent Competition, and have completed many college student scientific research projects and college student innovation and entrepreneurship projects. Not only has students' ability to solve complex problems significantly improved, but their success rate and high-quality employment rate have been significantly improved.

Course effectiveness: 3 educational reform projects and 5 scientific research projects have been built around the course. The course has been established as a first-class undergraduate course of Sichuan University for Nationalities. Relying on the course design teaching cases and participating teaching competitions, we have won provincial or above awards many times; other course construction and teaching competitions related to the course have also obtained a number of provincial and school-level results.

Teacher effectiveness: Many teachers in the course team have obtained the data analyst (advanced) professional technical certificate and the AIGC artificial intelligence prompt word engineer certificate, providing support for the AI-enabled teaching of the course. Many teachers have been rated as dual-teacher and dual-energy teachers, and the members of the teacher team have received a variety of provincial rewards. A complete faculty team provides talent guarantee for the construction of this project.

This teaching reform aims to optimize the course content and methods by introducing academic

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frontiers and latest scientific research achievements, combining the achievements made in early course construction and scientific research, cultivate students' advanced thinking, practical innovation ability and ability to solve practical problems, improve the curriculum learning effect, and provide strong talent support for national and local economic and social development.

6. Continuous improvement direction for probability theory and mathematical statistics courses

Based on the previous achievements, the construction of advanced courses in probability theory and mathematical statistics also requires continuous improvement in the following aspects.

The construction of the course faculty team is the basis for ensuring the quality of teaching. We should regularly arrange for course instructors to attend national and international academic conferences and training programs to enhance their academic expertise and teaching competencies. Additionally, we should recruit interdisciplinary professionals to strengthen the teaching team. Finally, we should establish a mentorship system for young faculty members to foster their professional growth through peer guidance and collaborative support, thereby building well-structured teaching teams with clear roles.Optimizing teaching content is the key to curriculum construction. The construction of advanced courses in probability theory and mathematical statistics needs to continue to combine the major national strategic needs and local industrial characteristics, update the course content, and add cutting-edge modules such as "artificial intelligence and probability statistics" and "big data analysis". Developing an Interdisciplinary Case Repository with Practical Scenarios (e.g., Financial Risk Assessment, Macroeconomic Data Analytics) to Enhance Theory-Practice Synergy. The current combination of courses with computer science and technology, data science and big data is still on the surface, and there is a lack of practical cases of deep integration. A joint laboratory is built with computer science and technology, data science and big data, veterinary medicine and other disciplines to develop interdisciplinary course modules. Industry experts are invited to participate in curriculum design to ensure that the teaching content is synchronized with industrial needs. The lack of experimental equipment and software resources is mainly due to the use of laboratory resources and equipment of the existing science and engineering center, which is difficult to meet students' practical needs.

We should enhance laboratory infrastructure by increasing investments in advanced data analysis software and simulation platforms, and actively build applied statistics laboratories. Additionally, we should expand industry-academia collaboration by establishing additional practice bases and partnering with the Bureau of Statistics, Education Bureau, and enterprises to provide students with real-world project cases for hands-on experience.

Innovation in teaching methods is the direction of continuous progress in curriculum construction. This course will continue to promote the online and offline hybrid teaching model, use the virtual simulation experiment platform and the online teaching platform, and combine the teacher resources of dual-teacher teachers, big data analysts and other teacher resources to expand artificial intelligence-enabled course teaching and improve classroom interactivity. We should implement project-driven teaching methods, design comprehensive practical projects, and actively explore new teaching approaches in probability theory and mathematical statistics courses.

The improvement of the evaluation system is the measure of curriculum construction.Establish a multidimensional evaluation system integrating formative and summative assessments. Progressively involve industry mentors in curriculum evaluation to ensure alignment with professional competency standards. Engage corporate experts in curriculum development and academic research projects to assess students' real-world problem-solving capabilities. Develop a smart assessment platform with dynamic monitoring features for continuous performance tracking.

Of course, the construction of first-class courses is also a long way to go and it cannot be achieved overnight. It must be progressed step by step in teaching reform. Let schools also pay attention to curriculum construction from the institutional level and build institutional guarantees for first-class curriculum teaching reform. Students are changing and learning situations are changing. Only by continuously teaching reform can the construction of first-class courses achieve good teaching results.

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Sichuan Minzu College ' first-class undergraduate course "Probability Theory and Mathematical

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