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Exploration of Teaching Reform and Practice in Probability Theory and Mathematical Statistics under the Background of New Engineering

Zhonggang Hu[a], Zhifeng Yu[b]

Nanchang Institute of Science &Technology, Nanchang, Jiangxi, 330108, China
[a]15034976@qq.com, [b]289453859@qq.com

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Abstract: Under the background of the vigorous development of new engineering, the teaching of traditional probability theory and mathematical statistics faces many challenges. This article aims to explore the teaching reform path of this course under the background of new engineering, so as to improve the teaching quality and cultivate high-quality talents to meet the needs of new engineering. This article deeply analyzes the existing problems such as outdated teaching content, single teaching method and one-sided assessment method, and puts forward a series of targeted reform strategies based on educational teaching concepts and learning theories. Strategies include optimizing teaching content, integrating new engineering elements and integrating curriculum knowledge; Innovating teaching methods, adopting project-based and problem-oriented teaching methods and integrating information technology; Change the assessment methods, construct diversified assessment indicators and strengthen the process assessment. Through practical exploration, it is expected that students' academic performance, interest and ability to solve practical problems will be significantly improved, which will provide strong support for the training of new engineering talents.

1. Introduction

With the rapid development of science and technology and the deep transformation of industry, new engineering construction came into being and became an important direction of higher engineering education reform in China [1]. The new engineering course emphasizes the cross-integration of disciplines and the cultivation of students' practical ability and innovative thinking, aiming at conveying high-quality engineering and technical talents for emerging industries and new economic development [2]. Under the background of this era, new and higher requirements are put forward for the teaching of engineering courses.

Probability theory and mathematical statistics, as an important basic course for engineering majors, are widely used in many fields [3]. It not only provides the necessary mathematical tools for the follow-up professional courses, but also lays a solid theoretical foundation for students to solve practical engineering problems [4]. However, there are some problems to be solved urgently in the

traditional teaching of probability theory and mathematical statistics [5]. In terms of teaching content, it is relatively old, and it is not closely integrated with new engineering fields such as big data and artificial intelligence, so it is difficult to stimulate students' interest in learning and meet actual needs [6]. In teaching methods, teachers are the center of knowledge infusion, and students' active participation is low, which is not conducive to cultivating their innovative thinking and practical ability. The examination method is relatively simple, focusing on the memory of theoretical knowledge, ignoring the examination of students' comprehensive ability to use knowledge to solve problems.

In view of this, under the background of new engineering, it is particularly urgent to carry out teaching reform and practical exploration on probability theory and mathematical statistics. Through in-depth research and practice, it aims to optimize teaching content, innovate teaching methods, change assessment methods, improve the quality of course teaching, and cultivate high-quality talents to meet the needs of new engineering development.

2. Teaching reform theory

Under the background of new engineering, the teaching reform of probability theory and mathematical statistics should be guided by advanced educational and teaching concepts [7]. The student-centered concept emphasizes students' dominant position in the learning process, pays attention to students' individual differences, and encourages students to study independently and explore actively. Teachers should change from imparting knowledge to guiding learning, design diversified learning activities, meet the learning needs of different students, and stimulate students' learning drive. The results-oriented concept focuses on the achievement of students' final learning achievements, defines the expected goals of the course for students' knowledge, ability and accomplishment, and designs the teaching content and evaluation methods in reverse based on this [8]. Through a clear definition of learning achievement, students can make clear their learning direction, and it is also convenient for teachers to evaluate teaching effectiveness and adjust teaching strategies in time. The concept of continuous improvement requires the establishment of teaching quality monitoring and feedback mechanism. In the course of teaching, students' learning information is continuously collected, problems existing in teaching are analyzed, teaching contents, methods and evaluation are optimized in time, and closed-loop optimization of teaching activities is formed to ensure the steady improvement of teaching quality.

It is very important to create real problem situations in the teaching of probability theory and mathematical statistics [9]. For example, by introducing practical engineering cases, students can actively build a knowledge system in the process of solving problems and deepen their understanding of concepts and methods. Cognitive learning theory emphasizes the importance of learners' internal psychological process and pays attention to the structure and systematicness of knowledge [10]. In teaching, teachers should help students sort out the context of curriculum knowledge, guide students to establish links between new knowledge and original knowledge, and form a complete cognitive structure, thus improving learning efficiency and knowledge application ability.

3. Teaching reform strategy

3.1. Teaching content optimization

Under the background of new engineering, the courses of probability theory and mathematical statistics need to be closely integrated with the current scientific and technological development. The application examples of new engineering fields such as probability model in big data analysis

and statistical inference in artificial intelligence algorithm are integrated into the teaching content. Taking Bayesian classification algorithm in machine learning as an example, its core is based on Bayesian theorem in probability theory. By introducing such cases, students can understand the importance of curriculum knowledge in cutting-edge technology. Break the traditional chapter boundaries and reorganize the course content [11]. Integrate related concepts and methods to highlight the core content. For example, the random variables and their distribution, digital characteristics and other contents are explained in a centralized way, so that students can systematically understand the knowledge logic from variable description to feature description. Specific integration contents are shown in Table 1:

Table 1: Integration of Course Content in Probability Theory and Mathematical Statistics

Original Chapter Content	Integrated Content	Key Emphases
One-dimensional Random Variables and Their Distributions, Two-dimensional Random Variables and Their Distributions	Random Variables and Their Distributions	Emphasize the connections and differences between multi-dimensional and one-dimensional random variables, as well as the concepts and calculations of joint distributions and marginal distributions.
Mathematical Expectation, Variance, Covariance, and Correlation Coefficient	Numerical Characteristics	Highlight the role of numerical characteristics in describing random variables, as well as the relationships and practical significance among various numerical characteristics.
Law of Large Numbers, Central Limit Theorem	Limit Theorems	Elaborate on the importance of limit theorems in theory and practical applications, such as their application principles in quality control and sampling surveys.

3.2. Innovation of teaching methods

Using project-based learning, teachers give practical engineering-related projects, such as "Bridge Structure Reliability Assessment Based on Probability and Statistics", and students complete the projects in groups, from data collection and analysis to establishing probability models and drawing evaluation conclusions, so as to train students' ability to solve practical problems in the whole process. Problem-oriented learning sets questions around key knowledge points, such as "how to use probability knowledge to determine reasonable odds in insurance claims" to guide students to think and explore independently. Group cooperative learning can analyze complex cases, and members can work together to complete tasks and cultivate students' teamwork ability.

With the help of online teaching platforms, such as MOOC and Rain Classroom of China University, teachers release course materials, homework and tests, and students can learn and communicate online. Using mathematical software such as Matlab and R language to assist teaching, for example, when explaining the graphic drawing of probability distribution and the calculation of statistical hypothesis test, students can intuitively understand abstract concepts and complex calculation processes through software demonstration.

3.3. Assessment methods change

The construction of diversified assessment indicators requires us to design assessment indicators from multiple dimensions such as knowledge memory, understanding, application and innovation. Knowledge memory tests the recitation of basic concepts and formulas; Knowledge understanding

allows students to explain the concept meaning and principle through short answer questions; Knowledge application solves problems through practical problems and tests students' ability to use knowledge; Innovation encourages students to put forward unique ideas and methods through open questions.

To strengthen the process assessment, it is necessary to increase the proportion of process assessment such as usual homework, classroom performance and group projects. Usually homework pays attention to knowledge consolidation and expansion, classroom performance pays attention to students' participation and thinking activity, and group projects examine teamwork and problem-solving ability. For example, homework accounts for 30% of the total grade, class performance accounts for 10%, group project accounts for 20%, and final exam accounts for 40%, which comprehensively and dynamically evaluates students' learning situation.

4. Practical exploration and expected effect

(1) Practice scheme design

This teaching reform practice has been carried out in many science and engineering majors in our school. The specific implementation steps and time schedule are shown in Table 2 below:

Table 2: Steps and Time Schedule for the Teaching Reform Practice of Probability Theory and Mathematical Statistics

Phase	Time Period	Specific Contents
Preparation Phase	Weeks 1-2	Form a teaching reform team, conduct a survey on the current teaching status of Probability Theory and Mathematical Statistics in the context of new engineering disciplines, collect feedback from students and teachers, and analyze existing teaching problems. Meanwhile, based on the theoretical basis and strategies of teaching reform, formulate a detailed teaching syllabus, teaching plan, and assessment scheme.
Implementation Phase	Weeks 3-16	Teach according to the optimized teaching content, incorporating elements of new engineering disciplines and integrating course content. Adopt diverse teaching methods, such as project-based learning and problem-oriented learning, and utilize information technology tools to assist teaching. Teachers publish learning materials, assignments, and discussion topics through online teaching platforms, and use mathematical software to demonstrate complex concepts and calculation processes. During this period, regularly conduct teaching activities, where team members exchange teaching experiences and problems encountered, and adjust teaching strategies in a timely manner.
Assessment and Evaluation Phase	Weeks 17-18	Comprehensively evaluate students based on diversified assessment indicators and strengthened process-oriented assessment methods. Compile statistics on students' regular homework, classroom performance, and group project grades, and organize final exams. Meanwhile, collect feedback from students on the teaching reform, and understand students' acceptance, learning experiences, and suggestions for the new teaching mode through questionnaires, student symposiums, and other forms.

(2) Analysis of expected effect

By optimizing teaching content and innovating teaching methods, it is expected that students' understanding and mastery of course knowledge will be improved, which will be reflected in the final exam results. Taking two parallel classes as an example, one class adopts the traditional teaching method (control class) and the other class adopts this teaching reform method (experimental class). It is expected that the average score of students in the experimental class will

be 10-15 points higher than that in the control class. The specific score distribution is expected as shown in the following Table 3:

Table 3: Expected Comparison of Final Grade Distributions Between the Experimental Class and the Control Class

Grade Range	Expected Proportion in Control Class	Expected Proportion in Experimental Class
90-100 Points	10%	25%
80-89 Points	25%	35%
70-79 Points	30%	25%
60-69 Points	20%	10%
Below 60 Points	15%	5%

Diversified teaching methods and teaching contents incorporating new engineering elements are expected to stimulate students' interest in learning and make them change from passive learning to active exploration. Through the statistics of students' participation in class, the number of active questions and the time of self-study after class, it is expected that the frequency of students' active participation in class discussion will increase by 50%, and the time of self-study after class will increase by 2-3 hours on average every week.

With the implementation of project-based learning, problem-oriented learning and the introduction of practical cases, it is expected that students' ability to solve practical problems will be significantly improved. In the actual project assessment after the end of the course, it is expected that the students in the experimental class can analyze and solve problems more systematically and deeply, and the quality of project completion will be significantly higher than that in the control class. The proportion of students who can skillfully use probability and statistics knowledge to propose innovative solutions will increase from 20% in the control class to 40% in the experimental class.

5. Conclusions

Under the tide of new engineering construction, it is urgent and necessary to carry out teaching reform on probability theory and mathematical statistics. This article puts forward and practices a series of teaching reform strategies by combing the traditional teaching problems and combining the educational teaching concept and learning theory.

From the perspective of practical exploration, the carefully designed practical scheme has achieved positive expected results in many aspects. The optimization of teaching content makes the course closely connected with new engineering courses, and students can really feel the application value of knowledge in practical fields. Innovative teaching methods stimulate students' initiative in learning, and the classroom is no longer a teacher's "centralized learning". Students actively participate in project-based learning, problem-oriented learning and other activities, which not only enhances their interest in learning, but also cultivates the ability of teamwork and independent exploration. The reform of assessment methods has evaluated students' learning process and achievements more comprehensively and objectively, and strengthening process assessment has urged students to pay attention to knowledge accumulation and ability improvement. In terms of expected effect, it is expected to greatly improve students' academic performance, improve the distribution structure of performance, and enable more students to reach the excellent level. The change of students' learning interest and attitude will push them from passive acceptance to active acquisition of knowledge, which has far-reaching significance for their long-term development. The enhancement of the ability to solve practical problems meets the requirements of new engineering courses for talents, so that students can use their knowledge to solve complex engineering problems. This teaching reform is of great significance to the development of probability theory and

mathematical statistics courses and the cultivation of new engineering talents.

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