Teaching Reform of "Probability Theory and Mathematical Statistics" Under the Background of New Engineering

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Abstract: Probability theory and mathematical statistics are fundamental courses for various majors in science and engineering. In response to the current teaching situation, we should integrate theory with practice, implement teaching reform, and carry out teaching innovation. The article carries out blended teaching with deep integration of online and offline modes and within and outside of class, constructing innovative measures of "four integrations and four reshaping." The article conducts diversified evaluations to stimulate learning motivation and help achieve talent cultivation goals. Through the close integration of probability theory and mathematical statistics course teaching with professional education and practical application, the "three-in-one" teaching goal of value shaping, ability cultivation, and knowledge exploration is achieved. The fundamental task of "cultivating morality and talents" is implemented.

Keywords: "Four integrations and four reshaping"; BOPPPS blended teaching; Classified and layered teaching; Interdisciplinary integration; Full nested evaluation system

1. Introduction

Since 2017, the Ministry of Education has actively promoted the construction of new engineering disciplines to explore and develop the Chinese model and experience of higher education [1]. The construction of "new engineering" is a transformation and upgrading of traditional engineering majors. The core is enhancing students' engineering innovation ability and adaptability to change. To promote the construction of "new engineering" subjects and carry out independent talent cultivation, it is necessary to continuously promote disciplinary and professional reforms [2].

Probability theory and mathematical statistics are disciplines that study the statistical laws of random phenomena. Their application scope covers various fields of social economy. They are public basic courses for students in science, engineering, economics, and management. In the context of new engineering, in order to meet the needs of social development and cultivate high-quality composite talents with practical and innovative

abilities, it is necessary to innovate the teaching of probability theory and mathematical statistics courses [3,4]. The innovation of probability theory and mathematical statistics teaching should be student-centered and improve students' ability to continue learning. It should reflect the gender balance of the curriculum. In the context of our school's in-depth implementation of the construction of new engineering courses, and based on the needs of new engineering education construction, this article constructs the "four reshaping" innovative measures of "teaching mode, teaching content, teaching practice, and evaluation system" through the "four integrations." This article also explores the teaching reform plan of probability theory and mathematical statistics courses based on the OBE (outcome-based education) concept. The teaching reform can cultivate students' ability to analyze, apply, and solve probability and statistics problems. Highlighting the demand for independent talent cultivation in the context of new engineering disciplines, this paper aims to create an efficient classroom and continuously promote educational achievements to comprehensively enhance students' knowledge acquisition, ability development, and value cultivation as well as improve the high-level, innovative, and challenging nature of the curriculum.

2. Current situation of course teaching

2.1. Complex course content

The content of probability theory and mathematical statistics is abstract, dull, and uninteresting. The concepts and theorems are complex, scattered, and difficult to understand. The obscurity and difficulty of the course decrease students' learning interest and enthusiasm as they do not fully understand the content, leading to the failure to meet the needs of new engineering construction.

2.2. Rigid and outdated teaching mode

The traditional curriculum teaching is teacher-centered, focusing on teaching theoretical knowledge with outdated teaching methods. This situation results in low learning interest and classroom participation and a dull classroom atmosphere. Plus, there is an imbalanced proportion of teaching and learning, where the proportion of teaching is relatively larger, which is not student-centered and fails to meet students' personalized needs. Students are accustomed to cramming learning, and it is difficult to form effective teacher-student interactions. Some students' learning goals are merely to pass the exams and lack the motivation for deep learning, which cannot support their future development needs.

2.3. Lack of practical teaching

The content of probability theory and mathematical statistics is highly theoretical. Classroom teaching activities only focus on problem-solving and exams, while practical cases and cutting-edge disciplines have not been effectively introduced into the teaching content. This cannot stimulate students' interest in learning and cannot fully utilize the role of probability theory and mathematical statistics courses. Students learn the knowledge but cannot apply it in practice, failing to meet the requirements for cultivating students' comprehensive abilities.

3. Innovative ideas and measures for teaching reform

Based on the above issues, it is particularly important to deepen teaching reform and promote teaching innovation. In the context of the new engineering discipline and based on the OBE concept, we adhere to the idea of "moral education first, result-oriented, student-centered, and continuous improvement." We carry out blended teaching with deep integration of online and offline modes, within and outside of class. Our reform and

innovation measures of "four integrations and four reshaping" are shown in **Figure 1**.

Figure 1. Innovative measures for "four integrations and four reshaping"

3.1. Integrating multiple activities to reshape a student-centered teaching model

In the teaching of probability theory and mathematical statistics, modern information technology tools such as Learning Pass, Rain Classroom, and Smart Classroom are utilized, and the BOPPPS hybrid teaching mode is adopted. We integrate various activities such as peer teaching, group cooperation, and real-time testing to create a complementary dual channel for online and offline, within and outside of class. Through "autonomous learning + flipped classroom internalization improvement + post-class consolidation and sublimation," various teaching activities are carefully designed according to the course content, transforming from a focus on "teaching" to "learning" and promoting students' active participation in deep learning.

The classroom communication mode implements two-way communication between teachers and students, as well as multidirectional communication between students. We set up "peer teaching" for autonomous learning and collaborative discussions on abstract and difficult problems, such as multidimensional random variables, numerical features, laws of large numbers, central limit theorems, maximum likelihood estimation, hypothesis testing, etc. The conditions and conclusions of these problems are complex and varied. A question can be raised by the teacher for students to first think independently and answer, then communicate with peers based on the answer situation. They can discuss and question each other, explain themselves, or seek evidence to support each other. Subsequently, students present their conclusions in class, and teachers can provide feedback and ask questions to further expand their knowledge. After class, students can further review the materials to consolidate and sublimate the knowledge. Based on pre-class learning guidance, in-class activity design, and post-class homework test tracking feedback, we can timely adjust teaching strategies to form a teaching loop. We conduct multidirectional interactive discussions to guide students to actively think, discuss, question, practice, explore, and comprehend, at the same time encouraging students to actively explore. These reform measures not only improve learning efficiency and innovation ability but also allow students to learn about cooperation and sharing through peer communication, thus influencing each other and progressing together in their studies.

3.2. Integration of teaching with majors

In the context of the construction of the new engineering discipline, based on the different characteristics of each professional discipline, teaching plans are classified and formulated according to the four different majors

of "science, engineering, economics and management, and literature and philosophy" [5]. Probability theory and mathematical statistics teaching is integrated with students' majors, reshaping the teaching content according to the characteristics of different majors. Breaking the original knowledge system of the textbook, we design different types of courses for various majors and levels. We reshape the course content into four categories (for different majors), three course types (compulsory courses, elective courses, and subject competition training), and three levels (regular classes, experimental classes, and cooperative education classes). We develop teaching objectives, syllabi, and plans based on different professional classifications and arrange the teaching content as needed. We also integrate knowledge transfer, ability development, and value shaping into every type of teaching content. Based on classification and layering, the three-dimensional and multi-dimensional teaching contents integrate basic theoretical knowledge with practical cases, professional courses, and cutting-edge achievements. We establish a "spiral progressive" content system that can innovate through continuous iteration. It can improve the high-level, innovative, and challenging nature of the curriculum, so as to integrate "basic theories, disciplinary frontiers, professional courses, and practical cases" in four dimensions. The reshaped teaching content progresses from basic to high-level and ensures the integrity of the knowledge system. These measures not only meet the personalized learning needs of students and teach them according to their aptitude but also meet the needs of talent cultivation in the construction of new engineering disciplines.

3.3. Integrating mathematical modeling, practice, competition, and teaching

Based on the needs of talent cultivation in the digital era, a multidisciplinary and integrated teaching model of "probability and statistics + program design + mathematical modeling + mathematical competition" will be established. Based on probability and statistics, abstract conclusions such as formulas and theorems in the course will be presented intuitively through computer random simulation. After students have mastered the basic knowledge and principles, they will process large sample data and solve classic application cases combined with mathematical modeling. They can diverge and transfer knowledge points, and program the results to assist in implementation. We guide students to use probability and statistical knowledge to solve problems in mathematical modeling competitions and innovation and entrepreneurship projects, cultivating their ability to handle complex problems.

We promote a practical teaching method of "learning plus practice, practice leading competition, competition integrating scientific research, and scientific research promoting innovation." Based on mathematical modeling activities and mathematical competitions, a "platform + module + project" internship and training model has been formed, which is expanded by modeling cases and big data technology-related projects. Through classroom teaching, competition training, national and school level innovation and entrepreneurship projects, we select students to join research teams. Interdisciplinary integration enables students to systematically complete the teaching practice process. We utilize online courses, QQ, WeChat, and other online platforms to organize and expand teaching. We regularly hold community activities such as lectures, forums, and salons related to probability and statistics. We also conduct mathematical modeling competition training based on probability and statistics knowledge, and allow students to participate in big data practice projects related to the course. We organically integrate course theory, mathematical modeling, competitions, practices, and teaching to promote interdisciplinary integration. By reshaping the teaching practice model, we aim to achieve interdisciplinary cooperation. We can guide students to learn by doing, and effectively enhance their practical skills and innovative ability.

3.4. Integrating learning evaluation and teaching activities

Course assessment is an important part of the teaching process. In order to achieve multi-dimensional course teaching objectives, innovative multi-dimensional course assessment and evaluation models are being developed, and blended online and offline teaching has become a strong support for diversified assessment methods. We build an evaluation mechanism based on learning objectives that combines multiple methods (quantitative and qualitative, process and outcome) and multiple subjects (student self-evaluation, mutual evaluation between students and students, teacher evaluation). It can integrate online and offline, process and outcome evaluations. We also conduct a "full nested" evaluation before, during, and after class. Process evaluation is the evaluation and assessment of students' participation in the learning process, as well as the recording and observation of the teaching process. It includes the evaluation of students' pre-class autonomous learning, in-class interactive learning, and post-class consolidation and expansion of learning activities. Among them, the pre-class self-learning assessment is conducted by the intelligent teaching platform to collect statistics on online self-learning and attendance. The self-learning content mainly includes basic concepts and backgrounds of probability statistics, simple calculations, mathematical culture, and other low-level and easy-to-understand knowledge. It mainly guides preview learning and tests the effectiveness of students' preview. We can dynamically adjust teaching according to the preview situation. Classroom learning assessment includes assessments such as classroom quizzes, group tasks, and shared discussions. It is jointly evaluated by teacher and students and plays a role in promoting learning and providing feedback on learning outcomes. We can timely grasp the dynamics of learning and adjust teaching strategies. The post-class consolidation assessment includes required assignments and selected expansion assignments. It mainly provides feedback on learning outcomes, and analyzes the achievement of learning goals. We use them as a basis for continuous improvement of the course. Resultant evaluation is quantitatively evaluated using a final exam based on the teaching syllabus. A multi-modal and multi-agent curriculum assessment system can not only assess students' mastery of probability theory and mathematical statistics knowledge, but also evaluate their ability to apply theoretical knowledge to practice. It stimulates students' learning enthusiasm and it can comprehensively and effectively improve learning effectiveness.

4. Conclusion

Starting from the demand for talents in the construction of new engineering and social development, this article constructs the "four reshaping" teaching reform of "teaching mode, teaching content, teaching practice, and evaluation system" through the "four integrations." It stimulates students' learning enthusiasm and initiative, and significantly improves classroom participation. Through the blended teaching reform, the teaching effect has been enhanced and students' grades have steadily improved. At the same time, through this teaching reform, students' ability to solve practical problems has been strengthened. They have achieved excellent results in the national college student mathematical modeling competition, with their confidence enhanced. We achieved the "three-in-one" teaching goal of value shaping, ability cultivation, and knowledge exploration, and implemented the fundamental task of cultivating morality and talent.

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Disclosure statement

The author declares no conflict of interest.

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