

# Teaching Reform of Probability Theory and Mathematical Statistics in Applied Undergraduate Universities

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**Abstract:** With the development of society and the progress of science and technology, the demand for applied talents is increasing. In this background, the teaching reform of applied undergraduate universities is particularly significant. As a widely applied mathematics course, the teaching reform of probability theory and mathematical statistics aims to enhance students' practical application ability and innovation ability. This paper discusses the teaching reform strategies in probability theory and mathematical statistics courses in applied undergraduate colleges, including the integrated teaching of science and reality, the teaching of rethinking, and case teaching. Through the integrated teaching of science and practice, theoretical knowledge is combined with practice to enhance students' data analysis ability; through the teaching of focusing on ideas, the understanding of the ideological methods of probability statistics is emphasized rather than the mere derivation of theorems; through the teaching of case studies, practical problems are combined with theoretical knowledge to enhance students' sense of application and problem-solving ability. Studies have shown that these reform measures can significantly improve students' academic performance and practical ability, and provide strong support for the cultivation of application-oriented talents. Future teaching reforms need to constantly summarize experiences and improve measures to adapt to the changing social needs and technological progress.

**Keywords:** Applied talents; Case teaching; Teaching reform

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## 1. Introduction

With the development of society and the progress of science and technology, the demand for applied talents is getting higher and higher. Cultivating applied talents requires teachers to change their teaching concepts and focus on cultivating students' practical application ability and problem-solving ability. By adopting teaching methods such as integrated teaching of science and reality and case teaching, students' interest in learning can be stimulated, and their application ability can be improved<sup>[1,2]</sup>. Probability theory and mathematical statistics, as one of the core courses of mathematics and statistics, has a wide range of applications in scientific research,

engineering practice, and social decision-making, which directly creates value for society and promotes the development of social productivity. This mathematics course is highly practical, focusing on the combination of theoretical knowledge and practical problems. For students in applied undergraduate colleges and universities, this course is not only a study of academic knowledge, but also a tool for solving practical problems <sup>[3]</sup>. However, the current teaching mode often focuses on the teaching of theoretical knowledge and neglects the combination with practical application, which makes students' application ability in practice weak <sup>[4]</sup>. Therefore, reforming teaching methods and improving the practicality and relevance of the course have become urgent tasks to be solved at present.

## **2. The current situation of teaching probability theory and mathematical statistics in applied undergraduate universities**

### **2.1. Disconnection between theory and practice**

The content of probability theory and mathematical statistics courses in applied undergraduate colleges usually includes the basis of probability, random variables and their distribution, the basis of mathematical statistics, parameter estimation, hypothesis testing, and so on. However, the curriculum is too theoretical, which makes it difficult for students to combine what they have learned with practical problems <sup>[5]</sup>. The content of probability and mathematical statistics courses in most applied colleges and universities tends to focus on the explanation of theoretical knowledge, including probability distributions, parameter estimation, hypothesis testing, and so on. Although these theoretical contents are basic and important, if they are not combined with practical applications, it is difficult for students to understand the significance and role of these theories in practice <sup>[6]</sup>. For example, teachers will explain in detail the definitions, properties, and formulas of normal distribution, Poisson distribution, etc. in class, but they do not introduce the practical application scenarios of these distributions into teaching. Therefore, when students learn normal distribution, the teacher only explains the formula derivation and properties, but does not explain how to use the normal distribution for actual data analysis. The actual normal distribution is widely used in life, such as market research, risk management, error control, and so on. Through the rational application of normal distribution, the purpose is to make scientific decisions and predictions, not just memorize the formula or properties. The course content and teaching methods mainly focus on the explanation of theoretical knowledge, and lack the part of combining with practical problems <sup>[7]</sup>. This makes it difficult for students to understand the application of probability theory and mathematical statistics in practice, and affects their interest in the course and learning effect.

### **2.2. Teaching methods and means**

Traditional teaching methods are mainly based on lectures, and the classroom is mainly taught by explaining formulas, theorems, and derivation processes, supplemented by exercises and practice. Teachers usually emphasize formula derivation and theoretical proofs, while there are fewer examples and case studies of practical applications <sup>[8]</sup>. Although this method can help students master the basic theories, it is difficult to stimulate students' interest in learning and neglects the cultivation of students' sense of participation and practical ability. Students often feel a disconnect between theory and practice in the learning process and are not interested in the course content. Due to the lack of opportunities for practical application, it is difficult for students to transform what they have learned into the ability to solve practical problems, thus affecting the learning effect and application level.

Traditional teaching usually lacks the application of modern technical means, such as data analysis

software and online learning platforms<sup>[9]</sup>. This single teaching method limits students' mastery of modern data analysis tools and affects their ability in practical application. In the era of educational informatization, data analysis software such as R, SPSS, Python, etc. can be applied more to analyze large amounts of practical data<sup>[10]</sup>. No longer just rely on paper and pencil and calculator to complete the exercises, unable to master the practical skills of modern data analysis. Especially when teaching statistical methods with a large amount of calculations, such as regression analysis, ANOVA, etc., the reasonable use of modern technological means not only diversifies the teaching strategy but also enables students to master the practical operational skills of data analysis.

### **2.3. Incomplete evaluation system**

The current evaluation system mainly relies on the final examination results, ignoring the assessment of students' practical ability and comprehensive application ability<sup>[11]</sup>. This single evaluation method cannot fully reflect the students' learning achievements, nor can it motivate students to apply what they have learned to practical problems. Students' memorization and understanding of theoretical knowledge and the use of formulas and calculations are mainly examined in the final examination, which does not involve students' performance in actual data analysis projects or practical problem-solving ability.

The process evaluation is small, and the process grades do not account for a large proportion of the overall course grades. There is a lack of comprehensive evaluation of students' performance in the whole learning process. For example, there is a lack of evaluation of students' performance in class discussions, group projects, and homework completion. Especially for the grades of the experimental part, teachers only focus on the final report grades and ignore the students' participation, analytical thinking, and data processing ability in the course of the experimental project. In this way, students may lack sufficient guidance and feedback at the beginning of the project, affecting the overall quality of the project.

The problem of single teaching means in the traditional teaching mode significantly restricts students' learning effect and practical application ability. The problems of mainly relying on the lecture method, lack of practical operation, insufficient interactivity, and insufficient application of technological means lead to the fact that although students can gain knowledge in theoretical learning, there is a great shortcoming in practical application and operational ability. In order to solve these problems, it is necessary to introduce more interactive teaching methods, increase practical operation sessions, utilize modern technological means, and enhance the teaching effect through diversified teaching strategies and evaluation methods.

## **3. Teaching reform strategies**

### **3.1. Integration of course content with practical application**

It is the key to reform to closely combine the course content with practical application. It can be realized through the following aspects:

First, case teaching: introduce a large number of actual cases to help students understand the application of theoretical knowledge in practice. For example, when explaining regression analysis, it can be combined with the enterprise's sales data to analyze and predict next month's sales, so that students can experience how to use statistical methods to solve practical problems. When introducing the two types of errors in hypothesis testing, you can cite the example of borrowing and lending risk control; borrowing money is a common scene in real life. The use of familiar scenarios not only allows students to empathize but also provides a deeper understanding of the difference between the two types of errors in hypothesis testing of this mathematical

concept. At the same time, it can also utilize examples to carry out course politics and inspire students to borrow money in good faith.

Second is project-driven: design data analysis projects as part of the course, requiring students to use the knowledge learned in the course to complete practical data analysis tasks. The project includes data collection, data processing, analytical modeling, and interpretation of results, simulating a real workflow and allowing students to apply what they have learned in the process of completing the project.

Finally, interdisciplinary integration can be carried out, combining probability theory and mathematical statistics with other disciplines, such as economics, management, engineering, etc., to enhance the practical applicability and interdisciplinary comprehensive ability of the course. Using real business data and real problems, students can analyze real data and solve real problems, and give reasonable predictions and strategies based on the results of data analysis.

### **3.2. Diversification of teaching methods and means**

In order to improve the teaching effect, diversified teaching methods and means should be adopted. First of all, advanced information technology should be applied, and data analysis software (e.g., R, Python, SPSS) should be used in the course for practical operation. Teachers provide training on the use of the software and give software demonstrations in the classroom to instruct students on how to analyze data with these tools. Through software operation demonstration and online discussion, students' practical operation ability is enhanced. Secondly, experimental sessions are added to strengthen practical teaching, so that students can apply what they have learned in a real environment. In addition, more interactive teaching methods, such as group discussion, classroom interaction, case study, etc., are used to stimulate students' learning interest and enthusiasm. Through discussion and interaction, students' understanding and application of the course content are enhanced.

### **3.3. Improvement of the evaluation system**

Improve the evaluation system to comprehensively assess students' learning outcomes and add process evaluation to the course, including class participation, group discussion, project progress, etc. Evaluation through regular assignments, project reports, and classroom performance provides timely feedback on students' learning. During the teaching process, evaluation is carried out through assignments, project reports, classroom performance, and other aspects to get a comprehensive understanding of students' learning and practical application ability.

Practical teaching should also be evaluated to increase the assessment of students' practical ability and comprehensive application ability, for example, the evaluation of students' performance in the data analysis project, the evaluation criteria include the accuracy of data processing, the reasonableness of the analysis method, and the clarity of the interpretation of the results. The practical ability of students is evaluated through the completion of the actual project and the quality of the project report.

Eventually, the comprehensive quality evaluation of students is also required, combining the final examination, project results, classroom performance, and other aspects of the comprehensive evaluation, to fully reflect the students' learning achievements and application ability. The final exam not only examines the theoretical knowledge, but also includes practical solutions to data analysis problems.

In the teaching process, through the example analysis, experimental simulation and other ways, let the students hands-on problem solving and data analysis, so as to improve the practical ability and innovation ability of students; through the case teaching, the abstract concepts are closely integrated with the actual

problems, so that students can experience the application value of probability theory and mathematical statistics in the process of solving practical problems. Through the above methods of teaching reform, students can fully understand and apply the knowledge of probability theory and mathematical statistics, improve their application and innovation abilities, and provide high-quality talent support for the modernization of our country.

In teaching probability theory and mathematical statistics courses, the “application-oriented” teaching method is very important to cultivate students’ practical ability. Heavy application refers to carrying out experimental teaching, improving students’ application ability, and transforming the probability theory and mathematical statistics course from a purely theoretical teaching course to a course combining theory and experiment. In the probability theory and mathematical statistics course, carrying out experimental teaching can help students better understand the basic concepts and principles of probability theory and mathematical statistics. The teaching of theoretical knowledge is often more abstract, and through experiments, students can more intuitively feel and understand the practical value of these theories. For example, (1) Combined with programming to simulate experiments such as coin tossing or dice rolling, students can gain a deeper understanding of the law of large numbers, and with the convenience of the programming language, change the number of experiments, so that students can intuitively see what changes will occur as the number of experiments increases, and what patterns appear when the number of experiments is large enough; (2) When introducing the central limit theorem, drawing the histogram of the overall population and the mean value of the samples of each group after sampling (i.e., the “center”) of the histogram, through visual graphs, intuitive comparison to let students feel the central limit theorem;

Plotting the probability density function of the  $t$ -distribution inspires students to understand the similarity between the  $t$ -distribution and the standard normal, and learn to present and portray the data. Secondly, experimental teaching can improve students’ application ability. Through experiments, students can feel the existence of a large amount of data in real life, as well as the value and information contained therein, and form a sense of data; understand random phenomena and experience qualitative descriptions of random phenomena according to the problems and data in various practical situations. Learning to use the knowledge gained to solve practical problems, according to analyze the actual data, students can sense and master the descriptive statistical methods, parameter estimation, analysis of variance, hypothesis testing, and other mathematical statistical methods of the example of the application and analysis process, to improve their ability to analyze data and the ability to solve practical problems. In addition, experimental teaching can cultivate students’ innovative thinking and practical ability. In the experimental process, students need to think independently and explore independently, which helps to stimulate students’ learning interest and innovative spirit. By adding experimental teaching to the teaching of probability theory and mathematical statistics, it can cultivate students’ innovative thinking, exercise their ability to think independently, and flexibly apply what they have learned, so as to improve their practical and problem-solving abilities.

The emphasis on the idea refers to the theoretical teaching focus on strengthening students’ understanding of the ideological methods of probability statistics, abandon the traditional way of teaching mathematics, no longer pay too much attention to the proof of the theorem, the derivation of the method and the steps of the exercises, but to highlight the transmission of important mathematical ideas, not only focusing on the transmission of knowledge and formulas, but also to allow students to use the method of learning to solve a variety of practical problems at the same time to gradually establish a sense of data. Teachers in the teaching process should focus on guiding students to understand the basic concepts, principles and methods in probability theory and mathematical statistics, help students understand the essence of the idea of probability theory and

mathematical statistics, break the situation where students only know how to set formulas to solve exercises, so that students can truly understand the ideological methods, so that they can better feel how probability theory and mathematical statistics as a rigorous mathematical tool to solve practical problems. Help students understand and master the basic principles and applications of statistical thinking methods through case studies and illustrative examples. Through examples of practical problems, the application of inference methods in solving practical problems is explained, and cases are used to demonstrate how to estimate the characteristics of the aggregate based on sample data and make inferences on the estimation results. The lectures constantly penetrate the application of probability statistical methods in modern science and technology. Enhance students' understanding of probability statistics ideas and methods, so that students can more comprehensively grasp the subject knowledge and can better apply it to practical problem solving. This is especially important for students who will face problems in the real world in the future, the significance of which lies in guiding students to discover and raise problems from the perspective of mathematics, comprehensively apply the knowledge and methods of mathematics and other disciplines, analyze and solve problems, so that they can become the application-oriented talents needed by enterprises and society. At the same time, through a deep understanding of the ideological methods of probability statistics, students can also improve their ability to learn and think, appreciate the value of mathematical knowledge, form their own learning mode and thinking mode, and lay the foundation for long-term career development.

Adopting diversified case teaching to cultivate students' ability to solve practical problems and their sense of application. Case teaching is a teaching method that takes practical problems as the background and guides students to think, explore, and solve problems actively by analyzing real data and situational cases. This approach can help students combine theoretical knowledge with practical application and deepen their understanding of the basic concepts and principles of probability theory and mathematical statistics. At the same time, creating a real situation and flexibly using case teaching can also cultivate students' interest and enthusiasm, and stimulate their enthusiasm and motivation for problem solving. In the probability theory and mathematical statistics course teaching, the important theorems, concepts of the practical application of the scene and examples of linkage through, for example: the number of volcanic eruptions compared to Poisson distribution, the length of corn compared to the normal distribution, it is easier for students to appreciate the characteristics of different random variable distribution; through the "gambling problem" to explain the mathematical expectation of the meaning and the difference between the mean value and the risk of financial investment compared to the variance, to experience the statistical significance of the numerical characteristics of random variables, and to consolidate the awareness of data; the use of parameter estimation to deduce the total number of fish in the pond, through real-life experience of the "taste before you buy the product promotions," to understand the principle of hypothesis testing, and the use of analysis of variance to explore the relationship between the weight of the pig and the feed, breed, and through real-life experience of "taste before you buy the product promotions. The use of analysis of variance to explore the relationship between pig's weight and its feed and breed, and the use of parent's height to predict child's height to reveal the linear correlation in regression analysis, etc., will enable students to understand the methods of mathematical statistics in real-life situations, and to develop a sense of inference and appreciate the value of statistical inference. Choosing appropriate cases to introduce knowledge points not only expands the breadth of the curriculum, but also is a good demonstration of converting concrete real-world problems into mathematical problems and expressing the information contained in the data in mathematical language, and also helps students reduce the difficulty of understanding abstract concepts and deepen their understanding of complex problems. Case studies are appropriately

integrated into teaching in a novel way, allowing students to think about them in order to arouse their interest, to experience the connection between theoretical knowledge and real life, and to enrich and develop their sense of application.

#### 4. The efficiency of reform

This paper takes the “Probability Theory” and “Mathematical Statistics” courses offered by the data science and big data technology majors of Ordos College of Applied Technology as an example to carry out a one-year teaching reform attempt, and through one year’s teaching practice reform, the effectiveness of the reform is specifically manifested in the following three aspects:

First, students’ practical application ability is significantly improved, and students’ case analysis ability is enhanced. Through practical cases and project-driven learning, students are able to more skillfully apply theoretical knowledge to practical data analysis after the course. For example, in the course project, students were able to independently complete data cleaning, modeling, and result analysis, and their application ability was significantly improved. In addition, skill mastery was more comprehensive, and students’ skills in using data analysis software and tools were improved. Most students are able to skillfully operate data analysis tools such as R, Python, etc., and are able to apply these tools to data analysis in actual projects.

Second, students’ classroom participation and interest in learning were enhanced, and students’ participation in the classroom increased significantly after the introduction of interactive teaching. Classroom discussions and case studies stimulated students’ interest in learning and enhanced their understanding and application of course content. In addition, students gained and accumulated valuable practical experience through the experimental program. Not only mastered the method of data analysis, but they also gained a deeper understanding and awareness of the problems in the actual work.

Third, the evaluation system is more comprehensive, and the effective process evaluation enables teachers to understand the students’ learning situation in a timely manner and provide targeted guidance. Students’ performance and progress in the program receive timely feedback, which contributes to the continuous improvement of learning. Through the evaluation of project results, students’ practical application ability can be accurately assessed. The practical abilities and problem-solving skills demonstrated by students in the projects are fully recognized.

Through the introduction of practical cases, project-driven learning, a diversified evaluation system, and other measures, significant results have been achieved. Students’ practical application ability, classroom participation, and learning interest have been significantly improved, and the combination of course content and practical application has been effectively enhanced.

The three teaching methods of “application-heavy,” “ideology-heavy,” and case teaching all have their unique advantages and values, and they can complement each other in practical teaching. Teachers should flexibly use innovative teaching methods and adjust the teaching system according to the needs of students and the actual situation, in order to help students better master the knowledge of probability theory and mathematical statistics and improve their problem-solving and application ability, and help the cultivation of applied talents. In conclusion, the reform of probability theory and mathematical statistics course is a continuous process, which needs to constantly summarize the experience, improve the measures, always pay attention to the cutting-edge dynamics of the course, based on the actual teaching situation, actively study the methods of teaching innovation, share the experience of educating people, and put the construction of the course into practice in

order to achieve better teaching results and better cultivate talents with application ability and innovative spirit.

## 5. Conclusion

This paper discusses the teaching status and reform strategies of probability theory and mathematical statistics courses in applied undergraduate colleges. Through the combination of course content and practical application, diversification of teaching methods and means, and improvement of the evaluation system, the teaching effect of the course and the practical application ability of students can be effectively improved. Future research can further explore the specific implementation details of the teaching reform and the evaluation methods, providing a reference for the teaching reform in applied universities.

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