ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202506_8(6).0010

Investigation into the Teaching Reform of Probability Theory and Mathematical Statistics for Economics and Management Majors

Xiqing Long

Chengdu Technological University, Chengdu 644000, China

Abstract

Probability theory and mathematical statistics serve as a foundational mathematics course for students majoring in economics and management. This course primarily aims to develop students' capabilities in abstract thinking, stochastic reasoning, and rigorous logical analysis, thereby establishing a robust theoretical framework for their future specialized studies. This paper systematically examines the challenges present in the teaching process of the "Probability Theory and Mathematical Statistics" course and explores teaching reform strategies from three key perspectives: enhancing instructional content, refining teaching methodologies, and actively incorporating targeted student feedback.

Keywords

Probability Theory and Mathematical Statistics, Economic Management, Teaching reform.

1. Introduction

Probability theory and mathematical statistics is a discipline that examines the quantitative patterns and laws governing random phenomena. It constitutes one of the three core courses in university-level mathematics, catering to a wide range of students across various academic disciplines. Additionally, it represents an essential branch of modern science with extensive applications in fields such as natural sciences, social sciences, economic management, and information technology. In the era of big data, its significance has become even more pronounced, providing a critical foundation for big data analysis, prediction, inference, decision-making, model establishment, and evaluation. Currently, the new wave of technological revolution and industrial transformation driven by artificial intelligence is accelerating, leading to an increasingly urgent demand for the application of probability theory and mathematical statistics knowledge. This places higher demands on the teaching of these courses. In this new era, society requires the cultivation of innovative talents who not only possess a robust theoretical foundation but also demonstrate strong capabilities in analyzing and solving practical problems, thereby adapting to the rapidly evolving technological landscape and complex, dynamic real-world challenges.

In the contemporary fields of economics and management, the application of quantitative analysis has grown increasingly significant. Nonetheless, many challenges in these domains involve inherent uncertainties. Probability and statistics, as the most effective mathematical tools for addressing uncertain problems, have become a crucial course that students specializing in economics and management must master[1]. However, based on observations from teaching practice, students often encounter difficulties in effectively understanding and applying probability and statistics within constrained timeframes. Moreover, traditional teaching approaches tend to focus excessively on exam-oriented instruction, which negatively affects both the practical application of disciplinary knowledge and the development of students' mathematical literacy. Therefore, it is essential to integrate the unique characteristics

ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202506_8(6).0010

of the course with the talent cultivation goals of the new era to promote teaching reform. This will not only enhance students' ability to comprehend and apply probability and statistics but also support their comprehensive development of mathematical literacy.

2. Challenges and Issues in the Instruction of Probability Theory and Mathematical Statistics

The Probability Theory and Mathematical Statistics course is primarily designed for sophomore students. By this stage, students have successfully completed foundational courses such as Advanced Mathematics and Linear Algebra, thereby equipping them with the necessary knowledge and skills to effectively learn and apply concepts from Probability Theory and Mathematical Statistics in solving real-world problems. Currently, within the instruction of probability theory and mathematical statistics, several notable issues frequently arise:

2.1. Overemphasis on Probability and Underemphasis on Statistics

The course on Probability Theory and Mathematical Statistics is highly comprehensive, encompassing several key modules, including random events and their associated probabilities, random variables and their distributions, numerical characteristics of random variables, laws of large numbers and central limit theorems, samples and sampling distributions, parameter estimation, and hypothesis testing [2]. These topics are essential for students to comprehend and address practical problems in subsequent specialized courses. However, the current course is typically allocated only approximately 48 class hours, which is insufficient to adequately cover the extensive range of knowledge points in probability theory and mathematical statistics. As a result, instructors often find themselves constrained to completing only the probability section within the limited time frame before the course concludes.

For students specializing in economics and management, the probability section primarily emphasizes theoretical knowledge and derivation. The primary objective of studying this content is to establish a solid foundation for acquiring statistical knowledge. However, within professional coursework, the application of probability concepts is relatively limited, and opportunities for their practical use in future careers are even more restricted. In contrast, the statistics component places greater emphasis on practical applications, focusing on equipping students with skills in data collection, processing, and interpretation to address real-world problems. Given the growing importance of statistical knowledge across various industries, acquiring proficiency in fundamental statistical principles and data analysis techniques holds substantial significance for students' long-term professional growth. Thus, for students specializing in economics and management, the approach of "overemphasizing probability at the expense of statistics" essentially represents a disconnection from practical requirements and a deviation from the intended objectives of the course. Statistical methods find broader and more direct application within the domain of economic and management studies. An excessive focus on probability theory may lead students to undervalue the practical significance of statistical analysis, thereby diminishing their capacity to address real-world challenges. This teaching inclination not only conflicts with the core needs of economics and management programs but could also result in diminished interest and confidence among students regarding the use of statistical tools throughout their academic pursuits.

2.2. Overemphasis on Computation and Underemphasis on Application

In the instruction of probability theory and mathematical statistics, the traditional teaching approach predominantly emphasizes theoretical explanations and formula derivations, with examples frequently lacking practical relevance. Driven by an exam-oriented educational paradigm, students are primarily required to proficiently master formulas for computational

ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202506_8(6).0010

purposes. Consequently, the course progressively becomes abstract and monotonous, thereby diminishing students' learning motivation and stifling their capacity for innovation.

The core of the Probability Theory and Mathematical Statistics course resides in translating probability or statistical problems into mathematical problems and solving them using mathematical tools. These translations depend on fundamental yet critical principles and methods within probability theory and statistics. Applying these principles and methods to address real-world problems constitutes the essence of the course and represents the central objective of instruction. However, in practice, students frequently place greater emphasis on the problem-solving process, devoting their efforts primarily to exercise computations while overlooking the acquisition and application of underlying principles and methods, as well as the development of analytical thinking. Consequently, students struggle to devise solutions for practical problems, leading to diminished learning enthusiasm and suboptimal learning outcomes.

2.3. Overemphasis on teaching and neglect of feedback

The Probability Theory and Mathematical Statistics course is characterized by a relatively limited number of formulas, theorems, and proofs. However, its research objects and methods possess certain unique features. During the teaching process, instructors, as classroom leaders, often emphasize theoretical derivations and problem-solving explanations, delivering knowledge at a rapid pace. Consequently, students tend to adopt a passive learning stance, exhibiting low levels of classroom participation, which often results in a scenario where "teachers speak incessantly while students drift into inattention." After class, students generally demonstrate weak self-study capabilities, and instructors lack effective strategies to assist students in systematically reviewing, consolidating, and deeply comprehending the textbook content. Communication between teachers and students is primarily confined to homework grading, with minimal interaction, making it challenging to accurately assess students' understanding of the course material and resulting in a lack of timely and constructive feedback. This teaching approach hinders the development of students' autonomous learning and innovation skills, while also impeding their ability to achieve a deeper understanding and practical application of the course content.

3. Reform Initiatives for the Probability Theory and Mathematical Statistics Course

Probability theory and mathematical statistics serve as a foundational mathematics course for economics and management majors, aiming to develop students' capacities for abstract thinking, stochastic reasoning, and rigorous logical analysis through systematic instruction [2]. This course thereby establishes a robust theoretical foundation for students' subsequent specialized studies. In the context of the current new era, the role of this course has evolved from solely providing theoretical support to actively supporting professional practice. It now equips students with tools and methodologies for solving real-world problems while enhancing their practical and hands-on skills. Grounded in the application-oriented talent development framework and the distinctive features of the "Probability Theory and Mathematical Statistics" course, this paper examines the necessity of teaching reform and explores strategies to optimize course design across several dimensions, thereby strengthening students' application capabilities.

3.1. Optimize teaching content

The Probability Theory and Mathematical Statistics course encompasses a substantial volume of content and is distinguished by its robust theoretical foundation and practical applicability. While ensuring the scientific rigor and rational organization of the knowledge structure in

ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202506_8(6).0010

Probability Theory and Mathematical Statistics, the essential teaching content required for economics and management students is systematically consolidated in alignment with the major's training program. Given that the geometric probability model in Chapter One, the conditional distribution of two-dimensional continuous random variables and the distribution of functions of random variables in Chapter Three, as well as the law of large numbers and the central limit theorem in Chapter Four have limited applications in economics and management, these sections can be appropriately streamlined or omitted during instruction[4]. The theoretical derivations of maximum likelihood estimation in Chapter Six and the principles of hypothesis testing in Chapter Seven can be de-emphasized, focusing instead on introducing their practical applications and results. By reducing content that is heavily theoretical but less applicable, while retaining and reinforcing topics relevant to economics and management, the learning needs of students in these fields can be better addressed, thereby enhancing the course's practicality and appeal.

3.2. Optimize Teaching Methods

In the process of refining the content of the Probability Theory and Mathematical Statistics course, it is essential not only to reduce the inclusion of highly theoretical yet less applicable content, but also to preserve key knowledge points closely aligned with economics and management disciplines. Furthermore, through the innovation of teaching methodologies, students' engagement and practical skills should be significantly enhanced.

3.2.1. Selecting representative cases to enhance students' engagement in learning

To better align with the requirements for practical skills in application-oriented talent development and to enhance students' learning interest and autonomous learning capabilities, the case-based teaching approach can be appropriately integrated into instruction. By addressing specific problems and meticulously designing illustrative cases and application scenarios for each knowledge point, theory and practice can be effectively combined. Furthermore, by organically incorporating course-related ideological and political elements, students can be guided to utilize the principles and methodologies of probability theory and mathematical statistics to transform real-world challenges into mathematical problems, construct probability models, and solve them using appropriate techniques. This pedagogical strategy not only strengthens students' practical abilities but also fosters their comprehensive competencies in tackling complex issues. Through the integration of real-world examples, students are able to connect theoretical knowledge with professional challenges, deepen their understanding and application skills of the course content, and simultaneously stimulate their learning motivation and innovative thinking. The case-based teaching method not only facilitates students' mastery of the course material but also equips them with effective tools and methodologies for addressing practical problems, thereby achieving the dual objectives of curriculum optimization and instructional enhancement.

When teaching the probability calculations of independent events, the probabilistic concepts embedded in proverbs such as "Three ordinary people are smarter than Zhuge Liang," "Many hands make light work," and "Constant dripping wears away a stone" can be integrated with the instructional content to foster students' interest in learning and intrinsic motivation, thereby enhancing the overall effectiveness of classroom instruction.

Case 1: "Three ordinary people are smarter than Zhuge Liang."[1]

The General Addition Formula for Probability: $P(A \cup B) = P(A) + P(B) - P(AB)$ When the number of events n > 2, there is $P\left(\bigcup_{i=1}^{n} A_i\right) = 1 - P\left(\overline{\bigcup_{i=1}^{n} A_i}\right) = 1 - P\left(\bigcap_{i=1}^{n} \overline{A_i}\right)$ Consider the case where n equals 3 as an illustrative example, Suppose $P(A_1) = P(A_2) = P(A_3) = 0.5$ The probability of the

ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202506_8(6).0010

three "amateur cobblers" achieving success. $P(B) = 0.85$ The probability of Zhuge Liang's success, assuming event independence, can be expressed as $P(A_1 \cup A_2 \cup A_3) = 1 - P(\overline{A_1})P(\overline{A_2})$ $P(\overline{A_3}) = 1 - 0.5^3 = 0.875 > 0.85$ Based on the aforementioned assumptions, the derived probability value provides a vivid interpretation of the proverb "Three cobblers with their wits combined equal Zhuge Liang in wisdom," thereby assisting students in comprehending the influence of an increasing number of events on the probability value. Naturally, as n progressively increases, $1 - 0.5^n$ The probability value will also increase accordingly. Moreover, the change in the probability value can be intuitively and vividly understood through proverbs such as "Many hands make light work."

When presenting the Bernoulli distribution, the case study of "evaluating a wine taster" can be introduced. By analyzing the accuracy rates of the wine taster's repeated judgments, this approach assists students in understanding the probability distribution of success and failure in Bernoulli trials, as well as the method of enhancing judgment accuracy through multiple trials.

Case 2: Interview for a Wine Taster [3]

An alcohol enterprise is recruiting a wine taster. To evaluate the wine discrimination ability of applicants, the enterprise conducts the following test: The applicant is required to taste two types of wine 10 times, with a 4-minute interval between each tasting session. If the applicant can accurately identify the two distinct wines in at least 7 out of the 10 trials, they will be hired; otherwise, they will not be hired. One applicant claims that they can distinguish between the two wines with a probability of 0.9. What is the probability that the enterprise will be deceived by an imposter under this testing method? Additionally, what is the probability that the enterprise will fail to hire a genuine wine taster?

Let \(k \) denote the number of successful identifications out of 10 wine-tasting trials in which the two types of wine are correctly distinguished. If the applicant is an imposter, the probability of making a correct judgment in each trial is 0.5.

$$P(k \geq 7) = P(k = 7) + P(k = 8) + P(k = 9) + P(k = 10)$$

$$= C_{10}^7 0.5^7 (1 - 0.5)^3 + C_{10}^8 0.5^8 (1 - 0.5)^2 + C_{10}^9 0.5^9 (1 - 0.5)^1 + 0.5^{10} = 0.1791$$

If the applicant is a genuine expert, the probability of accurately distinguishing between the two wines in each wine-tasting trial is 0.9.

$$P(k \geq 7) = P(k = 7) + P(k = 8) + P(k = 9) + P(k = 10)$$

$$= C_{10}^7 0.9^7 (1 - 0.9)^3 + C_{10}^8 0.9^8 (1 - 0.9)^2 + C_{10}^9 0.9^9 (1 - 0.9)^1 + 0.9^{10} = 0.9872$$

Thus, the probability that an imposter passes the wine-tasting test by chance is 0.1791, indicating a relatively low likelihood. When the applicant is a genuine expert, the probability of successfully passing the wine-tasting test is 0.9872, while the probability of erroneously rejecting a genuine expert using this method is 0.0128.

When presenting the Bayes' formula, illustrative stories such as "The Boy Who Cried Wolf" and "King You of Zhou's Beacon Tower Hoax" can be incorporated into the explanation. These classic narratives help students grasp the practical application of conditional probability and the Bayes' theorem, particularly in terms of updating the likelihood of an event based on new evidence. By integrating these examples and anecdotes, students are not only able to comprehend the theoretical foundations of probability and statistics more intuitively but also identify practical applications in real-world scenarios, thereby fostering both their interest and proficiency in learning. This pedagogical approach, which integrates theory with practice, effectively stimulates students' intrinsic motivation while enhancing the engagement and efficacy of classroom instruction.

ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202506_8(6).0010

3.2.2. Integrate real-world problems to elevate the practical application value of probability and statistics knowledge.

The application value of probability and statistics is not only demonstrated through its strong alignment with real-world social issues but also aids students in gaining a deeper understanding of the real world while enhancing their problem-solving abilities through practical application of learned concepts. In comparison to other economic mathematics courses, probability and statistics exhibit superior practicality and applicability in addressing real-world challenges and optimizing resource allocation. Within the framework of course instruction, integrating real-life scenarios and societal issues enables students to better comprehend course content and strengthen their capacity for solving practical problems. For instance, when introducing classical probability models, the topic of winning probabilities in welfare lotteries can be utilized to provide students with an intuitive grasp of probability's real-world applications. When discussing mathematical expectation, the context of nucleic acid testing can be employed to analyze the merits and drawbacks of single-person single-testing versus multi-person mixed-testing strategies. Through the computation of mathematical expectation, students discover that the multi-person mixed-testing approach offers advantages in terms of reducing the average number of tests required, thereby underscoring the critical role of probability and statistics in optimizing resource utilization.

Furthermore, probability and statistics play a crucial role in the domain of economic management. For example, in areas such as insurance, economic forecasting, investment risk assessment, and managerial decision-making, the foundational principles of probability and statistics serve as indispensable analytical tools [4]. From the standpoint of random variables, factors such as bank deposit balances, the number of individuals falling ill, life expectancy, and time intervals can all be modeled as random variables. Probability distribution models, including the normal distribution, binomial distribution, and Poisson distribution, effectively capture the underlying patterns of these stochastic phenomena. In economics, measures such as the mean and variance are frequently employed to quantify the returns and risks associated with investment products. Additionally, the law of large numbers provides a robust theoretical foundation for estimating the long-term return rates of financial markets.

By incorporating these practical problems into the teaching process, students can not only acquire proficiency in the computational methods of probability and statistics but also develop their critical thinking and practical skills for addressing real-world challenges. This pedagogical approach, which integrates theory with practice, not only heightens the engagement of the course but also enables students to gain a deeper appreciation of the importance of probability and statistics in societal and economic contexts.

3.3. Emphasize student feedback to foster an efficient learning environment.

In the context of educational reform, students' feedback plays a pivotal role in enhancing teaching quality and refining teaching design. Teachers can gather student feedback through diverse approaches, such as structured questionnaires, interactive classroom activities, analysis of post-class assignments and exams, student symposiums, online platforms, case studies and project reports, evaluations of teaching effectiveness, individual interviews, teaching logs, and systematic classification and analysis of feedback. By employing these methods, educators can gain a comprehensive understanding of students' learning experiences and needs, enabling timely adjustments to both teaching content and methodologies. For example, well-designed structured questionnaires allow students to anonymously provide insights into course content, teaching strategies, and case studies. Interactive classroom tools, such as instant quizzes and anonymous feedback mechanisms, facilitate real-time assessment of students' comprehension. Analysis of post-class assignments and exam results offers empirical data on students' grasp of key concepts. Furthermore, student symposiums,

ISSN: 2637-6067 DOI: 10.6918/IJOSSER.202506_8(6).0010

discussions on online platforms, and case study reports contribute valuable feedback for teachers. Through this feedback, educators can pinpoint areas requiring improvement, optimize teaching strategies, and enhance overall teaching quality. This feedback-driven mechanism not only supports the implementation of educational reform but also fosters active learning and innovation among students, thereby ensuring continuous improvement and optimization of the teaching process.

4. Conclusion

The reform of probability theory and mathematical statistics instruction is not an endeavor that can be achieved instantaneously. In consideration of the educational objectives for students specializing in economics and management, as well as the requirements for nurturing new types of talents in the contemporary era, this paper systematically examines the issues present in the course of probability theory and mathematical statistics, such as overemphasizing probability at the expense of statistics, prioritizing calculation over application, and focusing on teaching while neglecting feedback. It proposes to implement reforms in several key areas: optimizing teaching content, carefully selecting cases to enhance students' interest in learning, integrating real-world problems to elevate the practical value of probability and statistics knowledge, and emphasizing feedback mechanisms to foster highly effective classrooms. These measures aim to stimulate students' intrinsic motivation and improve both the engagement and efficacy of classroom instruction.

Acknowledgements

Key Teaching Reform Projects at Chengdu Technological University in 2023: Research and Practice in the Development of Ideological and Political Education within the Probability Theory and Mathematical Statistics Curriculum (20230104).

2024 Project of the Yangtze River Upper Reaches Shipping and Logistics Collaborative Innovation Center: Study on the Digital Transformation of Industrial Enterprises in Yibin City (XTCX2024B06).

References

[1] Jin Chunhong, Sui Zhenhui, Cao Ying. "Research on Teaching Reform of Probability and Statistics Courses for Economics and Management from the Perspective of Mathematical Culture" [J]. Forum on Industry and Science & Technology, 2024, 23: 158-160.

[2] Hao Junjie. "Exploration of Teaching Strategies for Probability Theory and Mathematical Statistics in Undergraduate Education at Institutions of Higher Learning" [J]. Journal of National Common Language and Character Teaching, 2024, 12: 88-91.

[3] Wang Yongli. "Application of the Case Teaching Method in Probability Theory and Mathematical Statistics Instruction at Higher Vocational Colleges of Finance and Economics" [J]. Teaching in Forest Areas, 2019(7): 87-89.

[4] Yang Lifu. "Research and Practice on Teaching Reform of Probability Theory and Mathematical Statistics in the Context of New Engineering" [J]. China Science and Technology Journal Database - Online Publishing Platform.