Integration of Ideological and Political Education into the Probability Theory and Mathematical Statistics Course: A Teaching Design Based on Estimation and Hypothesis Testing

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Abstract: With the rapid development of higher education in China, colleges and universities are facing new challenges and impacts in talent training. Probability Theory and Mathematical Statistics is one of the important courses in higher education for science and engineering majors and economics and management majors. Its critical role in cultivating students' thinking skills and improving their problem-solving skills is self-evident. Course ideological and political education construction is an important link in college talent training work. Combining ideological and political education with course teaching can help students establish correct value concepts and play a certain role in improving their comprehensive ability and quality. At present, the construction of ideological and political education in the Probability Theory and Mathematical Statistics course still faces some problems, mainly manifested in the lack of attention paid by teachers to course ideological and political education, insufficient exploitation of ideological and political elements, and the simplification of ideological and political education implementation methods. In order to comprehensively deepen the construction of course ideological and political education in line with the actual needs of Probability Theory and Mathematical Statistics course teaching, we should strengthen the construction of teacher teams, improve teachers' ability to carry out course ideological and political education, integrate educational resources, develop educational resources for ideological and political education, and innovate teaching methods to improve the overall effect of ideological and political education integration.

Keywords: Probability Theory and Mathematical Statistics; Course education; Teaching strategy

1. Introduction

Probability Theory and Mathematical Statistics is a characteristic and active branch of mathematics. It has a unique research topic, unique concepts and methods, rich content, and profound results. It is also closely related to other disciplines and is an important part of modern mathematics. At present, the teaching reform of Probability Theory and Mathematical Statistics is constantly deepening. Based on the ideological and

political construction of the course, it can help students understand the basic knowledge of the course from the perspective of ideological and political education, and promote the further improvement of students' cognitive level on the basis of continuously improving students' comprehensive ability. Currently, the ideological and political construction of the curriculum is receiving widespread attention. In the teaching of Probability Theory and Mathematical Statistics, some teachers have made some attempts at the ideological and political construction of the curriculum, hoping to help students solve various problems through ideological and political education, and lay a foundation for promoting the optimization of students' knowledge structure and the development of comprehensive quality. This paper discusses the ideological construction of the Probability Theory and Mathematical Statistics course and related problem analysis through the estimation and hypothesis test and puts forward the curriculum implementation and optimization strategies for the construction of ideological and political education.

2. The necessity of the ideological construction in the Probability Theory and Mathematical Statistics course

2.1. The key to enriching the humanistic connotation of the curriculum

Curriculum ideological and political construction is the key to enriching the humanistic connotation of Probability Theory and Mathematical Statistics courses. Compared with traditional education mode, the teaching of Probability Theory and Mathematical Statistics based on ideological and political education lays more emphasis on guiding students' ideological values. Whether it is the development of ideological and political elements in the course or the guidance of relevant cases, these can become the driving force for the comprehensive improvement of students' humanistic quality. In the construction of course education to help students feel the unique charm of the Probability Theory and Mathematical Statistics course [1]. Curriculum ideological and political construction itself is a systematic activity. Under the condition of strengthening ideological and political guidance for students, it can build a diversified growth platform and space for students. Both the monitoring of students' growth performance and the educational management of students can become the key to enriching students' humanistic experience. The comprehensive quality of students themselves can be further strengthened.

2.2. The basis for the implementation of the goal of establishing moral education

The cultivation of talents is a fundamental task in college education. In the context of the new era, as society places increasing emphasis on ideological and political work, integrating this focus into the curriculum can fully implement talent development. Under the guidance of teachers, students' overall abilities can be significantly improved, laying a solid foundation for enhancing their moral character and personal development. College students are the favored students of the new era. The education they receive in the process of growing up is closely related to the environment they live in and the formation of their values [2]. Based on the positive influence brought by the ideological and political construction of the curriculum, the implementation effect of the ideological and political education-related activities in the course of Probability Theory and Mathematical Statistics can be significantly improved, and a collaborative system adapted to the ideological and political courses of the curriculum can be built, which plays a crucial role in the construction of the ideological and political pattern of the three aspects of education. Only on the basis of the in-depth implementation of the task and goal of establishing morality and educating people can the teaching resources of Probability Theory and Mathematical Statistics be further guaranteed, and the comprehensive ability and accomplishment of the subsequent students can be further strengthened in the process of growth.

3. Teaching design

3.1. Introducing examples

The example description is as follows: A well-known electronics manufacturer produced two batches of smartphones and wanted to assess whether there was a significant difference in battery life between the two batches. To do this, the manufacturer decided to conduct a sampling inspection. Specifically, 50 smartphones were randomly selected from each batch, and their battery life (in hours) was recorded using professional battery life testing software. The next step is to statistically analyze the data to determine if there is a significant difference in battery life between the two batches of phones.

3.2. Explaining the estimation theory

3.2.1. Overview of estimation theory

Estimation theory is one of the core aspects of statistics, which is concerned with how to infer the parameters of a population from a limited sample of data. In this example, we are concerned with the overall mean of the battery life of the two batches of phones [3]. Since the population data is not fully available, we can only estimate the population mean from the sample data.

3.2.2. The nature of the estimator

A good estimator should have the following properties:

(1) Unbiased: The expected value of the estimator should be equal to the population parameter.

(2) Validity: Among all unbiased estimators, the variance of this estimator should be the smallest.

(3) Consistency: When the sample size increases, the estimator should tend to be general parameters.

(4) Adequacy: The estimator should contain all the information about the population parameters in the sample.

3.2.3. Estimation formula and calculation method

For this example, we can use the sample mean to estimate the population mean.

The sample mean is calculated by the formula: $\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$

Where x represents the sample mean, n represents the sample size, and x_i represents the ith sample value.

The specific calculation process is as follows:

For the first batch of mobile phones, calculate the sample mean $(\bar{x}_1): bar x_1 = \frac{1}{50}\sum_{i=1}^{50} x_{1i}$

Among them, x_{1i} is the mobile phone's battery life in the first batch of mobile phones in the first i. For the second batch of mobile phones, calculate the sample mean $(\bar{x}_2): bar x_2 = \frac{1}{50}\sum_{i=1}^{50} x_{2i}$

Where, x_{2i} represents the battery life of the i phone in the second batch of mobile phones.

3.2.4. Intelligent application

In today's intelligent era, the use of advanced computing tools and programming languages for data analysis has become the norm. Taking Python's NumPy library and R language as examples, these intelligent means provide a great convenience for calculating the sample mean. Both the mean function in the NumPy library and R language can quickly and accurately calculate the sample mean based on the input sample data, which greatly improves the efficiency of data analysis [4]. In addition, the intelligent tool also has a powerful simulation experiment function. By setting up different sample sizes and distribution patterns, we can use these tools to conduct a large number of simulation experiments to explore the specific effects of these factors on the estimated results. This not only helps us to a deeper understanding of statistical theory but also provides strong support for the practical application of the data. Therefore, intelligent application has become an indispensable

part of the field of data analysis, which provides us with more convenient and accurate data analysis methods and promotes the continuous development of data analysis technology.

3.3. Explaining the hypothesis testing theory

3.3.1. Overview of hypothesis testing theory

Hypothesis testing theory is an important method of statistical inference, which is used to determine whether the differences between samples and samples and between samples and populations are caused by sampling error or by essential differences. Its basic idea is to first make a certain hypothesis about the characteristics of the population, and then use the sample data to infer whether the hypothesis is valid through statistical methods [5]. Hypothesis testing methods including *Z* test, *t* test, chi-square test, *F* test, etc., and their respective applications to different data types and testing purposes. The results of the hypothesis test depend on the choice of significance level, usually set at 0.05 or 0.01, to control the probability of making the first type of error. Through hypothesis testing, we can make statistical inferences and decisions more scientifically.

In this example, we need to determine whether there is a significant difference in the overall mean battery life of two batches of phones. To this end, we propose the following hypothesis:

Null hypothesis (H_0): The overall mean battery life of the two batches of mobile phones is equal, that is, $\mu_1 = \mu_2$. Alternative hypothesis (H_1): The overall mean battery life of the two batches of mobile phones is not equal, that is, $\mu_1 \neq \mu_2$.

3.3.2. Steps of hypothesis testing

Hypothesis testing includes the following steps:

(1) Hypothesis: Based on the research purpose and data, null hypothesis and alternative hypothesis are proposed.

(2) Selecting test statistics: Appropriate test statistics are selected according to the type of hypothesis test and the characteristics of sample data. In this case, we choose the *t*-test statistic.

(3) Calculating test statistics and *P* values: The value of the test statistics is calculated according to the formula of the sample data and test statistics, and the *P* value is calculated according to the nature of the *t* distribution.

(4) Making a decision: Based on the *P* value and significance level (such as 0.05), it is decided whether to reject the null hypothesis. If the *P* value is less than the significance level, the null hypothesis is rejected and the overall mean battery life of the two batches is considered to be significantly different. Otherwise, the null hypothesis is accepted.

3.3.3. Formula and calculation of hypothesis test

For this example, we can use the *t*-test to test the hypothesis. The formula for calculating the statistics of the *t*-test is: $t = \frac{\bar{x}_1 - \bar{x}_2}{s_{\bar{x}_1 - \bar{x}_2}}$

Where, $s_{\bar{x}_1 - \bar{x}_2}$ represents the standard deviation of the difference between the two sample means, which is calculated according to whether the variance of the two samples is equal. When the variance of the two samples is equal and unknown, the combined variance is calculated. When the variance of two samples is not equal, Welch's *t*-test is used to calculate.

The specific calculation process is as follows:

When two sample variances equal: $s_{\bar{x}_1 - \bar{x}_2} = \sqrt{\frac{s_1^2 + s_2^2}{n_1 + n_2}} \cdot \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}$

Where, s_1^2 and s_2^2 respectively represent the sample variance of the battery life of the two batches of mobile phones, and n_1 and n_2 respectively represent the sample size of the two batches.

When two sample variances are not equal (Welch t-test): $s_{\bar{x}_1-\bar{x}_2} = \sqrt{\frac{(n_1-1)s_1^2+(n_2-1)s_2^2}{n_1+n_2-2}} \cdot \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}$

Then, according to the calculated t value and the nature of the t distribution, we can find the critical value of t distribution table or intelligent tool is used to calculate the P values. Finally, decisions are made based on P values and significance levels.

3.3.4. Intelligent application

Using intelligent means such as Python's SciPy library or R language, we can easily calculate t-test statistics and P values, which is difficult to compare with traditional manual calculation. These software built-in rich statistical functions and efficient algorithms, so that the accuracy and speed of test results have been greatly improved [6]. In addition to the basic hypothesis testing function, intelligent tools also provide us with the ability to simulate experiments. By setting different sample sizes, distribution patterns, and parameter settings, we can conduct a large number of simulation experiments to explore the specific impact of these factors on the test results. This not only helps us to understand the principle of hypothesis testing more comprehensively but also provides more reliable data support for decision-making in practical applications. Therefore, intelligent application has become an indispensable tool in hypothesis testing, which provides us with more convenient and accurate data analysis methods and promotes the continuous development of data analysis technology.

3.4. Case analysis
3.4.1. Estimated analysis

First, we calculate the sample mean and sample variance of the battery life of two batches of mobile phones based on the collected data. These sample statistics were then used to estimate the overall mean and variance of battery life for the two batches of phones. Due to the large sample size (both 50), we can assume that the sample mean and variance are fair representative of the population mean and variance.

The specific verification process is as follows:
Sample mean and variance of battery life of the first batch of mobile phones: $bar x_1$ = calculated value, s_1^2 = calculated value.

Sample mean and variance of battery life of the second batch of mobile phones: $bar x_2$ = calculated value, s_2^2 = calculated value.

3.4.2. Hypothesis testing analysis

Next, we performed a t-test to determine whether there was a significant difference in the overall mean battery life of the two batches of phones. Firstly, according to whether the variance of the two samples is equal, a suitable calculation formula is selected to calculate the value of the t-test statistic. Then, the P value is calculated according to the properties of t value and t distribution. Finally, decisions are made based on P values and significance levels.

The specific calculation process is as follows:

When two sample variances equal: $t = \frac{\bar{x}_1-\bar{x}_2}{s_{\bar{x}_1-\bar{x}_2}}$ = computed value, P value = Find a table of t-distributed critical values or use intelligent calculations to obtain the value.

When two sample variances are not equal (Welch t-test): $t = \frac{\bar{x}_1-\bar{x}_2}{s_{\bar{x}_1-\bar{x}_2}}$ = computed values, P value = Find a table of t-distributed critical values or use an intelligent tool to calculate the value. Based on the calculated P value and significance level (e.g. 0.05), we can make a decision on whether to reject the null hypothesis.

3.5. Integrating the curriculum ideological and political elements

In the process of teaching estimation and hypothesis testing, we combined the actual case of mobile phone

battery life, not only deeply teaching statistics knowledge but also cleverly integrating the ideological and political elements of the course, and cultivating students' scientific spirit, humanistic quality, and rigorous scientific research attitude.

3.5.1. Cultivating students' scientific rigor

As the famous statistician R.A. Fisher said, "In science, every number has its own special meaning." In the estimation and hypothesis testing of mobile phone battery life, data collection, processing, and analysis at each step are crucial [7]. Students will learn how to carefully design sampling schemes, accurately record data, and use appropriate statistical methods for estimation and testing. This process not only exercises the students' ability of data analysis, but more importantly, cultivates their reverence for scientific research, understanding that any slight negligence may have a significant impact on the conclusion, and thus establishes a scientific rigorous attitude.

3.5.2. Cultivating students' integrity-based quality

In the data processing and results analysis stage, students will deeply appreciate the importance of integrity. In this case, if the mobile phone battery life is exaggerated to meet the market demand, it will not only mislead consumers but also damage the brand image [8]. By discussing the consequences of data falsification, students can realize that integrity is a cornerstone of scientific research and business activities. In the process of estimation and hypothesis testing, they must maintain the authenticity of the data and must not tamper with or fabricate the results, thus cultivating the quality of honesty.

3.5.3. Cultivating students' wisdom in mathematical decision-making

In modern society, data has become an important basis for decision-making. By studying estimation and hypothesis testing, students will learn how to extract valuable information from complex data and make scientific decisions based on this information. In the case of mobile phone battery life, students will learn how to evaluate mobile phone performance, predict market demand, and formulate marketing strategy through data analysis, so as to establish data awareness and learn to speak with data, laying a solid foundation for future work and life.

4. Conclusion

To sum up, comprehensively promoting the ideological and political construction of Probability Theory and Mathematical Statistics is the key to helping students establish correct values, and is also an important prerequisite and basis for improving students' ideological and political literacy. Teachers should be good at grasping the key points of ideological and political construction in the curriculum, strengthening ideological guidance to students, helping students solve various problems in a good ideological and political education environment, and helping students constantly improve their comprehensive ability and accomplishment through the positive atmosphere created by the ideological and political construction in the curriculum.

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