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Research Article

Reform and practice of higher mathematics teaching with outcome-based education concept

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Abstract

In order to gain a deeper understanding of the application effect of Outcome-Based Education (OBE) concept in higher education, this study chose the university's Higher Mathematics course as the research object. Take Finance Class 1 as the experimental group and Finance Class 2 as the control group, and randomly select 30 students from each class for the study. The independent sample t-test method was used for hypothesis testing, and normality and homogeneity of variance tests were used to make sure the reliability of the data and credibility of obtained results. These results show that the experimental group students have significantly higher grades than the control group, indicating that in the classes that adopt the OBE concept for teaching reform, students have achieved significant improvement in grades. This discovery not only validates the effectiveness of the OBE concept in the field of education, but also provides new ideas and methods for educational reform. By cultivating students' comprehensive qualities such as problem-solving ability, innovation ability, and teamwork skill, the OBE concept helps to improve their academic performance and promote their comprehensive development.

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Introduction

The Outcome Based Education (OBE) concept was first proposed by American educator William Spady in 1981. Compared to traditional teaching concepts, this teaching concept has advantages such as clear learning objectives, emphasis on practical applications, diverse evaluation methods, and student participation and feedback. By setting clear learning objectives, students are able to clarify their expected skills and knowledge levels. The focus is on practical applications, enabling students to utilize the knowledge they have learned to deal with real-world problems. Adopting diversified evaluation methods to gain a more comprehensive understanding of students' actual abilities. Encourage students to actively join in the learning process, develop problem-solving and creative thinking. At the same time, provide timely feedback to help students better understand their learning progress. This makes OBE teaching more adaptable to individual student differences, cultivates more comprehensive abilities, and has been applied in multiple disciplines, proving to be an effective method for educational reform (Mark, 2010; Thomas, 2008).

In recent years, there have been many practices regarding the OBE teaching philosophy, and many scholars have conducted research on its reform achievements. Liu W, Li W & Lu Y (2024) adhere to the OBE concept of engineering

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education, focus on cultivating the design ability of complex engineering control systems, and continuously carry out comprehensive reforms from the aspects of curriculum system optimization, teaching mode innovation, practical platform virtual and real collaboration, and ability goal achievement evaluation. They explore the interactive and exploratory teaching mode of BPS and CPS, which deeply integrates concepts, methods, and approaches. Lin P, Song S, & Fan J (2024) conducted teaching reform and practice on the course of Food Immunology based on the OBE teaching philosophy. Starting from the perspective of ideological and political education in the course, they regarded moral education and talent cultivation as the cornerstone of teaching reform. They explored and practiced teaching reform from the aspects of reorganizing teaching content, integrating theory and practice, improving teaching modes, strengthening teacher team construction, and combining various assessment methods. Wang et al. (2023) designed and practiced ideological and political case studies for university chemistry courses with the OBE concept, including design ideas, teaching goals, introduction design, and teaching processes. By conducting a questionnaire survey and comparing grades, a comparative evaluation was conducted between the experimental and control group of students. These results indicated that under the OBE concept, not only did students improve their course grades, but also developed their logical thinking ability and innovative consciousness, stimulating their interest in learning. Based on a questionnaire survey of seven universities in Shanghai, Hu M & Li L (2022) explored the impact mechanism of the interaction between various teaching stages under the OBE orientation on learning output from an empirical data analysis perspective. Their research results found that teaching objectives have a significant positive promoting effect on learning output, and teaching design plays a partial mediating role. Formative evaluation and summative evaluation positively regulate the relationship between teaching objectives and learning output. It also positively regulates the relationship between instructional design and learning outcomes. Zhang et al. (2021) constructed a comprehensive robot training teaching model reform based on OBE. By comparing the results before and after the reform, student grades significantly improved, and the number of learning outcomes such as winning works and applying for patents also increased significantly, confirming the effectiveness of OBE based reform.

Gurukkal (2020) refered to the potential of OBE in a larger global context, and higher education institutions must apply OBE education concepts to adapt to the ongoing economic revolution. In the classroom of learning English as a second language for chemical engineering students, the Pakistan Engineering Commission has started applying OBE in its affiliated engineering organizations during the undergraduate stage, using the quasi experimental approach to analyse the effectiveness of OBE. The experimental results show that students have improved their learning outcomes in terms of course content and skills (Yasmin & Yasmeen, 2021). Wang (2011) conducted in-depth research on the design as well as implementation of OBE in the context of Hong Kong, focusing on the gradual formal adoption of OBE by higher education institutions since 2006. Taking the Hong Kong Institute of Education as an example, the effectiveness of OBE was verified, and the challenges faced in implementing OBE were proposed at the end of the paper. Nopiah, Baharin & Razali (2021) used K-means clustering analysis to evaluate the practical achievements of OBE in engineering mathematics subjects, involving direct evaluation of data scores from final exams, quizzes, tests, and assignments and so on. The results showed that the average grades of the two departments studied were both above 3.5, and course outcomes of both institutions achieved over 70% in completing project outcomes, verifying the effectiveness of OBE. Overall, the research findings of scholars demonstrate the widespread practice of OBE teaching philosophy in different disciplines and national contexts, and emphasize its positive effects in improving student performance, cultivating practical application abilities, and innovation awareness.

Teaching Reform and Practice

Main problems in traditional teaching of higher mathematics

(1) The course content is abstract, complex, and highly theoretical. The abstract complexity and theoretical strength of higher mathematics courses are reflected in the depth and complexity of the many concepts and principles they cover. These abstract and complex contents require students to have high abstract thinking and logical reasoning abilities. However, these highly theoretical concepts lack intuitive practical application scenarios in the curriculum, making it difficult for students to intuitively connect abstract theories with practical problems.

(2) The evaluation method is fixed. The traditional evaluation method usually focuses on exams, focusing on testing students' memory and computational abilities of knowledge, but lacks the application and comprehensive consideration of practical understanding. The high-pressure examination environment may cause students to experience anxiety, affecting their normal performance and thus unable to demonstrate their true level of knowledge mastery (Molsbee & Benton, 2016). "Regular grades" is an effective reform of the traditional fixed evaluation method, covering the entire semester's learning process of students (Deng, 2020), but some universities have not effectively implemented it (Xiang, 2019).

(3) Lack of interaction and practical learning. Traditional teaching mainly relies on one-way teacher explanations and student acceptance, lacking interaction and cooperation among students. Students may have difficulty raising questions, sharing viewpoints, or engaging in in-depth discussions while passively receiving information. Interactive and practical learning are effective ways to cultivate practical skills (A1-Natour et al., 2021; Zhou & Huang, 2019), while traditional assessment methods focus more on testing the mastery and memory of knowledge, making it difficult to comprehensively cultivate the skills required by students in practical work.

(4) Lack of feedback mechanism. Traditional evaluation feedback is usually limited to simple scores or comments, and it takes a long time to provide in-depth and timely guidance, helping students understand the reasons for their mistakes or providing more specific academic advice. Interactive and practical learning are often accompanied by timely feedback, allowing students to stay informed of their learning progress and areas for improvement, in order to better adjust their learning strategies (A1-Natour et al., 2021).

Teaching Design Based on OBE Concept

To address this issue in traditional teaching of Higher Mathematics, we carry out teaching reform and practice based on the OBE concept. This concept is an educational method which emphasizes the actual ability development and learning outcomes of students. It focuses on ensuring that students can achieve established learning goals, rather than just focusing on the teaching process or knowledge transfer. The core philosophy of OBE includes setting clear learning objectives, student based assessment, emphasizing student participation, and continuous improvement. Through this approach, educators are committed to ensuring that students not only master knowledge, but also apply it, develop practical skills, cultivate problem-solving abilities and creative thinking during the learning process. The OBE teaching concept proposes three major teaching concepts: student-centered, results oriented, and continuous improvement (Steven et al., 2022).

We have applied the OBE teaching philosophy to higher mathematics education and carried out teaching reforms and practices as follows: (1) Clarify learning objectives. Set clear and quantifiable mathematical learning objectives, emphasizing the basic concepts, skills, and practical application scenarios that students need to master. (2) Design courses based on practical problems. Integrating theoretical knowledge of advanced mathematics with practical problems, designing course content that can stimulate students' interest and apply mathematics to practical situations. (3) Diversified evaluation methods. Introduce diversified evaluation methods, including project assignments, practical case analysis, group collaboration, etc., to comprehensively evaluate students' mathematical abilities and application levels. (4) Encourage students to actively participate. Make the students take part in the learning process actively and cultivate their problem-solving and teamwork abilities through discussions, experiments, group projects, and other means. (5) Provide real-time feedback. Establish a timely feedback mechanism, provide personalized and real-time feedback to students through regular evaluations and communication between students and teachers, and help them continuously improve their learning strategies. (6) Continuously improving the curriculum. Regularly evaluate and adjust teaching devices to admit the learning needs of students and the constantly changing educational environment, promoting continuous improvement and innovation in teaching.

Problem of Research

Considering the above description, we are trying to investigate the following problem:

Is the Higher Mathematics learning outcomes of students who have undergone OBE teaching philosophy reform better than those who have used traditional teaching methods?

Method

Research Model

This study belongs to the quasi experimental category. Students who have undergone the OBE teaching philosophy reform are selected as the experimental group, while students who have undergone traditional teaching methods are selected as the control group. This quasi experimental study connects these two groups of people, namely the experimental group and control group.

Participants

The research population consists of 211 students from Finance Class 1 and Finance Class 2 of Guangdong University of Finance and Economics. This study was conducted from September 2023 to January 2024, and random sampling technique was used for sample selection. Among them, Finance Class 1 underwent teaching reform on the OBE concept, and 30 students were randomly selected as the experimental group; Finance Class 2 did not undergo any teaching reform, and 30 students were randomly selected as the control group. Conduct post testing after the experiment.

Teaching evaluation

The course of Higher Mathematics adopts a combination of closed book examination (60%) and process based examination (40%) for assessment. The closed book exam is the final assessment, which includes all the knowledge covered in class, including single-choice questions, fill in the blank questions, and calculations, with moderate difficulty; The regular process assessment consists of student attendance (5%), course practical activities (5%), course assignments (5%), classroom open book quizzes (10%), and group cooperation projects (15%). The summary of the teaching evaluation system for Higher Mathematics is shown in Table 1, with a total score of 100 points.

Table 1. Teaching evaluation system for higher mathematics

Assessment items	Assessment process	Evaluation method	Proportion (%)
Assessment of Higher Mathematics	Formative assessment	Final exam	60%
	Summative assessment	Student attendance	5%
		Practical activities	5%
		Coursework	5%
		Classroom quiz	10%
		Group collaboration	15%

Data Analysis

The data of the scores in Higher Mathematics were tested after the experimental and control group conducted experiments. Use SPSS 27.0 software to conduct independent sample t-tests on the scores of the experimental group students and the control group students. Before conducting the t-test, it is necessary to perform normality and homogeneity of variance tests on the grades of each group of students respectively to prove the normality and consistency of variance of the sample.

Results

Post test experimental group data

After the teaching reform based on the OBE concept, the experimental group (Finance Class 1) conducted a post test to obtain the final assessment and evaluation of the course Higher Mathematics from 98 students in the experimental class. Then, random sampling technology was used to select the assessment and evaluation of 30 students for analysis. The descriptive statistics of the post test are shown in Table 2:

Table 2. Post-test experimental class

N	Min	Max	Mean	Std. Deviation
30	60.00	96.00	82.23	8.78

According to Table 2, the average score of the 30 experimental group students in the Higher Mathematics assessment was 82.23, with a maximum value of 96 and a minimum value of 60. The standard deviation of the data is 8.78.

To further analyze the distribution of the assessment scores, we have drawn the following group diagram based on the scores of experimental group students in Higher Mathematics.

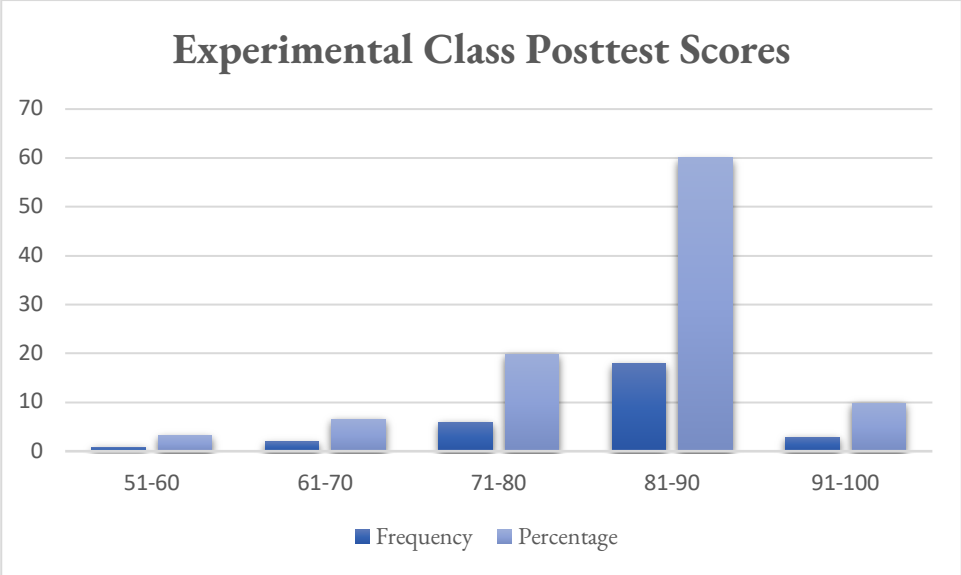

Figure 1. Scores distribution chart of experimental class

Post test control group data

The control group (Finance Class 2) underwent a post test after traditional teaching, and the same as the experimental group, 30 students were selected for analysis of their assessment and evaluation of Higher Mathematics. The descriptive statistics of the post test are shown in Table 3:

Table 3. Post-test Control Class

N	Min	Max	Mean	Std. Deviation
30	51.00	95.00	74.70	10.81

By Table 3, we know that the average score of the 30 control group students in the Higher Mathematics assessment was 74.70, with a maximum value of 95 and a minimum value of 51. The standard deviation of the data is 10.81.

To further analyze the distribution of grades among the control group students, we drew the following grouping chart based on their scores in Higher Mathematics.

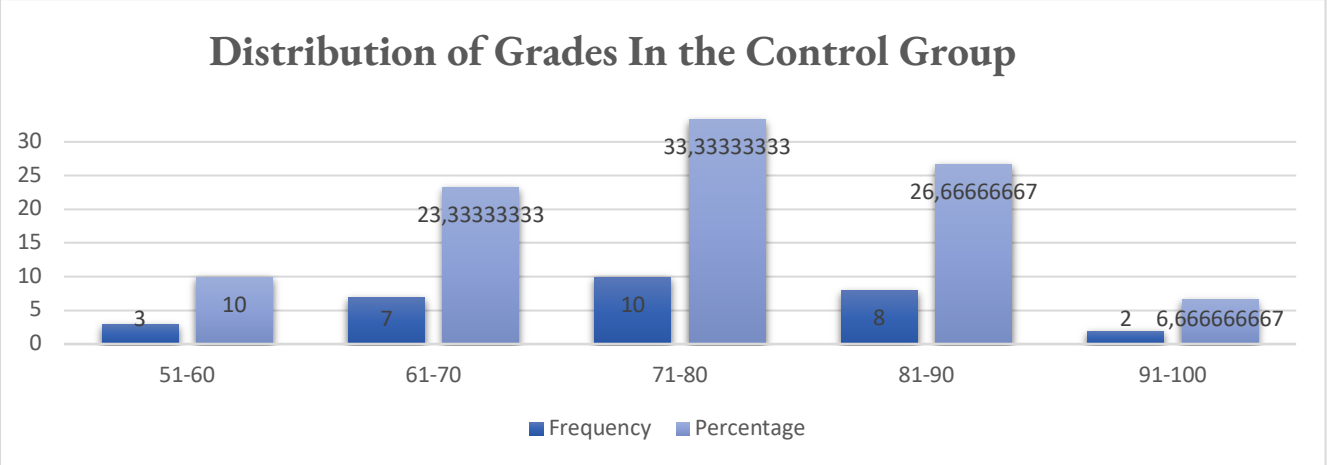

Figure 2. Scores distribution chart of control class

Comparison of results between the experimental group and the control group

Normality test

Before conducting independent sample t-tests, it is necessary for the samples to meet a normal distribution in order to obtain accurate results. If the data does not follow a normal distribution, it may lead to distorted hypothesis test results. Therefore, conducting normality tests before conducting hypothesis tests can ensure the effectiveness and accuracy of subsequent statistical methods (Yusof et al., 2020).

Among them, Kolmogorov Smirnov (K-S) normality test is to test whether the data conforms to a normal distribution by comparing the difference between the cumulative distribution function (CDF) of the sample data and the theoretical cumulative distribution function of the normal distribution. The results of K-S normality test are shown in Table 4 below.

Table 4. Normality test

	K-S Statistics	Df	P value
Experimental Group	0.156	30	0.059
Control Group	0.074	30	0.941

From the results, it can be seen that the significant values of the K-S normality test for both groups of students are greater than 0.05. Therefore, whether it is the experimental group or the control group of students, the results of the K-S normality test cannot reject the null hypothesis, and it can be considered that their scores conform to a normal distribution.

Test of homogeneity of variances

After conducting normality tests on two groups of students, the homogeneity of variance test is continued. The homogeneity of variance test is utilized to determine whether two samples come from populations with the same variance. Before conducting independent sample t-test, it is also necessary to conduct homogeneity of variance test because in independent sample t-test, it assumes that the variances of both groups of samples are the same. Levene's test of variance is based on the variance of sample data to evaluate the differences in variance between different groups or samples. It determines whether the variances of each group or sample are equal by comparing the differences between the data points of each group or sample and the mean of their respective group or sample. Table 5 shows the results of conducting homogeneity of variance tests on two groups of students.

Table 5. Test of homogeneity of variances

Levene Statistic	df1	df2	P value
1.388	1	60	0.244

From the results of the homogeneity of variance test, it can be seen that the significant value is 0.244, indicating that the null hypothesis cannot be rejected. It is believed that the scores of the experimental and control group students in Higher Mathematics are evenly distributed and have the same variance.

Hypothesis test

After passing two prerequisite tests, hypothesis testing can continue. This study adopts the independent sample t-test method to explore if the experimental group students have significantly improved scores in Higher Mathematics compared to the control group students.

Table 6. Independent sample t-test results

	Df	Mean Difference	t	P value
Equal variances assumed	58	7.533	2.961	0.004
Equal variances not assumed	56.989	7.533	2.961	0.004

According to Table 6, the probability significance value is less than 0.01, which means that the experimental group based on the OBE concept of Higher Mathematics teaching reform has significantly improved academic performance compared to the control group without reform.

Conclusion

The aim of this study is to demonstrate the impact of adopting the OBE concept in teaching reform of higher mathematics courses at Guangdong University of Finance and Economics on student performance. Under the premise of passing normality tests and homogeneity of variance tests, the experimental group (Finance Class 1) was compared with the control group (Finance Class 2), and the results showed that the students of experimental group had significantly higher grades than control group, further verifying the effectiveness of the OBE concept in educational practice.

The OBE concept emphasizes determining expected outcomes and using them as a guide to design courses and teaching methods, with a focus on student learning outcomes and practical applications. The results of this study indicate that in the experimental group that adopted the OBE concept for teaching reform, students achieved a significant improvement in their academic performance. This not only provides strong support for the practical application of the OBE concept in the field of education, but also provides new ideas and methods for educational reform.

The improvement in academic performance of the experimental group students not only means that they have achieved better results in higher mathematics courses, but more importantly, it reflects the improvement of their learning ability and practical application ability. Adopting the OBE concept for teaching reform can better cultivate students' comprehensive qualities, enabling them to have stronger problem-solving, innovation, and teamwork abilities, thereby better adapting to the development needs of future society.

Therefore, the results of this study not only have guiding significance for the educational practice of Guangdong University of Finance and Economics, but also provide useful insights for the educational reform of other universities. Adopting the OBE concept for teaching reform can effectively improve students' academic performance, promote their overall quality improvement, and lay a solid foundation for cultivating more high-quality talents. This will help promote the continuous development and progress of the education sector, and make positive contributions to promoting economic and social development.

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