Teaching Optimization of Machinery Foundation in Vocational Colleges Based on Orthogonal Experiment

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Abstract: The close combination of information technology and advanced manufacturing has promoted the process of global education modernization. Against this backdrop, this paper addresses issues inherent in the conventional instruction of the 'Machinery Foundation' course by employing an orthogonal experimental design to investigate the optimal pedagogical approach. This endeavor aims to markedly enhance teaching efficacy and quality, catalyzing educational innovation. Findings indicate that combining the ADDIE instructional model with on-site learning methods and multidimensional assessment yields superior educational outcomes. Based on this, the paper puts forward specific optimization measures for the classroom teaching of research courses from three aspects: teaching mode selection, instructional organization and teaching evaluation setting. Practice has proved that this method significantly promotes the innovation of education and teaching, and provides a reference for more extensive vocational education and training.

Keywords: Orthogonal experiment, Machinery Foundation course, Teaching optimization.

1 Introduction

With the deep integration of the latest information technology and the emerging manufacturing industry, the machinery manufacturing industry, as the cornerstone of the national economy, shoulders the heavy responsibility of strengthening the optimization of industrial structure. The experience of vocational education development all over the world show that vocational education is one of the elements to improve national core competitiveness [1]. This type of education should cultivate application-oriented skilled talents who can be used in the front line of production. The basic course of machinery is a comprehensive basic subject, which focuses on the understanding, mastering and application of the basic structure and key components in the field of machinery. This course is designed to provide students with a strong foundation through study and practical application, preparing them for future work and innovation in the field of mechanics. This paper employs an orthogonal experiment to explore the optimal combination of teaching mode, instructional organization, and evaluation settings, aiming to provide a scientific basis for enhancing Machinery Foundation course instruction.

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2 Current State of Machinery Foundation

2.1 Analysis of the Course Significance

The course of Machinery foundation systematically expounds the basic theory and practical skills of machinery. Through detailed analysis of all aspects, as well as the introduction of the latest industry standards and technological advances, we ensure that students have cutting-edge knowledge and adapt to the challenges of their future careers. Its importance can be analyzed from the following aspects: First, provide the basic knowledge. Second, improve work efficiency. Lastly, promote scientific and technological innovation and industrial development.

2.2 Analysis of Realistic Challenges in Teaching

The student group of vocational colleges has its unique characteristics. Most students have low self-identity, lack of discipline awareness and learning motivation, and poor academic performance[2]. Our distribution of pre-test questionnaires yielded 300 valid responses, highlighting issues with traditional teaching methods. The findings reveal that the traditional teaching model undermines the cohesion and logical flow of knowledge. Concurrently, deficiencies in the assessment system obstruct the enhancement of educational quality holistically.

3 A Practical Example of Teaching Optimization

3.1 Experiment Purposes

Superior teaching helps in transmitting the domain knowledge from teacher to student. An effective transmission may add values to student's performance[3]. This paper analyzes the key factors that affect the teaching effect and tries to determine the best classroom teaching strategy of this course. The purpose of this study is to provide practical guidance and insights for the improvement of classroom teaching quality of various courses in vocational colleges and even for the wider education field.

3.2 Experiment Conditions

The experiment centered on a vocational college located in Xuzhou, involving all second-year students enrolled in the Mechanical Foundation course. To ensure the objectivity of the test results, participants were randomly divided into 9 groups. This experiment will take 10 learning tasks and plan to conduct a test after studying. The total score of the test is 100 points. In order to evaluate the teaching effect scientifically, the average score of each group test will be used to measure the index.

3.3 Experiment Method

Orthogonal experiment design is an effective method to solve the problems of multi-factor and multi-level experiments, and it is an optimization design technology of experiments[4]. Based on this, we use Orthogonal experiment design to accurately calculate the main effects and interaction effects of each factor through processing a small amount of test data, so as to predict and optimize the test results.

3.4 Determination of factors and levels

The study based on the insights of 20 interviewed mechanical engineering educators, presents three factors: teaching model, teaching organization, and assessment setting and divides them into three levels. The distribution of factor levels s shown in Table 1.

Table 1. Orthogonal experiment factors and levels table

	Teaching mode	Instructional organization	Evaluation setting
1	Traditional teaching mode	On-site teaching form	Teachers evaluate students
2	Blending teaching mode	Class teaching form	Teachers and students evaluate each other
3	ADDIE teaching mode	Group teaching form	Teachers and students evaluate each other, students evaluate each other

Teaching Mode. Factor A encompasses three levels. In traditional teaching, teacher assumes the central role, with students functioning as passive receivers of information. Blending teaching, by contrast, capitalizes on the strengths of both online and offline methodologies, leveraging digital resources to enrich the learning experience. ADDIE teaching model, structured around five phases, emphasizes learner-centered and pays attention to the pertinence and effect evaluation of teaching activities.

Instructional Organization. The form of instruction organization directly affects the teaching effect and students' learning experience. On-site teaching integrates real-world work environments into the curriculum, often conducted at school practice bases. Classroom instruction as the most prevalent traditional form, involves uniform delivery by the instructor. In contrast, group teaching fosters student interaction and collaboration, enhancing knowledge sharing. There are notable differences between the latter two in terms of the extent of student engagement and the level of personalized attention received.

Evaluation Setting. The three levels represent distinct categories of evaluation subjects. Level 1 facilitates teachers in gaining insights into students' progress, enabling them to detect and address issues promptly. Level 2 fosters a culture of reflective teaching, contributing to the enhancement of students' interpersonal skills. Lastly, an emphasis on peer evaluation catalyzes the cultivation of critical thinking abilities among students.

3.5 Orthogonal Experiment

Orthogonal Table $L_9(3^4)$ was selected as the experiment scheme in this experiment, and Table 2 was prepared according to relevant conditions:

Table 2. Experiment scheme

No.	A	B	C	Blank column	Experiment scheme
1	1	1	1	1	$A_1B_1C_1$
2	1	2	2	2	$A_1B_2C_2$
3	1	3	3	3	$A_1B_3C_3$
4	2	1	2	3	$A_2B_1C_2$
5	2	2	3	1	$A_2B_2C_3$
6	2	3	1	2	$A_2B_3C_1$
7	3	1	3	2	$A_3B_1C_3$
8	3	2	1	3	$A_3B_2C_1$
9	3	3	2	1	$A_3B_3C_2$

3.6 Experiment Results

The experiment is carried out according to the above designed table. Table 3 shows the results and Table 4 illustrates the variance analysis.

Table 3. Analysis of experiment results

	Factor A	Factor B	Factor C	Experiment results
1	1	1	1	64
2	1	2	2	50
3	1	3	3	62
4	2	1	2	70
5	2	2	3	67
6	2	3	1	71
7	3	1	3	83
8	3	2	1	73
9	3	3	2	76
K_1	176	217	208	
K_2	208	190	196	
K_3	232	209	212	
k_1	58.67	72.33	69.33	
k_2	69.33	63.33	65.33	
k_3	77.33	69.67	70.67	

Determining whether factors exert a significant influence on the experimental outcomes is accomplished via the utilization of ANOVA techniques. As illustrated by the above trend chart, $A_3B_1C_3$ emerges as the superior choice. The specific calculation process is as follows:

(1) Calculating the grand mean $\bar{y}$=68.44;

(2) The mean values of the experimental outcomes at each factor level, represented by k_{1A}, k_{1B}, k_{1C}, etc., up to k_{3C}, are displayed in the experimental results;

(3) Calculating the total sum of squares of deviations, the result is SS_T=702.22. The formula is as follows:

$$SS_T = \sum_{i=1}^{n}(y_i - \bar{y})^2 \tag{1}$$

(4) Use the following two formulas to calculate the sum of squares and the experimental error:

$$SS_j = n/r \sum_{i=1}^{r}(k_i - \bar{y})^2 \tag{2}$$

$$SS_e = SS_T - SS_A - SS_B - SS_C \tag{3}$$

The calculated result is SS_A=526.22; SS_B = 128.22; SS_C = 46.22; SS_e = 1.56;

(5) Calculating the degrees of freedom. The result is df_T=8; df_A=df_B=df_C=2; df_e=2; Since the df=2, the mean square is MS_A=263.11, MS_B= 64.11; MS_C= 23.11; MS_e=0.78;

(6) Calculating F value. The result is F_A=338.29; F_B=82.43; F_C=29.71;

(7) Test each factor's significant effect: Having determined the critical F-values to be $F_{0.05}(2,2)$=19.00 and $F_{0.01}(2,2)$=99.00, we conclude that at the stipulated significance level of α = 0.05, Factor A exerts the most substantial effect. Furthermore, both Factor B and C are found to exert significant effects as well. This suggests that the teaching mode predominantly influences classroom effectiveness, with Factor B and C exerting lesser yet statistically significant effects. Finally, the analysis results are listed in Table 4:

Table 4. Analysis of experiment results

	SS	*dF*	*MS*	*F*	Significance
A	526.22	2	263.11	338.29	**
B	128.22	2	64.11	82.43	*
C	46.22	2	23.11	29.71	*
Error	1.56	2	0.78		
Sum	702.22	8			

Note: * indicates a significant impact, ** indicates a highly significant impact.

(8) Formulate the optimal experimental design: Table 4 reveals that the optimal scheme is $A_3B_1C_3$, this means ADDIE teaching model, on-site teaching format, and integration of three forms of mutual assessment are more conducive to enhancing the teaching effect.

4 Teaching Optimization of Machinery Foundation

4.1 Teaching Mode Optimization

Innovative teaching mode is "the fundamental reform and redesign of teaching mode"[5]. ADDIE instructional design model covers a series of core steps in the instructional design process[6]. For the teaching of research courses, educators could integrate case teaching. On the premise of ensuring knowledge acquisition, instructors are able to emphasize key concepts[7]. Through the "evaluation" stage in the ADDIE model, the links between the various aspects of teaching can be promoted.

4.2 Instructional organization Optimization

The experimental result shows that the effect of on-site teaching is slightly better. Teachers should pay attention to the close connection between textbooks and practice in classroom teaching. The word "site" should not be limited to the teaching site, combined with the course content should be in-depth field visits and operations, organize students to visit pharmaceutical enterprises or laboratories, let students operate the equipment by hand, intuitively feel the structure and operation process of the equipment, and enhance the combination of theory and practice.

4.3 Evaluation Setting Optimization

The results show that the effect of the last evaluation method is slightly better, but the overall effect of this factor is not significant. Educational evaluation is the process of evaluating students' learning outcomes and teaching quality. In vocational education, the multiple evaluation is conducive to the promotion of students’ status. They play an active role in evaluation process, promote cooperation and self-reflection. In addition, personalized evaluation and timely feedback are also need to be considered.

5 Conclusions

Teaching optimization experiments based on Machinery Foundation in Orthogonal experiment proved that $A_3B_1C_3$ was the optimal solution in all combinations. In other words, ADDIE teaching mode, on-site teaching form and multiple evaluation could achieve good results. In teaching process, teachers should pay attention to cultivating students' interest and independent learning ability and effectively experience the sense of achievement in learning. Meanwhile, teachers should highlight the consistency and fluency of teaching links, make full use of the teaching mode. Due to the chance factor of experiment, this experiment has a certain degree of confidence, and its conclusions are for reference only. In addition, this method provides some practical references for exploring the optimal teaching combination of different subjects. This use of computer mathematical statistics will also promote education to digital.

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References

1. Xiwen Wang and Yonghuan Guo.: An analysis of secondary vocational education development in China in recent ten years based on China statistical yearbook. ITEI 2, 23-30 (2022).
2. Shuanyun Zhang and Cui Yang.: Problems and countermeasures of classroom teaching reform in secondary vocational schools. Chinese Journal of Education (S1), 27-28 (2020).
3. Anupam Khan and Soumya K. Ghosh.: Data mining based analysis to explore the effect of teaching on student performance. Education and Information Technologies (23), 1677-1697 (2018).
4. Kaiwen Lei, Wubin Qu, Weichao Yang, Xin Li, and Fanzhe Meng.: Optimal design of structural parameters of water-lubricated bearing based on orthogonal experiment method. Mechanical Engineer (8), 93-95+98 (2023).
5. Xiaoying Feng, Ruixue Wang, and Yijun Wu.: A review of the research status of blended teaching at home and abroad. Distance education journal 36 (3), 13-24 (2021).
6. Harim Castellanos Altamirano and Everth Rocha Trejo.: Application of ADDIE in the process of building distributed educational tool b-learning. Revista Iberoamericana de Tecnología y Educación en Ingeniería y Tecnología (26), 634-646 (2020).
7. Rujun Zhou. The "three-way" dimension of the design of "Guide List" for online learning activities in vocational colleges. Educational Science Forum (15), 16-20 (2020).