Taguchi-fuzzy Theory Applied to Optimization of Teaching Module

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Abstract. In this study, a case-reference teaching method was selected, and Taguchi L9 orthogonal table combined with fuzzy control system was adopted to minimize the experimental design, maintain the high precision of the experimental data, and successfully develop the optimal analysis of teaching design mode. This model can effectively improve the quality of teaching. The research results have made a significant contribution to the optimization of teaching design, and can be replicated and followed up.

1. Introduction
In recent years, due to the rapid development of science and technology, colleges and universities have also strengthened practical curriculum education to meet the needs of the future society. In particular, the interactive design applied to the mobile devices has received great attention. Therefore, the department of optometry of Yuanpei University (Yuanpei Medical Science and Technology) has also reviewed the situation and planned an e-commerce course combining optometry and mobile devices. Based on this course (e-commerce), this study starts to develop an analysis model of the optimal combination of teaching process design, and conduct research on the design of classroom teaching process to improve the overall teaching effectiveness and provide classroom teaching reference and help.

2. Literature Discussion
How to effectively improve the overall effectiveness of classroom teaching is the most concerned issue for educators. According to the literature, there are many forms and methods of classroom teaching methods in Chinese areas, such as case reference teaching method[1], teaching demonstration teaching method[2] and task-driven teaching method[3].
From the discussion and analysis of the literature, most of the researches are about the types of teaching methods and the evaluation of teaching effects, but there are few studies on the design of teaching history and the application of field practice. That is to say, the research on teaching methods is relatively concentrated on the level of theoretical methods, but for the teachers who actually need to practice, how to practice them in particular, and the research on optimization analysis after application is relatively rare. Therefore, the focus of this research is to use an appropriate combination analysis model suitable for students' classroom teaching methods and research and development of practical teaching history. Really let the students become the masters of the classroom, truly embody the "student as the main body", so that students can learn in a relaxed and pleasant atmosphere and improve their learning outcomes.
3. Research Methods and Experiment Analysis

Through literature discussion, in-depth understanding of the research status and development trend of classroom teaching, analysis and comparison of several teaching methods commonly used in the current classroom[4], the number of times used is relatively more than the case reference teaching method, teaching demonstration teaching method. There are four methods, such as task-driven teaching method and guided heuristic teaching method. Therefore, this paper uses the above four teaching methods to carry out the anonymous survey of students to select the case teaching method as the teaching axis (44/53=83%).

The research scope focuses on the design and practice of the classroom teaching process, the specific implementation steps of the teaching process design, and the analysis and introspection of the results are explained below. The flow chart of its research structure is shown in Figure 1.

![Research architecture flowchart](image)

**Figure 1.** Research architecture flowchart

1. The research framework for teaching practice. The choice of teaching method is obtained through anonymous surveys of course students.
2. Prepare teaching materials and implement group teaching in accordance with the teaching method.
3. Develop the Taguchi-fuzzy model to analyze the learning effect of each group and select the optimal learning materials.
4. Continuous improvement of teaching methods and editing of teaching materials.

3.1. Multi-objective Optimization Analysis Method

In this study, the Taguchi method combined with the fuzzy theory was used to carry out multi-objective optimization analysis, and the analytical method was used to optimize the teaching process design to achieve the overall quality improvement of teaching effectiveness.

(1) Taguchi Method

The first step in the Taguchi experimental method[5] is to determine the quality characteristics of the problem. Its quality characteristics can be divided into three characteristics: the small characteristics, the large characteristics and the desired characteristics. According to different quality characteristics, different average quality losses will be used as quality indicators. Generally, in the Taguchi method, a Signal to noise ratio (S/N ratio) is used as a quality index. The characteristics selected in this study are the large quality characteristics. The quality characteristic value has a Lower Specification Limit (LSL) and is non-negative. The experimental data analysis of this study uses L9 to configure the orthogonal array and convert it into S/N ratio, as shown in Table 1.

"L": the orthogonal table (L is the first letter of Latin Square)
"9": number of straight table columns (number of experiments), No.1~No.9
"4": number of straight table rows (factor number), A~D
"3": the number of the level (the number in the number of lines is the level)

Four control factor codes (A, B, C, D), respectively, guided e-commerce website, sales e-commerce website, interactive e-commerce website, theme e-commerce website, four types of projects, each type of project contains three levels (each level, representing a project in the category).

(2) Fuzzy Logic Approach

Fuzzy theory is widely used in various fields. It originated from LA Zadeh of the University of California, Berkeley in 1965, and published in the Journal of Information and Control - Fuzzy Collection. Fuzzy theory is actually a general term for fuzzy sets, fuzzy relations, fuzzy logic, fuzzy
control, fuzzy measurement and other theories[6]. The basic structure are explained below and as shown in the figure 2.

1) Two parameters (total learning score and attendance rate) are used as inputs to the fuzzy system and processed by the fuzzier.
2) Enter fuzzy system and use fuzzy rules and fuzzy database to make fuzzy inferences.
3) The inference result is unfuzzified, and the MPCI indicator output is obtained.

Table 1. L9 configuration orthogonal array (S/N ratio)

| No. | A  | B  | C  | D  | Average total score | Average attendance rate |
|-----|----|----|----|----|----------------------|-------------------------|
| 1   | 1  | 1  | 1  | 1  | 38.72696             | 38.65627                |
| 2   | 1  | 2  | 2  | 2  | 39.02656             | 39.36237                |
| 3   | 1  | 3  | 3  | 3  | 37.92689             | 38.16616                |
| 4   | 2  | 1  | 2  | 3  | 36.92538             | 38.03527                |
| 5   | 2  | 2  | 3  | 1  | 36.16368             | 37.69806                |
| 6   | 2  | 3  | 1  | 2  | 38.89942             | 39.16229                |
| 7   | 3  | 1  | 3  | 2  | 39.64841             | 39.11077                |
| 8   | 3  | 2  | 1  | 3  | 38.89735             | 38.63831                |
| 9   | 3  | 3  | 2  | 1  | 37.48105             | 36.71343                |

Figure 2. The basic structure of the fuzzy inference system

3.2. Multi-objective Optimization Analysis Experiment

The Taguchi experimental method, fuzzy inference system and teaching process design are combined to design a multi-performance characteristics index (MPCI) as the output parameter of the experimental design. The contribution ratio of the output parameters is optimized for the teaching process design. Before performing fuzzy reasoning, first set the experimental design initial data (S/N Ratio) of the Taguchi L9 (table 1), the average total score of the semester, and the average attendance rate normalization in the interval of 0 to 1, in order to facilitate follow-up. After the formalization is completed, the fuzzy reasoning process can be performed. In the fuzzy logic controller system, there are two input processing and one output processing, in which the semester average total score, the average attendance rate, and the input are integrated, and the multi-performance characteristic index (MPCI) is used as an output after integration by the fuzzy control system. Two fuzzy sets in a fuzzy system, where the input attribution functions: small (S), medium (M), large (L); output attribution functions: small (S), small medium (SM), medium (M), Zhongda (ML), and Big (L).
The program can be arranged by MATLAB Fuzzy Toolbox[7], such as the fuzzy rule establishment of the fuzzy rule base, the fuzzy database input, the output variable structure, and so on. After the fuzzy rules constructed are arranged by MATLAB fuzzy toolbox, the nine rules are as follows, Fuzzy Rule 1~9:

Fuzzy Rule 1: If [average total score is S] and [average attendance rate is S] Then [MPCI is S]
Fuzzy Rule 2: If [average total score is S] and [average attendance rate is M] Then [MPCI is SM]
Fuzzy Rule 3: If [average total score is S] and [average attendance rate is L] Then [MPCI is M]
Fuzzy Rule 4: If [average total score is M] and [average attendance rate is S] Then [MPCI is SM]
Fuzzy Rule 5: If [average total score is M] and [average attendance rate is M] Then [MPCI is M]
Fuzzy Rule 6: If [average total score is M] and [average attendance rate is L] Then [MPCI is ML]
Fuzzy Rule 7: If [average total score is L] and [average attendance rate is S] Then [MPCI is M]
Fuzzy Rule 8: If [average total score is L] and [average attendance rate is M] Then [MPCI is ML]
Fuzzy Rule 9: If [average total score is L] and [average attendance rate is L] Then [MPCI is L]

Through the fuzzy logic controller (MATLAB fuzzy toolbox), the 9 sets of values normalized are substituted as input variables, and the fuzzy rule base constructed is used for nine calculations, and then fuzzified. Nine sets of final MPCI output values are available, table 2 can be obtained after finishing.

| No. | A  | B  | C  | D  | Average total score | Average attendance rate | MPCI |
|-----|----|----|----|----|--------------------|--------------------------|------|
| 1   | 1  | 1  | 1  | 1  | 0.74               | 0.73                     | 0.65 |
| 2   | 1  | 2  | 2  | 2  | 0.82               | 1.00                     | 0.804|
| 3   | 1  | 3  | 3  | 3  | 0.51               | 0.55                     | 0.534|
| 4   | 2  | 1  | 2  | 3  | 0.22               | 0.50                     | 0.363|
| 5   | 2  | 2  | 3  | 1  | 0.00               | 0.37                     | 0.241|
| 6   | 2  | 3  | 1  | 2  | 0.79               | 0.92                     | 0.73 |
| 7   | 3  | 1  | 3  | 2  | 1.00               | 0.91                     | 0.846|
| 8   | 3  | 2  | 1  | 3  | 0.78               | 0.73                     | 0.664|
| 9   | 3  | 3  | 2  | 1  | 0.38               | 0.00                     | 0.242|

According to the Taguchi experiment L9 configuration of the orthogonal array plan (table 1), the MPCI values of the same level in the four fields A, B, C, and D are averaged, for example:
The MPCI of No.1~No.3 of factor A is ((0.65+0.804+0.534)/3)=0.6627
The MPCI of No. 4 to No. 6 of the A factor is ((0.363+0.241+0.73)/3)=0.4447
The MPCI of No.7~No.9 of factor A is ((0.846+0.664+0.242)/3)=0.5840
The level effect of the MPCI value for each factor (four factors of A, B, C, and D) can be calculated (each factor has 3 levels), as shown in table 3, called the MPCI reaction table. The range column is used to test the importance of the factor. It refers to subtracting the smallest reaction value from the largest reaction value. The reaction value after the addition and subtraction is sorted from large to small. The larger the difference of the reaction values. The greater the importance of the factor; conversely, the smaller the difference in the reaction value, the smaller the importance of the factor.

Table 3. MPCI reaction table

|   | A     | B     | C     | D     |
|---|-------|-------|-------|-------|
| Level 1 | 0.6627 | 0.6197 | 0.6813 | 0.3777 |
| Level 2 | 0.4447 | 0.5697 | 0.4697 | 0.7933 |
| Level 3 | 0.5840 | 0.5020 | 0.5403 | 0.5203 |
| Max-Min | 0.2180 | 0.1177 | 0.2117 | 0.4157 |
| Rank    | 2     | 4     | 3     | 1     |
From the variability analysis results in table 3, it is obvious that Factors “D” has the largest contribution, which can be used to reduce the variability of the system quality characteristics and to reach the target value of the quality characteristics, so that the design quality of the teaching process is better; Factors “A” and “C” are The secondary auxiliary role can reduce the proportion of the teaching process design to enhance the overall combination of teaching results. The multi-objective optimization method combined with Taguchi method and fuzzy theory calculates the multi-objective optimization combination of MPCI, and finally selects the level parameter combination of the best factor. The corresponding case is: A^1 B^1 C^1 D^2.

4. Conclusion

Based on the above chapters, the following conclusions can be summarized as the innovation and contribution of this research:

(1) Research method According to the proposed Taguchi experiment and fuzzy theory rule, the S/N ratio of quality characteristics is calculated by using the Taguchi direct table to calculate the average total score and average attendance rate of each study group. You can enter the fuzzy inference system.

(2)After entering the fuzzy inference system, through a series of fuzzy, fuzzy rule base, fuzzy database, fuzzifier steps, and the fuzzy controller programmed by MATLAB Fuzzy Toolbox. Perform the fuzzy inference operation, obtain the multi-performance index (MPCI), and make the MPCI reaction table analysis, select the optimal combination of the factor level, and finally use ANOVA analysis to calculate the influence contribution rate of each factor level in the best combination.

(3) Using the Taguchi L9 orthogonal array, with reliable experimental theory support, with the most streamlined experimental design times, maintaining the high accuracy of experimental data analysis, and finally completing the new application of using the Taguchi experiment combined with the fuzzy theory system, research and development case reference teaching The analysis model of the optimal design of the legal process design serves as the basis for continuous improvement of the instructional design. The results of the study have made a significant contribution to the optimal combination of teaching process design, which can be used by teachers to refer to the value of application and researcher's continuous research.

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