



Teaching Quality Evaluation of Error Theory and Data Processing Based on AHP Entropy Weight Method

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Abstract. By analyzing the relevant factors that affect teaching quality, an evaluation index system that affects teaching quality is constructed from five aspects: teaching objectives, teaching content, teaching methods, teaching resources, and teaching effectiveness. By applying the AHP entropy weight method to calculate weight values and analyzing the results of each weight, improvement measures were proposed for various influencing factors, providing direction for the next stage of teaching improvement.

Keywords: Teaching Evaluation; AHP Entropy Weight Method; Improvement Measures

1 Introduction

In recent years, with the rapid development of modern educational technology, the teaching mode of the curriculum has further shown diversity. The factors that affect teaching quality are also more diverse, and the evaluation methods of teaching quality need to continue to develop accordingly. The research and improvement of teaching quality evaluation have become problems that researchers need to face. At present, Cao Hongjiang and others in China have explored the ideas for evaluating teaching quality and proposed a strategy that balances teaching management and teaching assistance. Li Yuefeng et al. proposed a multidimensional, multi-level, and multi-index teaching quality evaluation system based on the three basic stages of pre-class, in-class, and post-class, as well as core elements such as professional ethics and knowledge skills, combined with educational and teaching concepts. The evaluation index weights were set through questionnaire surveys, interviews, expert evidence, and other methods [1-3].

Error Theory and Data Processing, as a foundational course in the discipline of Measurement and Control Technology and Instrumentation, plays a crucial role in enhancing the knowledge level, practical skills, and professional competence of specialized talents. The evaluation of teaching quality in this course effectively promotes the improvement of instructional quality. Leveraging expert experience, industry background, as well as the Analytic Hierarchy Process (AHP) and entropy weight method, the course team has established an AHP-entropy weight-based teaching qual-

ity evaluation index system. By combining and weighting various evaluation indicators, the validity of each indicator's information is determined. Based on the evaluation results, effective improvement measures are proposed, contributing to the enhancement of teaching quality.

2 Evaluation System Design

This evaluation system combines the AHP model with the entropy weight method. The system design steps are as follows: First, design teaching quality as the primary indicator, with teaching objectives, teaching content, teaching methods, teaching resources, and teaching effectiveness as secondary indicators. Second, use the AHP model to conduct pairwise comparisons for each indicator to determine their relative importance. The comparison results are converted into a judgment matrix, and the eigenvalue method is employed to calculate the weight vector, thereby obtaining the weight of each indicator within the overall evaluation system. Third, apply the entropy weight method to calculate the weight of each indicator. By analyzing the weight coefficients, the key areas and optimization directions for curriculum reform are identified. The system indicator Table 1 is as follows:

Table 1. Teaching Quality Evaluation System

| | first-level indicator | second-level indicator | Indicator Description |
|------------------|-----------------------|----------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|
| | | rationalityB11 | Meets the requirements of the training program, and the course plan is reasonable and feasible |
| teaching quality | Teaching objectivesA1 | feasibilityB12 | Feasible and able to translate into specific teaching activities and strategies |
| | | developmental B13 | Suitable for students' situation and development level, able to promote their development |
| | teaching contentA2 | adaptabilityB21 | Meets the requirements of the syllabus and is suitable for the development level of students |
| | | timelinessB22 | Timely content updates |
| | | PracticalityB23 | Reasonable setting of practical activities, closely integrated with teaching content |
| | teaching methodA3 | systematicness B31 | The explanation content is comprehensive, the key points are highlighted, and the thinking is clear |
| | | interactivityB32 | Smooth classroom interaction and communication |
| | | guidingB33 | Diversified teaching methods inspire students to think independently and enhance their innovation ability |
| | teaching resourcesA4 | integrityB41 | The teaching syllabus, textbooks, lesson plans, and other materials are comprehensive and rich in content |
| | | compatibilityB42 | The content of teaching resources is suitable for the development level of students |
| coherenceB43 | | Strong content relevance and orderly knowledge structure | |

| | | |
|------------------------------|----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|
| teaching effectiveness A5 | knowledgeB51 | Good mastery of teaching content and solid theoretical knowledge |
| | practical abilityB52 | Knowledge of practical problems, possess analytical and problem-solving skills, master teaching content well, and have solid theoretical knowledge |
| | professionalism B53 | Having preliminary professional ethics can promote future career development |

3 Analytic Hierarchy Process

3.1 Steps

Step 1: Analyze the relationships between various factors and establish a hierarchical model: the highest layer (Layer 1) is the target layer, the middle layer is the principle layer (which may also include some subcriterion layers), and the lowest layer is the solution layer.

Step 2: Based on the importance of the criteria from the previous layer, construct a judgment matrix and make pairwise comparisons between factors at the same level.

Step 3: Construct a judgment matrix. According to the hierarchical structure model, the relative importance of each element at a certain level is compared to determine the judgment score of that level, and the judgment scores of each level are finally formed into a judgment matrix.

Step 4: Calculate the maximum eigenvalue and corresponding eigenvectors of each judgment matrix, and perform consistency checks; If it passes the inspection, proceed to step 4; otherwise, return to step 2 [4-6].

3.2 Weight Determination

1) Construct a judgment matrix by quantifying the importance of each influencing factor on a scale of 1-9. When A is more important than B, it is marked as 3; conversely, when B is more important than A, it is marked as 1/3. In this system, 10 experts were invited to conduct an anonymous questionnaire survey on the importance of evaluation indicators[7-8]. Table 2 shows the judgment matrix of Expert 1.

Table 2. AHP model judgment matrix

| | Teaching objectives | Teaching content | Teaching method | teaching resources | teaching effectiveness |
|------------------------|---------------------|------------------|-----------------|--------------------|------------------------|
| Teaching objectives | 1 | 3 | 5 | 3 | 7 |
| teaching content | 1/3 | 1 | 3 | 2 | 5 |
| teaching method | 1/5 | 1/3 | 1 | 3 | 5 |
| teaching resources | 1/3 | 1/2 | 1/3 | 1 | 2 |
| teaching effectiveness | 1/7 | 1/5 | 1/5 | 1/2 | 1 |

2) Find the maximum eigenvalue and eigenvector

Find the maximum eigenvalue λ_{\max} of judgment matrix A and its corresponding vector $\omega = (\omega_1, \omega_2, \dots, \omega_n)^T$. It can be seen that the subjective weight coefficients of each factor are the eigenvectors ω of the judgment matrix A. After normalization, the subjective weight allocation of each indicator is obtained.

$$\omega = (\omega_1, \omega_2, \dots, \omega_n)^T \quad (1)$$

$$\omega'_i = \frac{\omega_i}{\sum_{i=1}^n \omega_i} \quad i = 1, 2, \dots, n \quad (2)$$

3) Hierarchical single sorting

The matrix corresponds to the eigenvector of the maximum eigenvalue, and after normalization, it becomes the ranking weight of the relative importance of the corresponding factors at the same level to a certain factor at the previous level. Complete the consistency check of the judgment matrix using formulas (3) and (4):

$$C_I = \frac{\lambda_{\max} - n}{n - 1} \quad (3)$$

$$C_R = \frac{C_I}{R_I} \quad (4)$$

CI: Consistency Indicator; λ_{\max} : maximum eigenvalue; n: Matrix order; RI: Average Random Consistency Index; When $RI < 0.1$, matrix consistency is considered passed. According to the above matrix, the eigenvalue λ_{\max} is 5.19, the eigenvector w_1 is $\omega_1 = [0.3347 \ 0.2559 \ 0.1708 \ 0.1591 \ 0.0796]$, and the consistency ratio CR is 0.04 ($CR < 0.1$), which meets the requirements.

4) Hierarchical total sorting: Synthesize the weights of the criterion layers, calculate the comprehensive weights in sequence, and form the total sorting matrix B_{ij} .

4 Entropy Weight Method

The entropy weight method is widely used in indicator evaluation and data-assisted project decision-making. The smaller the information entropy of the evaluation factors, the greater the amount of information provided, and the higher the objective weight values corresponding to the evaluation factors. Therefore, the entropy weight method can be used to calculate the weights of experts themselves. Firstly, construct an expert-level vector, assuming that n experts evaluate m objectives. B_{ij} is the weight coefficient value of the i-th decision expert for the jth objective, that is, the matrix obtained by the hierarchical total ranking is the evaluation result of the expert group. Based on the weights of each expert, calculate their average as the optimal weight, and then use the difference between each expert's evaluation weight and the optimal weight as the basis to infer the expert's evaluation level and credibility. Finally, the weights of each indicator obtained from the AHP model and entropy weight method are combined to obtain the final weight vector, reflecting the importance of each indicator in the entire evaluation system.

$$f_{ij} = \frac{\omega'_i - \bar{\omega}'_i}{\sum_{i=1}^n \omega'_i - \bar{\omega}'_i} \tag{5}$$

$$h_i = -\frac{1}{\ln^n} \sum_{i=1}^n f_{ij} \ln f_{ij} \tag{6}$$

The smaller the entropy value H_i , the higher the evaluation level of the decision expert and the higher the credibility of the evaluation results. The weight of decision-making experts in the evaluation process of each objective; the higher the k_i value, the higher the evaluation weight of the expert.

$$H_i = \sum_{j=1}^n h_{ij} \tag{7}$$

$$k_i = \frac{1/H_i}{\sum_{i=1}^n 1/H_i} \tag{8}$$

5) Using the AHP entropy weight method, the subjective weight ω_{ji} and objective weight k_i of the expert evaluation indicators are fused and calculated as follows: the combination vector of the evaluation indicators $\omega' = (\omega'_1, \omega'_2, \dots, \omega'_n)^T$, where

$$\omega'_i = \omega_{ji} * k_i \tag{9}$$

The weight values calculated by combining the evaluation indicators that affect teaching quality based on the AHP entropy weight method are shown in Table 3.

Table 3. Weight values of evaluation indicators

| first-level indicator | AHP legal value | AHP entropy weight method | second-level indicator | AHP legal value | AHP entropy weight method |
|--------------------------|-----------------|---------------------------|------------------------|-----------------|---------------------------|
| Teaching objectivesA1 | 0.0796 | 0.0702 | rationalityB11 | 0.0419 | 0.0386 |
| | | | feasibilityB12 | 0.0459 | 0.0435 |
| | | | developmentalB13 | 0.0321 | 0.0217 |
| Teaching contentA2 | 0.1708 | 0.2016 | adaptabilityB21 | 0.098 | 0.1059 |
| | | | timelinessB22 | 0.0545 | 0.0811 |
| | | | PracticalityB23 | 0.0598 | 0.0532 |
| teaching methodA3 | 0.2559 | 0.3022 | systematicnessB31 | 0.1056 | 0.1032 |
| | | | interactivityB32 | 0.1177 | 0.1376 |
| | | | guidingB33 | 0.0335 | 0.0312 |
| teaching resourcesA4 | 0.1591 | 0.1161 | integrityB41 | 0.0515 | 0.0321 |
| | | | compatibilityB42 | 0.0611 | 0.0525 |
| | | | coherenceB43 | 0.0381 | 0.0312 |
| teaching effectivenessA5 | 0.3347 | 0.3524 | knowledgeB51 | 0.1299 | 0.121 |
| | | | practical abilityB52 | 0.1071 | 0.1232 |
| | | | professionalismB53 | 0.0233 | 0.024 |

5 Analysis and Improvement

By analyzing the weight data, it can be concluded that teaching content, teaching methods, and teaching effectiveness are key indicators that affect teaching quality. Among them, the adaptability, timeliness, interactivity, and practicality of teaching content, teaching methods, and teaching effectiveness are particularly important and need to be improved and enhanced.

In terms of teaching content, timeliness needs to be improved. The teaching content should be organically integrated with the pace of technological and industry progress, as well as the knowledge points of the curriculum, and selected based on cutting-edge technology, engineering practical cases, etc. Introduce examples of rail transit in the course. In the introduction of the measurement scheme design, taking rail flaw detection as an example, organize students to consult relevant materials and propose solutions. Compared with the domestically produced GTC-80 II J car, this flaw detection car dynamically scans the steel rail at a speed of 120 kilometers per hour, with 18 probe chips and 3D laser technology, achieving millimeter-level error control. The fully autonomous flaw detection system accurately identifies fine cracks, achieving an 85% damage detection rate. Analyze their respective advantages. The comparison and analysis of various schemes based on this example introduces the latest technological developments and applications, enabling students to understand how to achieve higher accuracy through the rational design of measurement schemes.

In terms of teaching methods, it is necessary to enhance the teaching ability of teachers, achieve precise grasp of key and difficult points, and understand the basics in teaching, thereby improving the efficiency of knowledge acceptance; Using teaching methods such as case study to stimulate students' interest and initiative in learning; Teachers should maintain a high level of sensitivity in teaching, pay attention to their own level and learning status, as well as their mastery of course content, and adjust their interactive methods and pace in a timely manner. Raise open-ended questions to encourage students to think deeply. When analyzing the influencing factors of errors, brainstorming through group discussions and other forms can help students gain a deeper understanding of the knowledge points. By fully utilizing the advantages of digital technology, classroom interaction can be improved through forms such as online voting. After class, combined with online teaching platforms, homework and topic discussions can be assigned to encourage students to solve practical problems and effectively consolidate the knowledge points learned. At the same time, teachers use online platforms to understand students' learning progress and situation, provide timely feedback and guidance, and improve learning effectiveness.

In terms of teaching effectiveness, there has been a significant improvement in practical ability indicators, reflecting the increasing demand for students' practical abilities in modern industries. Multiple experiments can be conducted, and the locomotive water tank liquid level measurement experiment introduced various methods, such as the ruler method and pressure gauge method, through the introduction of the measured items and heuristic teaching. Let students analyze the possible sources of errors, error synthesis, and allocation results of various methods in the measurement process, and compare them accordingly. Considering various factors such as instru-

ment accuracy and the difficulty of measurement implementation, the appropriate measuring instruments, methods, and evaluation methods for measurement results are ultimately selected.

6 Conclusion

This article analyzes the influencing factors of course teaching quality, constructs a teaching quality evaluation system, and applies the AHP entropy weight method to calculate the course evaluation indicators. Through research, it is known that teaching content and teaching effectiveness are the main primary indicator factors affecting the quality of error course teaching. Therefore, improvement measures are proposed from the above three aspects to provide direction for the next stage of teaching improvement.

References

1. Li Bingjun, Xiao Chuang, Guo Sandang. Construction of an Evaluation System for Research based Teaching in Higher Education Institutions Based on Analytic Hierarchy Process [J]. Science, Education and Culture, 2023 (24): 1-4
https://kns.cnki.net/kcms2/article/abstract?v=f0DSObGwzqgA0CnjJ4Pa3-LSmmHDDbPo6wLHndwNnAOO5rOcf0VC7FOkq6r8sIXx01-rGEV7_yQIDIWA_mQZiTIfPpw7enPPF9I02Ncb8LVt4k3izaeYoyDYw2LoLZz3obvE7pZqaJF5prhlR3YH_dYtIJKBdaJYG-nyAWF7Lm4=&uniplatform=NZKPT
2. Yang Zhibo. Application of Analytic Hierarchy Process in Quality Evaluation of Online Teaching in Universities [J]. Research and Practice of Innovation and Entrepreneurship Theory, 2020, 3 (17): 61-62.
https://kns.cnki.net/kcms2/article/abstract?v=f0DSObGwzqi54kXf75G09J9w8aFu2xjS1T2g_WZ4xSnakrWRYd1aQjUTkm_6dyOrDMffNA-RziUjKpd1kOAgKakv005GPpqLnYsq9ycctGEv60VauPo3mJo6ZvI8fII1boMQFr2dR_1QOmNJTSo6eEKTThD51df0oOBOssat5UU=&uniplatform=NZKPT
3. Cao Yusong, Zeng Xianquan Research on Teaching Evaluation Method for University Teachers Based on AHP Method [J]. Journal of Xuchang University, 2020, 39 (5): 13-16
https://kns.cnki.net/kcms2/article/abstract?v=f0DSObGwzqhu8I3x6ZbTKcHUI9afowYLkZoW0KocoufPZKmfhEGvIcn4IxqLJeT8UfckjCL1cqINAuO5FHqV7eWIFGdbjT4L2jJVf673kuZThqi-gVoZiH-B9Aq4z_iQ2-GU-ixl37RiLy3HRknBIRHxFJB7hnNvAyCShp-M4=&uniplatform=NZKPT
4. Chu Jixun, Qi Xiaoqi, Zhang Ting Establishment and Analysis of Evaluation Index System for Course Teaching Satisfaction of College Graduates [J]. University Mathematics, 2021, 37 (6): 38-43.
https://kns.cnki.net/kcms2/article/abstract?v=f0DSObGwzqjtB7UuszJdQ-VuaAe32TzQnEMPzr3C7ha_Hm7ad3z_SR71EqZnmWDZvARqSaAbQ23n6YU_Q4W92jNMcJDSzov-KaG80YKkKw8gSnzZsZiY1npxQIyqAJZC2i7nssrK4yx0oQ1QmFWWhpZ3R4rS-SwoLfhVHN-4rzDdzUo=&uniplatform=NZKPT

5. Wang Fen, Yang Xiumiao. Research on Teaching Quality Evaluation of Chemistry Courses Based on AHP-Entropy Weight Method [J]. Journal of Jingdezhen Institute of Arts and Crafts, 2024, 39(3): 92-98.
https://kns.cnki.net/kcms2/article/abstract?v=f0DSObGwzqg5Q_HMIUE3we3fX-zjuppXZlbo-TA9dEKO PZRbhfDvMyRNvRRNjuK1o1zJZnrV9QRMy5AXmPrPGx1MFUKLKhbzY8M7Ec9kHuXLp6nX61t3ZuKzZP4j5OeaYoJvmEzinAFglsEGLqDaIOP-3JOiXW8K_-PdZ7oFXTxo=&uniplatform=NZKPT
6. Pei Shaojing, Su Ya Research on the Application of Analytic Hierarchy Process in the Evaluation System of Higher Education Teaching [J]. Light Industry Technology, 2021, 37 (4): 167-169.
https://kns.cnki.net/kcms2/article/abstract?v=f0DSObGwzqjEzRKTQ6CioZru0eqGv1EbSIYsaq-hOH3iD69Ugl_3PXDvpqaKpfgkWXpjyV5e5TTRBDQF4u9bM_Ds5kZ1pcTk79M7WQL2TSKkzzUP-LTrmhQdecjG4gT-Lq_IKUdJB-JDI-VVvZQfPuGYJnKaBmvb-M_PMYTMr0=&uniplatform=NZKPT
7. Bala Chandran, Bruce Golden, Edward Wasil. Linear Programming Models For Estimating Weights in The Analytic Hierarchy Process [J]. Computers and Operations Research, 2005(32):2235-2254.
8. PLESCHOVA G, MCALPINE L. Helping teachers to focus on learning and reflect on their teaching: what role does teaching context play? [J]. Studies in Educational Evaluation, 2016, 48(01):1-9.

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