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Research on Comprehensive Evaluation of Online-Offline Hybrid Teaching and Learning Effect of Experimental Course Based on AHP Method

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Abstract. The online and offline hybrid teaching mode has become a new direction of the experimental teaching, as the traditional evaluation method that evaluates the learning effect of students' experimental process based on the results is no longer applicable. In this paper, aiming at the problem of comprehensive evaluation of students' learning effect in online and offline mixed experimental teaching process, a comprehensive evaluation system based on AHP method is proposed, which includes eight evaluation index systems, determines index weights through expert opinions of network platform, standardizes the evaluation results, and obtains the final comprehensive evaluation results of students so as to provide theoretical and methodological basis for comprehensive evaluation of online and offline mixed experimental teaching.

Keywords: online-offline hybrid teaching · Comprehensive Evaluation · AHP

1 Introduction

In recent years, influenced by the new generation of digital information technology and social environmental factors, Internet education technology has developed rapidly. Internet education technology can not only be applied in the teaching of theoretical courses, but also can be effectively applied to the experimental teaching process through virtual simulation technology and experimental simulation software. The online and offline mixed teaching model of experimental courses is still in the developing stage in general, the understanding and the way of adopting this model are different among the teachers and many courses still follow the traditional evaluation index system especially in the evaluation mechanism of students' learning effect. With problems such as single evaluation subject, limited evaluation dimension and only focusing on the result evaluation, it seriously restricts the synchronous development of experimental teaching link and Internet teaching technology. Therefore, this paper takes the electronic information circuit experimental course as an example, considers the online and offline experimental teaching process and its experimental effect, and constructs a scientific and standard evaluation system of learning effect through AHP method. It provides some reference for the construction of evaluation system of online and offline hybrid experimental teaching [1].

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2 Design and Implementation of Online and Offline Hybrid Experimental Teaching Based on Network Teaching Platform

Taking Digital Logic Circuit Experiment as an example, through the integration of the knowledge points of the course, the course is divided into eight modules, with each module corresponding to a practical application project. The experimental objectives, requirements and contents are constructed in a Project-Driven way with the students trained from the three objectives of professional knowledge, professional skills and comprehensive ability [2].

The instructional design is revealed in Fig. 1. With the experimental process utilizing the online and offline mixed teaching mode. The experimental teaching tasks include three stages: online learning before class, online and offline combination in class, online consolidation after class. Through three stages of learning, the final experimental objective is ultimately reached [3].

2.1 Study Online Before Class

Before class, experimental teachers upload experimental course resources, including experimental theory knowledge PPT, experimental operation micro-class, pre-class test questions, experimental group discussion topics, to the network teaching platform for students to learn independently. As a result, students can understand the experimental principle, familiarize themselves with the experimental operation methods, master the specific steps of the experiment through PPT and micro-lessons, and upload the simulation results after the experiment simulation by the simulation software. Furthermore, students can communicate with teachers whenever they have any problems; students' tracks and progress can be recorded by the network teaching platform, and reflect the evaluation of self-study effect [4].

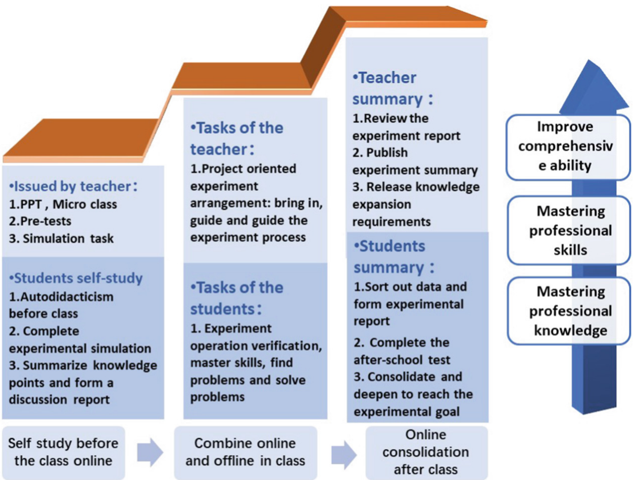

Fig. 1. Design of online and offline hybrid experimental teaching (Source: Author's own)

2.2 Combine Online and Offline in Class

Through pre-school network learning, students have a preliminary understanding of the experimental principles and methods, and predict the experimental results through simulation. The main task of classroom teaching is to confirm the results of experiments through actual operations and to complete the expansion of experiments and the students start the experiment step by step in the course of the classroom experiment. In the course of the experiment, they can also work in combination with the micro-lessons of the network teaching platform with teachers as a guiding role in the experiment, timely identify the problems in the students' experiment to expand their experimental ability.

2.3 Consolidate on the Line After Class

After class, students organize and analyze the experimental results and data, summarize the problems encountered during the experiment, form an experimental report, and submit the report to the network education platform. Teachers can read the experimental report in the platform; students can receive feedback in time, and other students can display excellent report models.

3 Construction of Comprehensive Evaluation Index System of Learning Effect Based on AHP

3.1 Analytic Hierarchy Process

With math and psychology, the Analytic Hierarchy Process (AHP) is a method for organizing and analyzing complex decisions which was developed by Thomas L. Saaty in the 1970s and has been refined since then [5]. In recent years, this method has been increasingly employed in the field of education and teaching. For example, AHP can be used to evaluate students' performance by selecting different indicators, or APH can be adopted as the main empowering method to construct the evaluation index system of teaching quality.

3.2 An AHP Based Method for Evaluating Students' Achievement in Online and Offline Hybrid Experimental Teaching

According to the requirements of multi-dimensional and procedural learning evaluation of online and offline hybrid teaching experiment teaching, the evaluation process is required to run through the entire teaching process, and from multiple dimensions, a variety of evaluation elements are used to form an evaluation index system. Based on the comprehensive analysis of the network teaching platform and integrated with the opinions of the education experts, including the principles of systematicness, scientificity, comparability, measurability and independence of the comprehensive evaluation, this paper has constructed a hierarchical model of comprehensive evaluation indicators for the learning effect of students in experimental courses, as shown in Fig. 2.

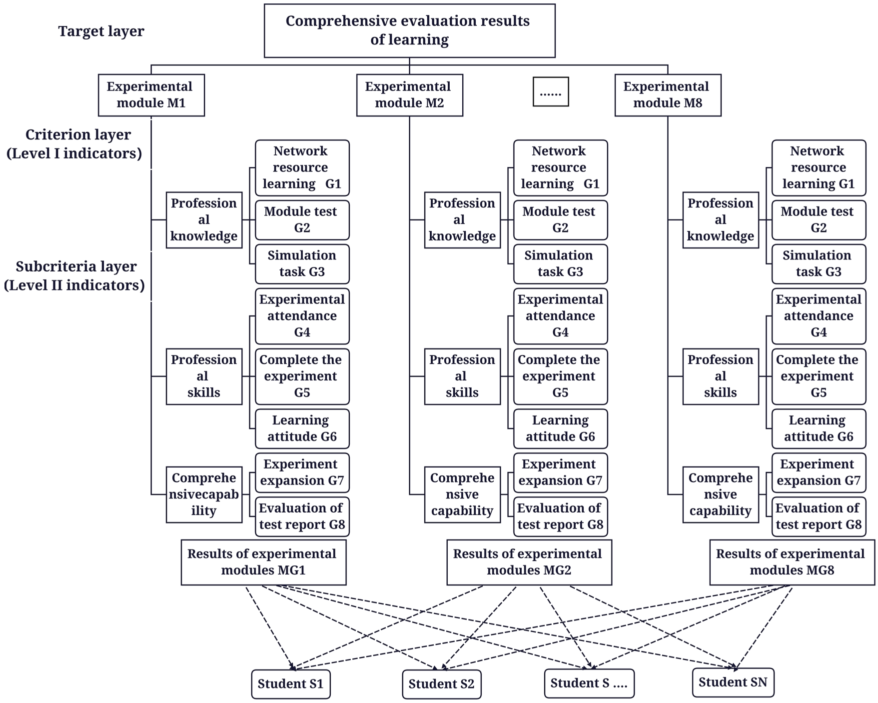

Fig. 2. Progressive Hierarchical Model for Student Comprehensive Evaluation (Source: Author's own)

The main elements in the model are:

(1) **Evaluators.** As the evaluator plays an important role in the evaluation process, the given purpose of evaluation, the establishment of evaluation index, the selection of evaluation model and the determination of weight factor are all related to the evaluator. In this system, the evaluator gives the evaluation of learning activities for the teachers' experts and the network teaching platform.

(2) **The object being evaluated.** In this evaluation system of learning effect, the evaluated objects are students.

(3) **Evaluation index.** It reflects the basic elements of the evaluated objects and constitutes the evaluation index system together [3]. In this system model, the target layer is the final evaluation results of students of this experimental course, while the criteria layer is the evaluation results of each module of the experiment, and the sub-criteria layer is the process elements and evaluation indicators of online and offline learning activities in the experiment. As shown in the figure, the course is divided into eight experimental modules, and each experimental module evaluation index is defined as a first-level indicator (M1, M2, M3,…, M8) while the second-level indicator is determined according to the subdivision activities of the first-level indicator and the online and offline evaluation requirements with eight process elements selected and defined as (G1, G2, G3, G4, G5, G6, G7, G8).

(4) **Weight Coefficients.** Relative importance of an evaluation index is different from that of an evaluation purpose [6]. The evaluation matrix is determined by the evaluation suggestions of the network education platform and expert opinions obtained through the questionnaire survey, which is established and the final weight is obtained. As shown in Table 1.

It can be seen from the above table that for network resource learning, module testing, simulation tasks, experiment attendance, timely completion of experiments, learning attitude, experiment expansion/flipped classroom, and experiment report evaluation, a total of 8 items were constructed to conduct AHP hierarchical research (calculation method: sum product method), and feature vectors were obtained through analysis, and the corresponding weight values of G1 ~ G8 were 11.416%, 12.304%, 13.098%, 7.520%, 18.461%, 8.606%, 12.812%, and 15.783% respectively. In addition, the maximum eigenvalue (8.166) can be calculated by combining the eigenvector, the CI value (0.024) can be calculated by using the maximum eigenvalue value, and the RI value (1.410) can be obtained by combining the order of the judgment matrix; the CR value can be figured, and the consistency judgment can be made [7] (Table 2).

The calculated CR value is $0.017 < 0.1$, which means that the judgment matrix in this study meets the consistency test and the calculated weights are consistent.

(5) **Comprehensive evaluation results.** Although the weight of each indicator is obtained according to the analysis model, it is not accurate to determine the students' knowledge mastery only by the score of each indicator and the score obtained by the weight product, and data standardization is also required. This model adopts

Table 1. AHP analysis results (Source: Author's own)

term	Eigenvector	Weight	Maximum eigenvalue	CI
Network resource learning	0.913	11.416%	8.166	0.024
Module test	0.984	12.304%		
Simulation task	1.048	13.098%		
Experimental attendance	0.602	7.520%		
Complete the experiment	1.477	18.461%		
Learning attitude	0.688	8.606%		
Experiment expansion	1.025	12.812%		
Evaluation of test report	1.263	15.783%		

Table 2. Consistency inspection results (Source: Author's own)

largest eigenvalue	CI	RI	CR	Consistency inspection results
8.166	0.024	1.410	0.017	Passed

minimum maximum normalization, and the conversion formula is as follows:

$$X^* = \frac{X - X_{min}}{X_{max} - X_{min}} \times 100$$

According to the formula, the standard mapping interval defined in this model is [0–100], X_ Max and X_ min represents the highest score and the lowest score in the same index. For example, a student gets 70 points in both the "module test" indicator and the "experiment report" indicator, while the lowest score in the "module test" indicator is 50 points and the highest score is 80 points, meanwhile the lowest score in the "experiment report" indicator is 60 points and the highest score is 90 points. After standardized conversion, the student gets 67 and 33 points in the standard scores of these two indicators, respectively. The standard score can more effectively reflect the students' mastery of certain indicators. Finally, the standard score of each index by its weight value is multiplied and it is added up until the comprehensive evaluation index of each experimental module is established, and then the final score from the weighted average of the evaluation results of each experimental module is calculated.

4 Application Examples

Taking the Digital Logic Circuit Experiment course of electronic information as an example, which relies on the network teaching platform, and the teacher opens the course class on the platform while students can enter the class through the registered account. As teachers can guide students to conduct online self-study and complete relevant indicators by publishing teaching resources, micro classes, self-learning tasks, launching tests, discussions, etc. in the class, all learning activities of students on the platform will be recorded and a database will be generated. During the implementation of classroom teaching, teachers will record students' scores in electronic files according to their attendance, experimental operation, ability development and other performances. After class, the experimental reports submitted by students will be graded, imported into electronic archives, and finally summarized into the database as the data will be imported into the evaluation system model to form the final evaluation scores of students. The following Table 3 shows the scores of each index of experimental module M1 of 10 students:

In the table, S represents the name of the student; G represents the original score of each process indicator in the experimental module M1. After the minimum maximum normalization of the data, the standard score and weighted score of each process indicator in the M1 module are obtained as follows (Table 4).

According to the same processing method, the evaluation results of each experimental module in the criteria layer are recorded and processed. As the class hours of each module from M1 to M8 are different, according to the class hour proportion, the weight distribution of the first level indicators in the model is.

M [0.10.10.10.10.10.10.20.2]

Therefore, the final process assessment scores of the 10 students' experimental courses are:

Table 3. 10 Original scores of each index of M1 experimental module for 10 students (Source: Author's own)

	G1	G2	G3	G4	G5	G6	G7	G8
S1	90	80	80	100	62	85	83	90
S2	70	93	82	100	82	90	73	85
S3	100	67	67	100	73	90	80	90
S4	45	80	77	100	85	70	73	90
S5	30	40	85	100	71	90	67	80
S6	50	80	76	100	73	90	80	85
S7	100	90	75	100	77	80	60	90
S8	100	90	80	100	85	90	85	95
S9	100	90	73	100	85	90	80	90
S10	90	80	82	100	72	80	90	90

Table 4. 10 Standard scores and weighted total scores of each index of M1 (Source: Author's own)

	G1	G2	G3	G4	G5	G6	G7	G8	Weighted total score M1
S1	86	75	72	100	0	75	77	67	63
S2	57	100	83	100	86	100	44	33	73
S3	100	50	0	100	49	100	67	67	62
S4	21	75	54	100	100	0	44	67	61
S5	0	0	100	100	38	100	22	0	39
S6	29	75	50	100	49	100	67	33	58
S7	100	94	44	100	64	50	0	67	63
S8	100	94	72	100	100	100	83	100	93
S9	100	94	35	100	100	100	67	67	81
S10	86	75	81	100	42	50	100	67	73

Although there are many indicators of each element in the implementation process of the model and there are many data to be recorded; many data can be directly generated and recorded by the network teaching platform (Table 5). Relying on the data processing means of the network teaching platform, teachers only need to make corresponding settings in the platform, and then the system can easily generate the corresponding comprehensive evaluation results. The evaluation index obtained by the evaluation system reflects the actual teaching situation of the course Digital Logic Circuit Experiment, and achieves the expected effect, which provides a reference for the establishment of the online and offline hybrid experimental course teaching evaluation system [8].

Table 5. Final Process Assessment Scores of 10 Students in Experimental Courses (Source: Author's own)

	M1	M2	M3	M4	M5	M6	M7	M8	Final result
S1	63	75	72	79	65	75	77	85	75
S2	73	85	83	80	75	70	82	85	80
S3	62	75	78	73	80	82	80	80	77
S4	61	75	65	78	80	78	82	85	77
S5	39	60	50	65	70	65	68	68	62
S6	58	75	70	85	80	82	78	85	78
S7	63	70	77	80	64	78	70	67	71
S8	93	94	88	93	92	90	92	95	92
S9	81	94	82	88	85	88	90	92	88
S10	73	75	81	88	75	78	82	90	81

5 Conclusion

This paper proposes a comprehensive evaluation model based on AHP, aiming at the comprehensive evaluation of students' experimental process in online and offline hybrid experimental teaching. Consequently, the teaching practice has proved that the comprehensive evaluation model has the strengths of combining the experimental objectives with the cultivation of students' professional abilities, allocating the objective evaluation of the experimental process according to different weights of the experimental process, and exceeding the weaknesses of the traditional evaluation method, such as the single evaluation subject and limited evaluation dimensions [9]; the model, therefore, can be widely applied in online and offline hybrid teaching experiment courses. However, due to the disparities in the subjects of different courses, online and offline hybrid models could also different, because in practical application, the content and weight distribution of the experimental process indicators can be reasonably adjusted according to the characteristics of the course so as to achieve the best comprehensive evaluation effect.

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