Construction of Combined Teaching Evaluation System Based on STATA Analysis

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Yutian Li(✉)
Shijiazhuang University of Applied Technology, Shijiazhuang, China
2014010685@sjzpt.edu.cn

Abstract—Designing a reasonable combined teaching scheme is not only the need to achieve teaching optimization, but also a reasonable choice to improve the overall level of teaching efficiency. The existing researches lack an evaluation system to judge the rationality of their designs. Therefore, this paper takes music teaching as an example to carry out the research on the construction of combinatorial teaching evaluation system based on STATA analysis. Firstly, the implementation process of the combined teaching strategy is provided here, and the construction of the combined teaching evaluation system is carried out from seven aspects, namely teaching in fun, emotional experience, student engagement, elicitation and induction, teaching according to students' aptitude, creative development and vividness and intuitiveness. The entropy weight method is adopted to assign the weight of the combined teaching evaluation index of music major courses. Based on stata15.1 software tool, regression analysis is carried out on the main factors that affect the effect of combined teaching, and the relevant regression analysis model is constructed to realize the effect prediction of short-term combined teaching scheme in the case of small samples. The experimental results verify the effectiveness of the evaluation system and analysis model.

Keywords—combined teaching, teaching evaluation system, regression analysis, STATA software

1 Introduction

The teaching for art majors stresses the unity of artistry and ideology, the combination of theoretical knowledge and practical application, the intuitiveness and visualization of students' learning experience, and the combination of teaching with pleasure and teaching according to students' aptitude [1–4]. Therefore, centering on the course objectives and according to the needs of teaching contents and teaching objectives, various teaching elements are optimized and combined in the process of implementing the teaching for art majors, especially video, audio, projection, VR and other modern teaching media are adopted, so as to create a lively teaching atmosphere in the process and achieve the best teaching effect [5–9].

Designing a reasonable combined teaching scheme is not only the need to achieve teaching optimization, but also a reasonable choice to improve the overall level of

teaching efficiency [10–13]. The evaluation of the combined teaching scheme is an important prerequisite for the implementation of the scheme. Through the evaluation of the combined teaching scheme, the final results of the teaching process planning and teaching means allocation in the early stage of the implementation of the scheme can be obtained, and the application problems that will occur when the combined teaching scheme is used in a teaching unit can be predicted [14–18]. The evaluation of combined teaching scheme provides a general evaluation tool for teachers, teaching quality supervision departments and professional departments. The evaluation of the combined teaching scheme will help to improve the understanding of all parties to the combined teaching scheme and promote the application of the combined teaching scheme.

As an educational model introduced in the reform of engineering technology education, the multimodal combined teaching method aims to improve the teaching quality and the competitiveness of students. In literature [19], aiming at the engineering major of Hebei University, a survey was conducted based on questionnaire to determine which factors have the greatest impact on the teaching quality and students' views on this teaching method. The results show that the teachers' ability and the students' existing knowledge have the greatest impact on the teaching quality, while the communication and learning opportunities between teachers and students have less impact, which effectively guides students to understand the complexity of real structural systems. Mosalam et al. [20] describes a teaching activity involving theoretical and practical experience. HS test demonstration is a part of the activity, and the results of the activity are introduced. The experience collected from this activity and the HS experience developed in various laboratories were used to carry out studies on new teaching cases using HS. Tortorella and Cauchick-Miguel [21] aims to integrate two teaching methods to strengthen lean manufacturing (LM) learning in graduate courses, and verify its effectiveness by comparing students' performance and learning preferences. This method integrates PBL (problem-based learning) into traditional teaching methods. Ibekwe-Sanjuan [22] reports an experiment using a mixed teaching method to meet the challenge of teaching *"Information and Communication Theory"* to students studying in the master's program of Communication and Digital Content in the School of Communication and Journalism of the University of Aix Marseille, France. The mixed teaching method combines the classical text/oral teaching method with the art-oriented teaching method, supplemented by creative writing and storytelling activities.

It can be seen from the existing research results that there have been some violations of the laws of teaching in traditional disciplines, which are mainly manifested in the lack of attention to the process of students' ability improvement and the neglect of the guidance of students' learning experience and emotion, resulting in a single teaching method and low enthusiasm of students for learning. The implementation of combinatorial teaching creates conditions for solving the above problems from such aspects as teaching means, teaching structure and teaching content, but an evaluation system is absent for judging the rationality of its design. In order to promote the application of combinatorial teaching scheme, this paper takes music teaching as an example to carry out research on the construction of combinatorial teaching evaluation system based on STATA analysis. First of all, Chapter 2 provides the implementation process of combinatorial teaching strategy, and the construction of combinatorial teaching evaluation system is carried out from seven aspects, namely teaching in fun, emotional experience,

student engagement, elicitation and induction, teaching according to students' aptitude, creative development and vividness and intuitiveness. In Chapter 3, the entropy weight method is used to assign the weight of the combined teaching evaluation index for music major courses. In Chapter 4, based on Stata15.1 software tools, the regression analysis of the main factors affecting the effect of the combined teaching is carried out, and the relevant regression analysis model is constructed to predict the effect of short-term combined teaching scheme in the case of small samples. The experimental results verify the effectiveness of the evaluation system and the analysis model.

2 Analysis of combined teaching strategies and evaluation factors

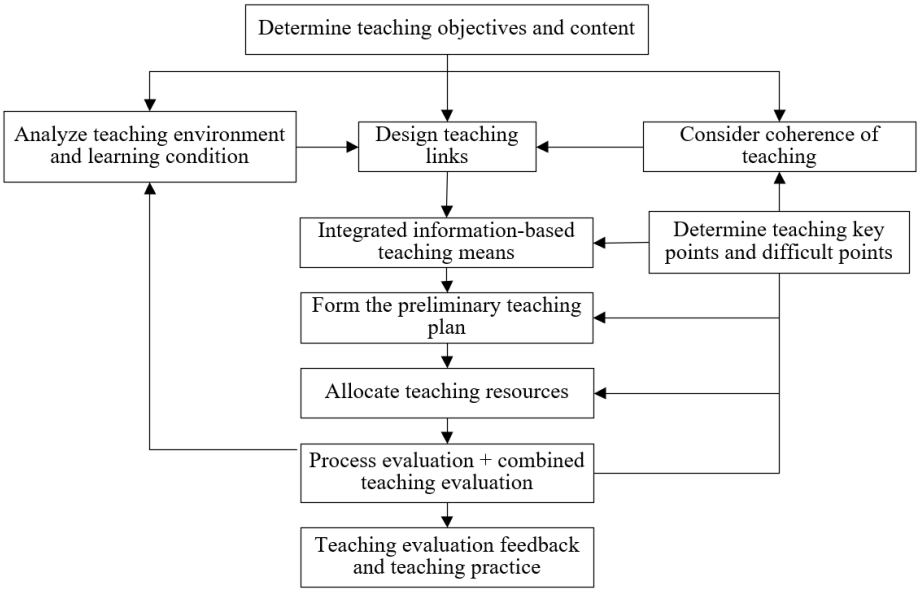

Fig. 1. The implementation process of combined teaching strategy

Figure 1 shows the implementation process of combined teaching strategy. It can be seen from the figure that when applying the combined teaching method to the music major courses, first it is necessary to determine the teaching objectives for the courses and carry out corresponding analysis. For example, in the teaching of solfeggio, ear training and music theory, the teaching purpose is to cultivate students' ability of independent reading and solfeggio, so that they can better feel music, understand music and express music. In actual teaching, the internationally used musical notation should be gradually adopted.

Next, the appropriate amount of teaching content with appropriate difficulty is determined around the teaching objectives, and teaching links with coherence, integrity and effectiveness are set up to embed all teaching knowledge points. For example, in the

teaching of new songs, it should include such teaching steps as introducing new lessons, model singing, brief introduction, lyrics and melodies learning, songs analysis and reviewing, and consolidating.

Then, teaching key points and difficult points shall be displayed effectively based on the actual teaching environment and the characteristics of students' learning situation, and integrating all kinds of information-based teaching methods that can be implemented. For example, ear training can be carried out by means of listening discrimination, model singing and notes while listening, so as to cultivate students' ability in listening discrimination of musical expression means such as pitch, beat, rhythm, speed, strength, timbre, interval and harmony.

According to the preliminary teaching plan, educational resources shall be allocated reasonably and efficiently to provide effective service for classroom teaching. For example, double hearing can be organized, so that students can fully appreciate the works again, and obtain a clearer musical image, thus understanding the works more deeply.

Finally, according to the new curriculum standards for music majors, the comprehensive evaluation results are achieved based on the student feedback information, teaching process evaluation, and scale generated combined teaching summary and evaluation, and the evaluation results are fed back to the following teaching practice, so that the teaching plan can be continuously improved and perfected.

To sum up, combined teaching should be carried out based on the characteristics of music art and the principles of pedagogy and psychology, and the evaluation system should be constructed from seven aspects, namely teaching in fun, emotional experience, student engagement, elicitation and induction, teaching according to students' aptitude, creative development and vividness and intuitiveness. The system frame is shown in Figure 2.

3 Calculation of weight of combined teaching evaluation

Currently, the entropy weight method has been widely used in quality evaluation and effect evaluation in various professional fields for its avoidance of subjective factors in the evaluation process. In this paper, this method is applied in the evaluation of combined teaching in music major courses. The degree of dispersion of each evaluation index is determined based on the calculation result of entropy value. The higher the entropy value is, the greater the degree of dispersion of the corresponding evaluation index is, indicating that the evaluation index has a greater impact on the combined teaching effect. The steps of entropy weight method are described in detail below:

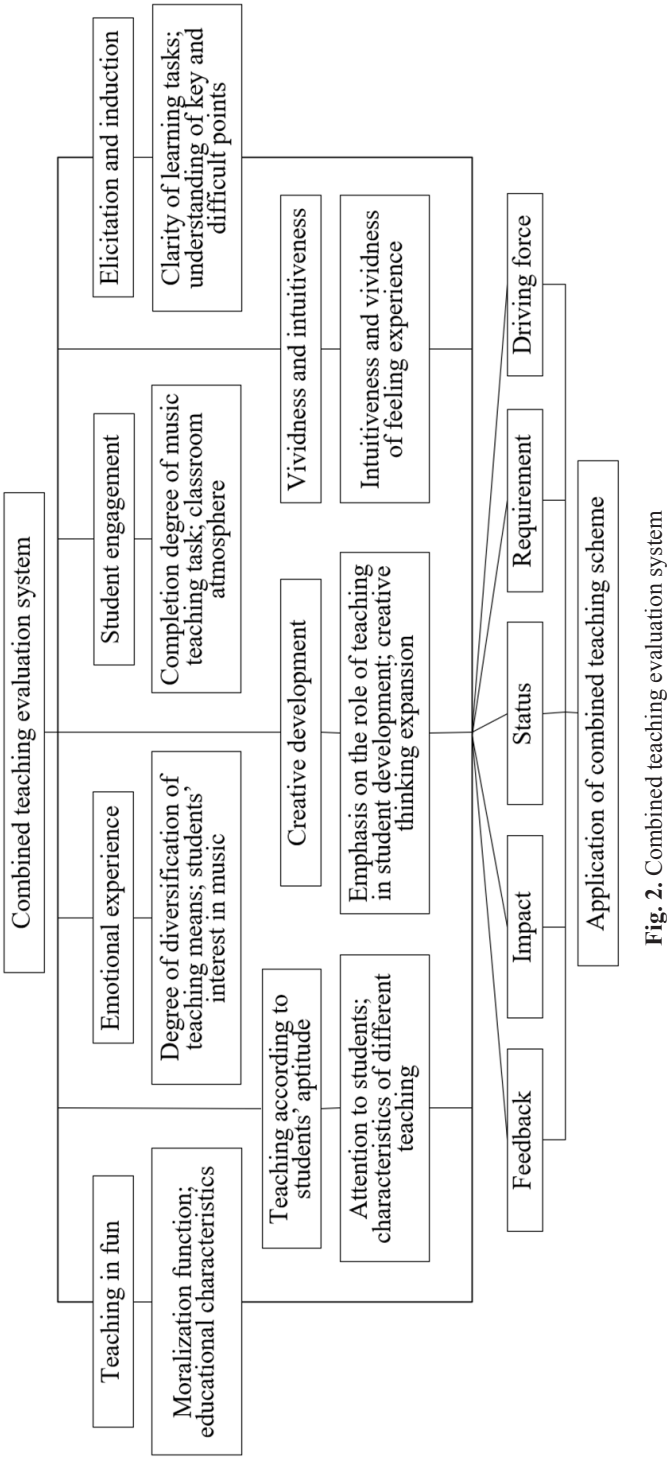

Fig. 2. Combined teaching evaluation system

Firstly, it is assumed that there are m items to be evaluated and n evaluation rules in the combined teaching evaluation system. First, the original data matrix of the evaluation index sample is constructed:

$$G = (g_{ij})_{m\times n} = \begin{bmatrix} g_{11} & g_{12} & \cdots & g_{1n} \\ g_{21} & g_{22} & \cdots & g_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ g_{m1} & g_{m2} & \cdots & g_{mn} \end{bmatrix} \tag{1}$$

Due to the dimensional difference between the sample data of evaluation indicators, it is impossible to make a direct comparison. Therefore, all sample data are normalized in this paper, and the formula for calculating the positive index is given:

$$g_{ij}^{'} = \frac{g_{ij} - g_{jmin}}{g_{jmax} - g_{jmin}} (i = 1,2,...,n; j = 1,2,...,m) \tag{2}$$

The calculation formula of negative indicators is also provided:

$$g_{ij}^{'} = \frac{g_{jmax} - g_{ij}}{g_{jmax} - g_{jmin}} (i = 1,2,...,n; j = 1,2,...,m) \tag{3}$$

The sample data matrix of the normalized evaluation index is:

$$G' = (g'_{ij})_{n\times m} = \begin{bmatrix} g_{11}^{'} & g_{12}^{'} & \cdots & g_{1n}^{'} \\ g_{21}^{'} & g_{22}^{'} & \cdots & g_{2n}^{'} \\ \vdots & \vdots & \cdots & \vdots \\ g_{m1}^{'} & g_{m2}^{'} & \cdots & g_{mn}^{'} \end{bmatrix} \tag{4}$$

The following formula gives the quantitative proportion of the i_{th} evaluation detail data under the j_{th} evaluation index to the importance of the index:

$$T_{ij} = \frac{g_{ij}^{'}}{\sum_{i=1}^{m} g_{ij}^{'}} \left(0 < t_{ij} < 1, \sum_{j=1}^{n} t_{ij} = 1 \right) \tag{5}$$

The normalized matrix $T=(t_{ij})_{m\times n}$ is obtained based on the above formula. Let $l=1/\ln(m)>0$, and $o_j \geq 0$ is satisfied, and then the entropy value of the j_{th} index is calculated:

$$o_j = -l \sum_{i=1}^{m} (t_{ij} \ln t_{ij}) \tag{6}$$

The formula for calculating the difference coefficient of the j_{th} index is provided in the following formula:

$$c_j = 1 - o_j, j = 1,\ldots\ldots,n \tag{7}$$

The larger the value of c_j is, the larger the information in the corresponding evaluation index is, and vice versa. The weight of the j_{th} index can be calculated using the following formula:

$$q_j = \frac{1 - o_j}{n - \sum_{j=1}^{n} o_j} \tag{8}$$

The index weight matrix is further obtained: $Q=(q_1,q_2,\ldots,q_n)^T$.

In order to improve the accuracy and reliability of weight calculation results, this paper combines the priority diagram method and entropy weight method, and calculates the evaluation index weights of the two methods. Assuming that the index weight vector calculated using the priority diagram method is represented by q_j^1, and the index weight vector obtained by the entropy weight method is represented by q_j^2, the specific calculation process is as follows:

$$q' = \frac{q_j^1 + q_j^2}{\sum_{j=1}^{n}(q_j^1 + q_j^2)} \quad j = 1\ldots\ldots n \tag{9}$$

$$\sum_{j=1}^{n}(q_j^1 + q_j^2) = 2 \tag{10}$$

The above formula can be simplified as follows:

$$q' = \frac{q_j^1 + q_j^2}{2} \tag{11}$$

$$\sum_{j=1}^{n} q_j^{'} = 1 \tag{12}$$

If the membership degree of the first element in the combined teaching evaluation sample set is s_{i1}, the result of the single factor evaluation of the i_{th} element can be expressed as $S=(s_{i1}, s_{i2}, \ldots, s_{in})$. The fuzzy comprehensive evaluation matrix is composed of m single factor evaluation sets $S_1, S_2, \ldots S_m$, which is represented with $S_{m\times n}$. The fuzzy transformation from V to U can be obtained based on the fuzzy relation S, $S\in G(V\times U)$, that is, $(V_i, U_j) = g(V_i)(U_j)=s_{ij}$, that is to say, a fuzzy comprehensive evaluation model is constructed based on (V, U, S). S_j can be evaluated by the fuzzy matrix $S\in\lambda mn$. Assuming that the probability degree of the i_{th} evaluation index being classified as the class j excellent teaching grade is represented by s_{ij}, that is, the membership degree of factor v_i to grade U_j, which constitutes the fuzzy relationship matrix between the evaluation index and the combined teaching effect evaluation grade, then:

$$S = \begin{bmatrix} s_{11} & s_{12} & \cdots & s_{1n} \\ s_{21} & s_{22} & \cdots & s_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ s_{m1} & s_{m2} & \cdots & s_{mn} \end{bmatrix} \tag{13}$$

The specific calculation method of membership function is described in detail as follows. It is assumed that the standard value of the i_{th} teaching excellence level of the j_{th} index is represented by R_{ij}, and the membership degree of the j_{th} index belonging to the i_{th} teaching excellence level is represented by s_{ij}. The following formula presents the membership function of the first level:

$$s_{ij} = \begin{cases} 1, (0 \le a_i \le r_{ij}) \\ \dfrac{(r_{i(j+1)} - a_i)}{(r_{i(j+1)} - r_{ij})}, (r_{ij} < a_i < r_{i(j+1)}) \\ 0, (a_i \ge r_{i(j+1)}) \end{cases} \tag{14}$$

The following formula provides the membership function expressions of the second level, the third level and the fourth level:

$$s_{ij} = \begin{cases} 0, (a_i \ge r_{i(j+1)} \,/\, a_i < r_{i(j-1)}) \\ \dfrac{(a_i - r_{i(j-1)})}{(r_{ij} - r_{i(j-1)})}, (r_{i(j-1)} < a_i \le r_{ij}) \\ \dfrac{(r_{i(j+1)} - a_i)}{(r_{i(j+1)} - r_{ij})}, (r_{ij} < a_i < r_{i(j+1)}) \end{cases} \tag{15}$$

The fifth level membership function is given by the following formula:

$$s_{ij} = \begin{cases} 1, (a_i \ge r_{ij}) \\ \dfrac{(a_i - r_{i(j-1)})}{(r_{ij} - r_{i(j-1)})}, (r_{i(j-1)} < a_i < r_{ij}) \\ 0, (a_i \le r_{i(j-1)}) \end{cases} \tag{16}$$

4 Construction of model for regression analysis of combined teaching effect

Based on STATA15.1 software tools, this paper makes a regression analysis of the main factors affecting the effect of combined teaching. This paper constructs a regression analysis model, which is suitable for the prediction of effect of short-term

combined teaching program with a small sample size. It is assumed that the current value of the evaluation index is represented by A_p, the constant term is represented by λ, the order is expressed by t, the autoregressive coefficient is expressed by $\alpha_i (i = 1, \ldots, w)$, and the error is represented by σ_p. The expression of autoregressive model is provided by the following formula:

$$A_p = \lambda + \sum_{i=1}^{t} \alpha_i a_{t-i} + \sigma_p \tag{17}$$

It is assumed that the moving average coefficient is represented by $\tau_i (i = 1, \ldots, w)$, and the moving average model is constructed as follows:

$$A_p = \sigma_p + \sum_{i=1}^{w} \tau_i \sigma_{p-i} \tag{18}$$

The autoregressive moving average model is shown by the following equation:

$$B_p = \lambda_i + \sum_{i=1}^{t} \alpha_i K_{p-1} + \sum_{i=1}^{w} \tau_j \sigma_{p-j} \tag{19}$$

The lag operator of the above equation is represented by K, and the autoregressive model based on the lag operator can be expressed as the following equation:

$$\sigma_p = \left(1 - \sum_{i=1}^{t} \alpha_i K_i\right) A_p = \eta_{A_i} \tag{20}$$

In the above formula, η is expressed as follows:

$$\eta = 1 - \sum_{i==1}^{t} \eta_i K_i \tag{21}$$

The corresponding moving average model is represented by the following equation:

$$A_i = \left(1 + \sum_{i=1}^{w} \tau_i K_i\right) \sigma_p = \tau_{\sigma_i} \tag{22}$$

In the above formula, τ is expressed as follows:

$$\tau = 1 + \sum_{i=1}^{w} \tau_i K_i \tag{23}$$

The corresponding autoregressive moving average model is represented by the following equation:

$$\left(1-\sum_{i=1}^{t}\eta_i K_i\right)A_i=\left(1+\sum_{i=1}^{w}\tau_i K_i\right)\sigma_p \tag{24}$$

The corresponding differential autoregressive moving average model is given by the following formula:

$$A_p=\eta_1 A_{p-1}+\eta_2 A_{p-2}+..+\eta_t A_{p-t}-\tau_1\sigma_{p-1}-\tau_2\sigma_{p-2}-\ldots-\tau_w\sigma_{p-w} \tag{25}$$

5 Experimental results and analysis

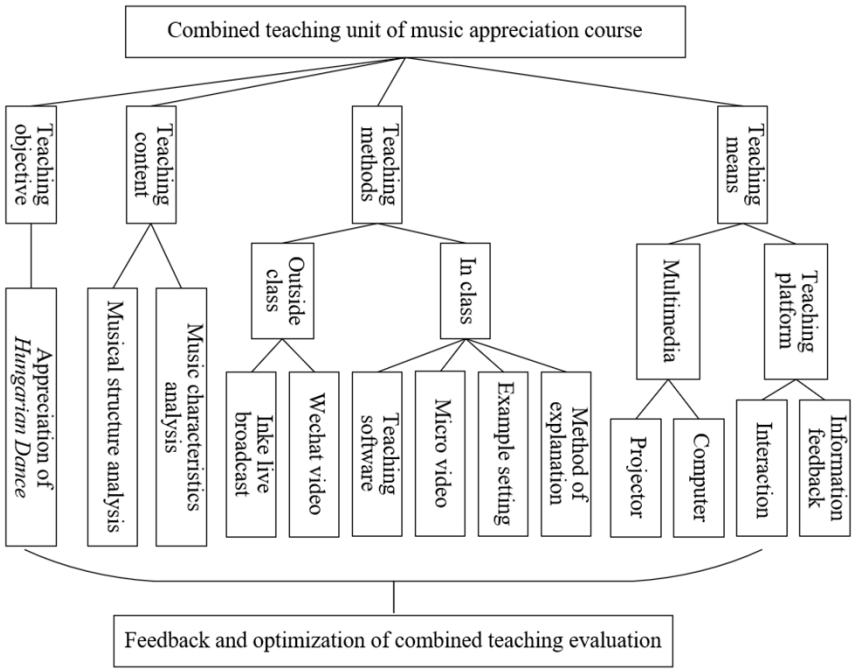

Fig. 3. Experimental structure

Figure 3 shows the structure of the experimental case of the multiple-method based teaching scheme for the unit of "*Hungarian Dance*" in the music appreciation course in higher vocational colleges. Based on the characteristics of unsatisfactory classroom

performance and lack of learning interest of higher vocational students, the "*Hungarian Dance*" is taken as the teaching objective. The teaching content is music structure analysis and music characteristics analysis. The teaching methods and teaching means are both designed according to the principle of applying multiple teaching methods. In view of the above cases, the evaluation index data of seven aspects, namely, teaching in fun, emotional experience, student engagement, elicitation and induction, teaching according to students' aptitude, creative development and vividness and intuitiveness are collected. The fuzzy comprehensive evaluation vectors corresponding to each evaluation index of three classes are calculated according to the formula. The calculation results are shown in Table 1.

Table 1. Alculation results of fuzzy comprehensive evaluation vectors of evaluation index

Class	Index No.	Evaluation Vectors
Class 1	1	(0.0152,0.1368,0.6274,0.1592,0.0021)
	2	(0.4158,0.3622,0.0284,0.0518,0.0132)
	3	(0.3528,0.1625,0.2851,0.0002,0.2815)
	4	(0.0036,0.4251,0.2639,0.2051,0.0006)
	5	(0.0002,0.5294,0.5382,0.0528,0.3169)
	6	(0.0416,0.3351,0.4139,0.2651,0.0106)
	7	(0.3912,0.2662,0.6739,0.0102,0.3048)
Class 2	1	(0.2639,0.2158,0.3412,0.1247,0.0006)
	2	(0.6259,0.1325,0.1841,0.0758,0.0001)
	3	(0.3512,0.1162,0.2639,0.0002,0.2748)
	4	(0.4158,0.3312,0.1829,0.1135,0.0001)
	5	(0.0003,0.0256,0.3415,0.1528,0.4187)
	6	(0.4529,0.1455,0.2715,0.0102,0.2815)
	7	(0.1512,0.2478,0.3895,0.2317,0.0106)
Class 3	1	(0.0257,0.0362,0.5158,0.2315,0.0001)
	2	(0.4185,0.1326,0.3958,0.0257,0.0003)
	3	(0.4629,0.1855,0.2625,0.0002,0.2715)
	4	(0.1362,0.2958,0.3415,0.2247,0.0006)
	5	(0.0001,0.0253,0.3518,0.1847,0.3625)
	6	(0.0517,0.0462,0.8158,0.2516,0.0302)
	7	(0.4875,0.5126,0.7458,0.8157,0.0303)

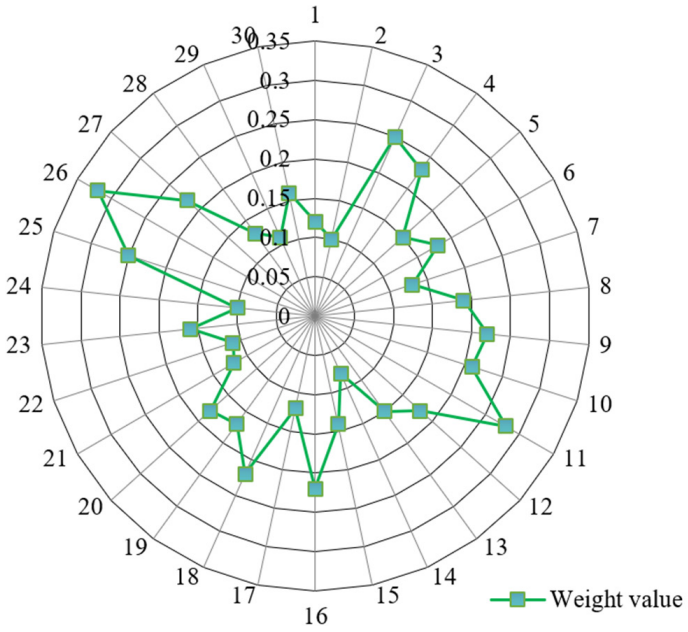

Fig. 4. Radar chart of evaluation index weight for combined teaching effect

The weight is used to represent the influence of each evaluation index on the combined teaching effect. In order to vividly show the weight and influence of the evaluation index of the effect of combined teaching of "*Hungarian Dance*" unit, Figure 4 shows the weight radar chart of the 30 evaluation rules to which the combined teaching effect evaluation index belongs. It can be seen from the figure that among all the evaluation indicators, the weight value of the vividness and intuitiveness evaluation indicator is the largest. Therefore, ensuring the vividness and intuitiveness of students' perception and experience is the most important evaluation indicator that affects the effect of combined teaching of "*Hungarian Dance*", and creative development is the evaluation indicator with the smallest weight. From the distribution of weight values, it can be seen that the evaluation indicators with large weight are concentrated in emotional experience and vividness and intuitiveness. Therefore, focusing on students' emotional experience and promoting their understanding of knowledge points are the main reasons that affect the effect of combined teaching of "*Hungarian Dance*".

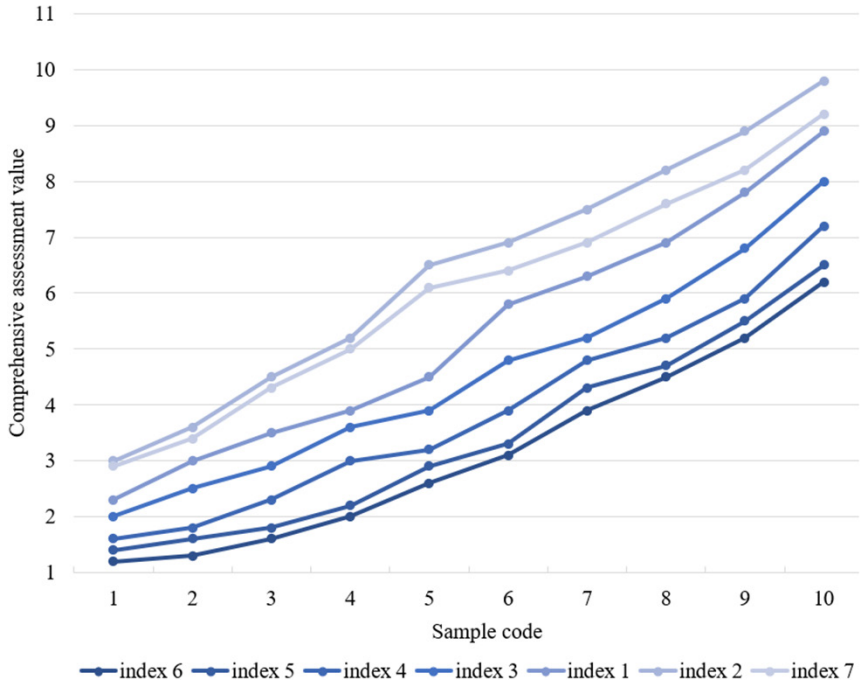

Fig. 5. Evaluation value of combined teaching effect of 10 class hours

The second level fuzzy relation matrix is constructed based on the evaluation index data of 7 aspects. According to the formula, the single-level evaluation value and comprehensive evaluation value of each evaluation index subset of the combined teaching effect can be calculated. The evaluation results are divided into four grades: excellent, good, medium and poor, and the comprehensive evaluation grade of the effect of combined teaching of "*Hungarian Dance*" can be obtained. The change trend of the combined teaching effect of 10 hours is shown in Figure 5. It can be seen from the figure that with the progress of the course, the combined teaching effect is getting better and better.

This paper uses STATA 15.1 software to make regression analysis on the main factors affecting the effect of combined teaching. In this paper, the autoregressive order and the moving average order in the autoregressive average moving model are determined based on the AIC value, the correlation coefficient value and the fitting value. The better the fitting effect of the model is, the smaller the AIC value is, and the larger the correlation coefficient value and the fitting degree value is. After comparison and screening, the optimal regression model is obtained. Table 2 shows the evaluation indicators of the fitting effect of the model.

Table 2. Evaluation index of fitting effect of optimal regression model

Evaluation Index Number	*AIC* Value	Degree of Fitting	Correlation Index
1	−63.28	95.62%	0.9285
2	−51.24	91.37%	0.9361
3	−61.59	96.28%	0.9475
4	−18.34	78.24%	0.8261
5	−45.62	97.66%	0.9672
6	−17.55	84.12%	0.8261
7	−46.87	90.13%	0.9311

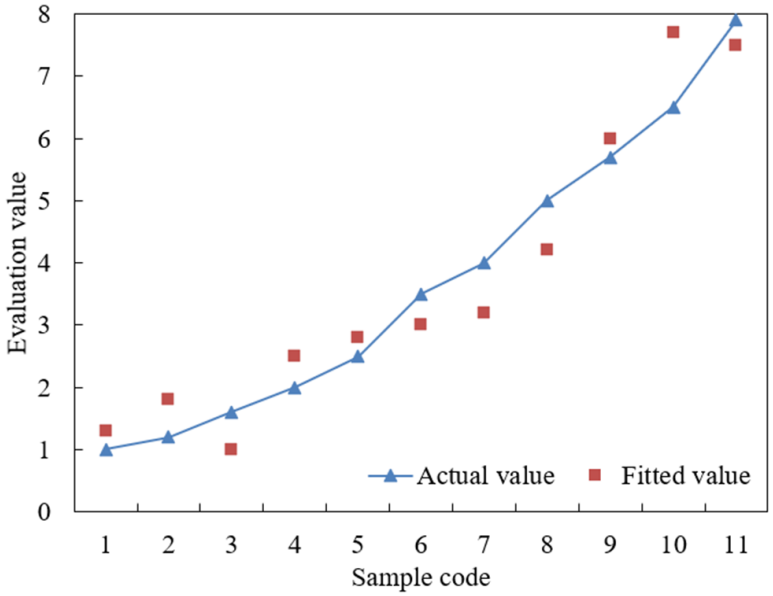

Fig. 6. Fitting curve of comprehensive evaluation value of combined teaching

Based on the collected sample data of 10 semesters, the single-layer evaluation value of the effect of the combined teaching of "*Hungarian Dance*" is fitted by using the autoregressive moving average model. Figure 6 shows the fitting curve of the comprehensive evaluation value of the combined teaching. Statistics of fitting error are given in Table 3.

Table 3. Fitting error cases

Number of Class Hour	Relative Error						
	Index 1	**Index 2**	**Index 3**	**Index 4**	**Index 5**	**Index 6**	**Index 7**
1	0.02	0.07	0.09	0.02	0.05	0.54	0.05
2	0.25	8.26	0.692	1.35	1.36	0.84	0.89
3	0.48	3.12	0.61	−3.47	7.42	−2.14	2.71
4	1.52	2.37	3.28	6.29	−8.29	3.02	1.74
5	0.39	−15.22	7.14	0.22	4.15	1.08	1.22
6	1.67	−2.59	1.29	−0.68	7.58	0.89	0.76
7	5.18	−0.85	1.32	0.72	−4.62	0.69	0.66
8	0.03	−1.37	3.28	−8.19	7.38	0.77	0.64
9	3.48	5.29	−3.15	11.22	11.27	1.58	4.57
10	0.01	0.57	0.61	0.09	0.01	2.28	0.74

It can be seen from the table that the fitting error of each evaluation index is basically controlled within plus or minus 10%, indicating that the fitting effect of the constructed regression model is relatively ideal, which is basically consistent with the changing trend of the effect of combined teaching of "*Hungarian Dance*" with the increase of class hours, and can predict the effect of combined teaching of "*Hungarian Dance*" well.

6 Conclusion

Taking music teaching as an example, this paper studies the construction of combinatorial teaching evaluation system based on STATA analysis. Firstly, the implementation process of the combined teaching strategy is presented, and the construction of the combined teaching evaluation system is carried out from seven aspects, namely, teaching in fun, emotional experience, student engagement, elicitation and induction, teaching according to students' aptitude, creative development and vividness and intuitiveness. The entropy weight method is used to assign the weight of the combined teaching evaluation index for music major courses. Based on STATA15.1 software tool, regression analysis is carried out on the main factors affecting the effect of combinatorial teaching, and the relevant regression analysis model is constructed to realize the effect prediction of short-term combinatorial teaching scheme in the case of small samples. This paper provides an experimental case of combined teaching of "*Hungarian Dance*" in the music appreciation course of higher vocational colleges, and summarizes the fuzzy comprehensive evaluation vectors corresponding to the evaluation indexes of three classes. The weight radar chart of 30 evaluation rules to which the combined teaching effect evaluation index belongs and the change trend of the combined teaching effect of 10 class hours are drawn. Finally, using STATA 15.1 software, the regression analysis of the main factors affecting the effect of combined teaching is carried out. After comparison and screening, the optimal regression model is obtained, and the

evaluation index of model fitting effect is given, which verifies the effectiveness of the evaluation system and analysis model.

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8 Author

Yutian Li, received her master's degree from Hebei Normal University, and now she's a teacher at Shijiazhuang University of Applied Technology. She is mainly engaged in musicology, music creation, music analysis, music education, music culture and other aspects of research.

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