Evaluation Method of Interactive Quality of Road and Bridge Construction Course Teaching Based on Principal Component Analysis

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Abstract. In order to improve the teaching quality of road and bridge construction course, an interactive quality evaluation method based on principal component analysis is proposed. According to the hierarchical model of teaching interaction, the evaluation index of teaching interaction quality is selected, and the evaluation system of teaching interaction quality is preliminarily constructed. On this basis, the principal component and its quantity of evaluation index are determined based on principal component analysis method, and the evaluation system of teaching interaction quality is determined, which is transformed into NVivo analysis and evaluation framework, and the relationship between superior and subordinate is used to evaluate teaching interaction quality Price index node is used for classification and management, and the linear weighted value of each principal component is calculated. The final evaluation result is obtained by weighted summation, so as to realize the evaluation of teaching interaction quality of road and bridge construction course. The experimental results show that the evaluation result of this method is more in line with the actual value, and the evaluation effect is better.

Keywords: Principal component analysis · Road and bridge construction course · Teaching interaction quality · Evaluation

1 Introduction

In recent years, my country's highway construction has achieved great results, and highway construction has also developed rapidly. As of the end of 2019, my country's total highway mileage has reached 125,400 km, ranking first in the world. At present, due to factors such as my country's population, private car ownership, passenger traffic, freight volume, inter-provincial, and international trade, the market has great potential for road demand [1]. As an important part of highway construction, bridge construction has also undergone major developments in terms of materials, structural design, bridge type, span, and construction methods. The world's bridges are moving towards new, long-span, lightweight, sensitive and beautiful new bridges. Goal development.

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The development of road and bridge engineering requires more high-level talents who are engaged in on-site construction technical work on the front line of production. How to train high skilled applied professional and technical personnel to meet the needs of highway development in China and meet the needs of road and bridge construction operators, organizers and managers, it is necessary for road and bridge construction teachers of civil engineering major in China to organize and carry out classroom teaching and practical teaching reasonably around the professional training objectives and combined with engineering practice.

Road and bridge construction is a professional course closely related to practice for civil engineering majors. It mainly includes two parts: road construction and bridge construction. The purpose and task of this course are: according to the latest development of the subject, through multimedia teaching with pictures and texts, practice Teaching and other teaching methods enable students to fully grasp modern road and bridge construction techniques after completing this course, and initially have the ability to design and guide construction of roads and bridges [2]. The teaching quality of this course directly affects the professional quality and engineering ability of civil engineering students. Therefore, in order to meet the current demand for the ability of road and bridge engineering professionals in our country, and improve the practical ability and engineering application ability of students, this paper puts forward the research on the interactive quality evaluation method of road and bridge construction course based on principal component analysis. The method of transforming a set of principal variables into a set of principal variables by principal component analysis is called orthogonal transformation. The paper obtains the evaluation index of teaching interaction quality, calculates the matrix of the evaluation indexes of teaching interaction quality by principal component analysis method, constructs the evaluation system of teaching interactive quality. Based on the above-mentioned evaluation system of interactive quality of road bridge construction course, it is transformed into NVivo analysis and evaluation framework, and the tree node is directly established, Through the relationship between the upper and lower levels, the paper classifies and manages the teaching interactive quality evaluation node, and completes the interactive quality evaluation of the road bridge construction course. Through the introduction of principal component analysis method, the evaluation index of teaching interaction quality is processed to obtain more accurate evaluation results of teaching interaction quality of road and bridge construction course [3].

2 Research on Interactive Quality Evaluation Method of Road and Bridge Construction Course Teaching

2.1 Preliminary Construction of Teaching Interactive Quality Evaluation System

Through the existing literature research, it can be seen that with the increasing attention to the factors of teaching interaction quality evaluation, the perspective of researchers has gradually shifted from the systematic perspective to the hierarchical research of various interaction quality, focusing on the level and depth of teaching interaction.

For the research on the level of teaching interaction, based on laurillard's conversation model of general learning process, Chen Li, a domestic scholar, has constructed a hierarchical model of teaching interaction as shown in Fig. 1.

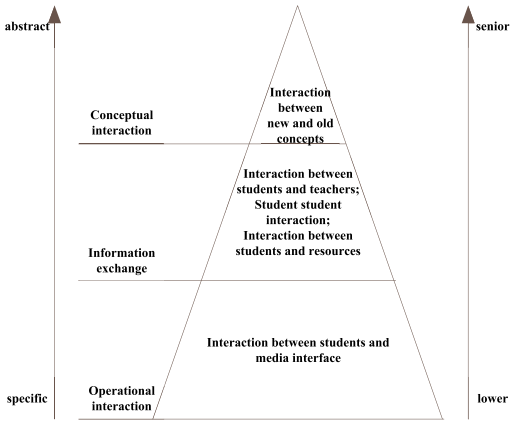

Fig. 1. Hierarchical model of teaching interaction

As shown in Fig. 1, the model divides the teaching interaction behavior in classroom teaching process from concrete to abstract and from low level to high level, which are operation interaction, information interaction and concept interaction. Among them, operational interaction refers to the interaction between teachers and students and media interface; information interaction refers to the information exchange behavior of learning between students and other teaching elements through various symbols, which is subdivided into the interaction between students and learning resources, between students and teachers, and between students and students; conceptual interaction refers to the relationship between the new and old concepts in students' minds Interaction [4].

Based on the content of the above-mentioned construction model, together with emotional interaction, it is used as the first-level indicator of the interactive quality evaluation of road and bridge construction courses, as shown in Table 1.

Table 1. The first-level index table of teaching interactive quality evaluation

First level indicator	Describe
Operational interaction	Interaction between teachers and students and media interface. It includes not only the non editing operations such as viewing and displaying resources by means of media, but also editorial operations such as annotating and changing resources by teachers and students through media
Information exchange	The act of transmitting information between teachers and students and between students
Emotional interaction	Teachers and students in the process of information exchange and classroom atmosphere related to a strong emotional attitude behavior
Cognitive interaction	The conceptual interaction between teachers and students in cognitive level based on information interaction

As shown in Table 1, interactive teaching behaviors may occur at the same time in the classroom teaching process, or may not occur at the same time, there is no strict hierarchical relationship [5].

After the above description, the interactive behaviors of road and bridge construction courses can be classified according to their respective attributes [6]. On this basis, combined with the first-level indicators established in Table 1 (operational interaction, information interaction, emotional interaction, cognitive interaction), some of the second-level indicators (the eight second-level indicators at the cognitive level are marked, understood, applied, and analyzed), Evaluation, creation, fascination, self-knowledge), as well as the specific teaching behaviors in the existing interactive teaching quality evaluation system, the interactive teaching quality evaluation system of road and bridge construction courses can be initially constructed, as shown in Table 2.

As shown in Table 2, the operational interaction level refers to the interaction behavior between teachers and students and media technology in the classroom environment of the road and bridge construction course. According to the different application activities carried out by teachers and students with the help of technology, summarized and sorted out from the 9 selected course teaching video examples. The simple "teacher operation technology" and "student operation technology" in the existing evaluation system are subdivided into "teacher and student simple operation technology" and "teacher and student editing resources", and the existing "technology acting on students" is changed into "real-time transfer of technology and technology".

At the information interaction level, it includes teacher's instruction, teacher's instruction, classroom management, peer discussion, students' practice and students' thinking. It mainly takes some speech and action behaviors without obvious emotional characteristics in the existing evaluation system as the secondary indicators of information interaction [7]. The teacher's control of classroom teaching tasks in the existing evaluation system, such as beginning, prompting, ending and other speech acts, are classified into teacher's instructions or instructions, because these behaviors have the function of expecting students to obey.

Emotional interaction specifically includes four aspects: positive feedback and negative feedback from teachers to students, positive responses from students to teachers, encouragement and assistance to students. Among them, the teacher's acceptance of emotions in the existing evaluation system, teachers' encouragement, and acceptance of opinions are combined into a behavior of positive feedback from teachers to students, because they all reflect the positive emotions between teachers and students Interactive. At the same time, through the coding analysis of nine cases, it is found that in addition to the emotional interaction of teachers' encouragement and praise to students, there are also students' emotional reactions to teachers. Therefore, students' positive responses to the teacher have been increased, such as students' positive actions. Hand, collective answer, etc. [8].

In this study, the interaction behavior at the cognitive interaction level mainly refers to the analysis of the content of teachers' and students' questions or responses in classroom teaching. In the existing evaluation system, "teachers raise open questions" and "teachers raise closed questions" are subdivided into eight dimensions of teachers' questions: memorization, comprehension, application, analysis, evaluation, creation, empathy and

Table 2. Teaching interaction quality evaluation system

Primary indicators	Secondary indicators	Encoded
Operational interaction	Teachers' operation technology	1
	Teacher editing resources	2
	Student operation technology	3
	Student editing resources	4
	Technology and technology sharing content	5
Information exchange	Teaching by teachers	6
	Teacher instruction	7
	Classroom management	8
	Student discussion	9
	Do exercises	10
	Students' thinking	11
Emotional interaction	Teachers' negative feedback	12
	Teachers' positive feedback	13
	Respond positively to teachers	14
	Encourage peers	15
Cognitive interaction—teacher questions	The level of memory	16
	Understanding level	17
	Application level	18
	Analysis level	19
	Evaluation level	20
	Creation level	21
	On the level of magic	22
	Insight level	23
Cognitive interaction—students answer or ask questions	The level of memory	24
	Understanding level	25
	Application level	26
	Analysis level	27
	Evaluation level	28
	Creation level	29
	On the level of magic	30
	Insight level	31

(*continued*)

Table 2. (*continued*)

Primary indicators	Secondary indicators	Encoded
Silence or silence confusion	Invalid language or behavior	32

self-knowledge. In the existing evaluation system, "students' active response" and "students' active questioning" are subdivided into eight dimensions of questions or answers in the following eight dimensions: recollection, comprehension, application, analysis, evaluation, creation, magic and insight [9]. Specific explanations are given at the end of each index to help researchers make behavior judgments.

The last one is the chaotic behavior or invalid language that may not help teaching in the course teaching, such as the problem behaviors shown by individual students in the classroom (weird, making faces, destroying things, etc.), or due to the out-of-control atmosphere of the activity And cause temporary confusion and other invalid behavior.

2.2 Determination of Teaching Interaction Quality Evaluation System

The above-mentioned preliminary construction of interactive quality evaluation system for curriculum teaching is a multi-index comprehensive evaluation method. At present, there are many comprehensive evaluation methods for multiple indicators at home and abroad. According to the different weight determination methods, these methods can be roughly divided into two categories: one is subjective weighting methods, such as analytic hierarchy process, Delphi method, etc., and most use comprehensive consulting scoring The qualitative method of this kind of method is influenced by human factors, which tends to exaggerate or reduce the effect of certain indicators, so that the result of the sorting cannot completely and truly reflect the actual relationship between things; the second is the objective weighting method, which is based on The correlation between indicators or the degree of variation of each indicator value is used to determine the weight, which avoids the deviation caused by human factors, such as principal component analysis and factor analysis. Because the principal component analysis method overcomes the influence of human factors, this research uses the principal component analysis method to determine the final teaching interactive quality evaluation system.

Principal component analysis is a very useful multivariate statistical analysis method. It is widely used in social economy, enterprise management, biochemistry, medicine, education and other fields. It is a statistical analysis method which transforms multiple indexes into a few comprehensive indexes. In the study of multi index (variable), because the number of variables is too many, and there is a certain correlation between them, so the collected data reflect the information to a certain extent, and when there are many variables, it is more difficult to study the distribution law of samples in high-dimensional space. Principal component analysis is to simplify this situation, that is to say, to adopt one method the method of dimensionality reduction is to find several comprehensive factors to represent the original variables, so that these comprehensive factors can reflect the information of the original variables as much as possible, and they are not related to each other. Almost all complex comprehensive evaluation problems will use this method to reduce the data dimension.

The basic steps of multi-index comprehensive evaluation with principal component analysis include:

Step 1: Standardization of the original indicator data, that is, dimensionless;
Step 2: Find the correlation coefficient matrix between index data;
Step 3: Find the characteristic root, characteristic vector and contribution rate of the matrix;
Step 4: Determine the number of principal components;
Step 5: Explain the meaning of the principal component in the network teaching system;
Step 6: Synthesize the determined principal components to obtain a comprehensive evaluation value.

Based on the principal component analysis method, the process of determining the teaching interaction quality evaluation system of road and bridge construction course is as follows:

Step 1: The original teaching interaction quality evaluation body index is dimensionless.

There are many methods for dimensionless processing, such as straight line type, fold line type and curve type. In this study, the linear dimensionless method is used for data processing, mainly because:

First, for the multi index comprehensive evaluation, the result of dimensionless evaluation is a relative description of the development level of the evaluated things, rather than an absolute scale;

Second, the non-linear dimensionless methods such as broken line and curve type are not more accurate than linear methods in any case;

Thirdly, from the case application experience of multi index comprehensive evaluation at home and abroad, the results of linear formula comprehensive evaluation are often similar to nonlinear method, but this method is easy to use and understand.

In the linear dimensionless formula, there are two commonly used methods: extreme value method and Z-Score method. Among them, the Z-Score method is more suitable for situations where there are a large number of evaluated objects. In view of the research needs, the Z-Score method is more suitable. In addition, taking into account the requirements of the multi-index comprehensive evaluation method used for the dimensionless method, the principal component analysis method requires the Z-Score method to be used for dimensionless processing.

Suppose there are n sample and p indexes, we can get the data matrix $X = \left(X_{ij}\right)_{nxp}$. Among them, $i = 1, 2, \cdots, n$ and n are the total number of samples; $j = 1, 2, \cdots, p$ and p are p indicators; X_{ij} is the j index value of the i th sample.

The Z-score method was used to standardize the data transformation

$$\begin{cases} Z_{ij} = \frac{X_{ij} - \overline{X}_j}{S_j} \\ \overline{X}_j = \frac{1}{n} \sum_{i=1}^{n} X_{ij} \\ S_j = \left[\frac{1}{n-1} \sum_{i=1}^{n} \left(X_{ij} - \overline{X}_j\right)^2 \right] \end{cases} \tag{1}$$

Step 2: The determination of index weight.

In order to make the comprehensive evaluation value synthesized by multiple indicators more accurately reflect the real situation of the interactive quality of road and bridge construction courses, so as to ensure the scientific nature of the comprehensive evaluation, it is necessary to assign different weights to the non-dimensionally transformed indicators. number.

When this study adopts the principal component analysis method for comprehensive evaluation, the weight of each indicator is automatically determined and guaranteed by the principal component analysis method, and no additional method is required to set the weight value for each indicator.

Step 3: Find the correlation matrix of the indicator data.

The expression of the correlation matrix between the evaluation indexes of teaching interaction quality is:

$$R = \left(r_{jk}\right)_{pxp} \tag{2}$$

In formula (2), r_{jk} represents the correlation coefficient between evaluation index j and evaluation index k, and the calculation formula is:

$$\begin{aligned} r_{jk} &= \frac{1}{n-1}\sum_{i=1}^{n}\left[\left(X_{ij}-\overline{X}_j\right)^2/S_j\right]\cdot\left[\left(X_{ik}-\overline{X}_k\right)^2/S_k\right] \\ &= \frac{1}{n-1}\sum_{i=1}^{n} Z_{ij}Z_{ik} \end{aligned} \tag{3}$$

Step 4: The eigenvalue and eigenvector of correlation matrix R are obtained to determine the principal component.

From the characteristic equation $|\lambda Ip - R| = 0$, one can obtain p characteristic roots $\lambda g(g = 1, 2, \cdots, p)$, and arrange them as $\lambda_1 \geq \lambda_2 \geq \cdots \geq \lambda_p \geq 0$ in order of magnitude. It is the variance of the principal components, and its size describes the role of each principal component in describing the object being evaluated size. From the characteristic equation, each characteristic root corresponds to a characteristic vector Lg, the expression is

$$Lg = Lg_1, Lg_2, \cdots, Lg_p = 1, 2, \cdots, p \tag{4}$$

The standardized index variables were transformed into main components:

$$Fg = Lg_1Z_1 + Lg_2Z_2 + \cdots + Lg_pZ_p \tag{5}$$

In the result of formula (5), call $F1$ as the first principal component, $F2$ as the second principal component, and Fp as the p th principal component.

Step 5: The variance contribution rate was calculated to determine the number of principal components.

Generally, the number of principal components is equal to the number of original indicators. If the number of original indicators is large, it is difficult to conduct comprehensive evaluation. Principal component analysis is to select as few as possible k

principal component ($k < p$) for comprehensive evaluation, and at the same time make the loss of information as little as possible.

k value is determined by variance contribution rate $\sum_{g=1}^{k} \lambda g / \sum_{g=1}^{k} \lambda g \geq 85\%$.

Through the above process, the principal components and quantity of the interactive teaching quality evaluation index are determined, and the structure of the teaching interactive quality evaluation system is determined to prepare for the follow-up road and bridge construction course teaching interactive quality evaluation.

2.3 Realization of Teaching Interaction Quality Evaluation

Based on the above-identified road and bridge construction course teaching interactive quality evaluation system, it is converted to the NVivo analysis and evaluation framework, tree nodes are directly established, and the teaching interactive quality evaluation index nodes are classified and managed through the subordinate relationship [10–12]. Part of the tree node relationship diagram is shown in Fig. 2.

Tree node

name	Source of materials	Reference point
Operational interaction	0	0
Simple operation for teachers	0	0
Teacher editing resources	0	0
Simple operation for students	0	0
Student editing resources	0	0
Media and media real time sharing	0	0
Information exchange	0	0
Teaching by teachers	0	0
Teacher instruction	0	0
Student discussion	0	0
Do study	0	0
Learning and thinking	0	0

Fig. 2. Partial tree node graph

After the node is established, it is necessary to code the teaching interaction quality evaluation indicators one by one according to the node, combine the principal component analysis method to calculate the linear weighted value A Fg of each principal component, and then perform the weighted summation of the k principal components, that is, The final evaluation value, the weight is the variance contribution rate of each principal

component, then the final evaluation value of teaching interaction quality is calculated as:

$$F = \sum_{g=1}^{k} \left(\lambda g / \sum_{g=1}^{p} \lambda g \right) Fg \tag{6}$$

The calculation result of formula (6) is the evaluation result of teaching interaction quality of road and bridge construction course, and its value range is [0, 100]. the larger the value, the better the teaching interaction quality.

Through the above process, the evaluation of interactive quality of road and bridge construction courses has been realized, which provides strong support for the cultivation of road and bridge construction talents in my country.

3 Experiment and Result Analysis

In order to verify the performance difference between the proposed method and the existing methods in teaching interaction quality evaluation, the MATLAB software platform is used to design the simulation contrast experiment.

3.1 Experimental Data Preparation and Processing

Because the dimensions, orders of magnitude and forms of each evaluation index in the evaluation index system of teaching interaction quality are different, it is difficult to compare and analyze them. Therefore, it is necessary to normalize the original data. In the linear dimensionless method, the threshold method has no strict requirements on the number and distribution of index data, and in the process of dimensionless processing, the original data is relatively less. Therefore, there is no need to process the data in the miniaturization experiment. Due to the limitation of space, it is not described in detail.

3.2 Determining the Weights of Teaching Interactive Quality Evaluation Index

According to the principal component analysis method to determine the weight of teaching interaction quality evaluation index of road and bridge construction course, to prepare for the follow-up experiment.

The weight values of teaching interaction quality evaluation index are shown in Table 3.

3.3 Analysis of Experimental Results

Based on the above-identified evaluation indicators, conduct interactive quality evaluation experiments of road and bridge construction courses, compare the experimental results with the given actual results, and judge the evaluation performance of the proposed method.

The evaluation data of teaching interaction quality obtained through experiments are shown in Table 4.

Table 3. Table of weights of evaluation indexes for teaching interactive quality

Primary indicators	Secondary indicators	Weights
Operational interaction	Teacher operation technology	0.0312
	Teacher editing resources	0.0420
	Student operation technology	0.0210
	Student editing resources	0.0203
	Technology and technology sharing content	0.0214
Information exchange	Teacher lecture	0.0201
	Teacher instruction	0.0259
	Management classroom	0.0219
	Student discussion	0.0228
	Do exercises	0.0227
	Student thinking	0.0214
Emotional interaction	Teacher negative feedback	0.0246
	Teacher positive feedback	0.0271
	Respond positively to teachers	0.0102
	Encourage companions	0.0328
Cognitive interaction—teacher questions	Memorization level	0.0412
	Understanding level	0.0321
	Application level	0.0128
	Analysis level	0.0415
	Evaluation level	0.0145
	Create level	0.0690
	Supernatural level	0.0548
	Self-knowledge level	0.0834
Cognitive interaction—students answer or ask questions	Memorization level	0.0124
	Understanding level	0.0525
	Application level	0.0301
	Analysis level	0.0567
	Evaluation level	0.0401
	Create level	0.0100
	Supernatural level	0.0300
	Self-knowledge level	0.0123

(*continued*)

Table 3. (*continued*)

Primary indicators	Secondary indicators	Weights
Silence or silence confusion	Invalid language or behavior	0.0412

Table 4. Teaching interaction quality evaluation data table

Number of experiments	Evaluation results (points)		
	Actual value	Proposed method	Comparison method
1	52.12	52.12	45.12
2	65.12	65.10	50.23
3	58.49	58.41	58.49
4	71.05	70.00	70.21
5	81.48	81.00	86.59
6	81.00	81.23	89.54
7	85.41	81.25	85.36
8	75.32	74.21	80.12

As shown in the data in Table 4, compared with the comparative method, the error between the teaching interactive quality evaluation result of the proposed method and the actual value is smaller, which fully proves that the proposed method has a better evaluation effect.

4 Conclusion

Aiming at the problem of inaccurate evaluation results in the traditional teaching interaction quality evaluation method of road and bridge construction course, this paper puts forward the evaluation method of teaching interaction quality of road and bridge construction course based on principal component analysis. This study determines the evaluation index of teaching interaction quality based on principal component analysis method, which greatly improves the evaluation effect and provides the teaching of road and bridge construction course help.

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