Construction of Teaching Quality Assessment Model Combined with Data Mining Algorithm

Jingjing Nie[1,*]
[1]School of Mechanical and Electrical Engineering, Wuhan Business University, Wuhan, Hubei, 430000, China.

Corresponding authors: Jingjing Nie (e-mail: jingjinglinda0324@163.com).

Abstract Whether a reasonable and objective scientific assessment can be made for the teaching quality of teachers is of great research significance in promoting the overall improvement of teaching quality. In this paper, the Apriori association rule mining algorithm is utilized to mine the association rules on the subject teaching quality assessment samples, and the support and confidence range of the results obtained are between 0.0836~0.1567 and 0.3148~0.3874 respectively, and the model has the ability of effective mining. Based on the PCA teaching quality assessment model, the covariance matrix and eigenvalues were calculated sequentially to complete the selection of principal components of teaching quality assessment, and the principal component loadings and scores were obtained. From the result of component matrix operation, the final result score of teaching quality assessment of the subject course is 8.3145, which can realize the quantitative assessment of teaching quality. Applying the model in practice, the teaching quality assessment results show that the top 5 dimensions of the teaching quality assessment score are proper course progress, on-time starting and stopping, student interaction, highlighting the key points, and neatness of the board, and the average value of the scores is more than 2 points.

Index Terms teaching quality assessment, apriori association rule mining, pca model, quantitative assessment, principal component analysis, educational data mining, teaching quality metrics

I. Introduction

In the teaching management of colleges and universities, teaching evaluation, that is, according to the teaching process links of teachers, the evaluation of their teaching value, teaching evaluation is one of the necessary links [1], [2], which serves in the teaching management and decision-making, and it is an important way of supervision to promote the improvement of teaching quality [3]. Teaching evaluation can provide a reliable basis for the assessment of teachers' teaching level, and it can adjust and optimize teachers' teaching programs, so as to improve the talent cultivation capacity of institutions [4], [5].

In recent years, under the background of informationization development and social change, the teaching quality assessment method has been unable to meet the informationization and modernized teaching mode in terms of accuracy and implementation efficiency [6], so various disciplines have begun to carry out reforms continuously [7]. Accurate teaching quality assessment results in colleges and universities are directly related to the comprehensive development of teaching quality construction work, which is a key element of the program of training talents in colleges and universities [8]. Teaching quality in colleges and universities is an important evaluation index of the level of colleges and universities, but the quality of teaching in colleges and universities is related to a variety of influencing factors, which is very complex, and the traditional method of assessment of teaching quality in colleges and universities constructs a simple assessment model, which is unable to accurately and efficiently carry out the evaluation of teaching quality, and therefore requires the design of a new model of assessing the quality of teaching in colleges and universities [9]–[11].

Data mining technology is born under this demand condition. Data mining technology is the process of extracting useful information and knowledge from massive, incomplete, fuzzy, mixed, and missing-value databases [12], [14]. Simply put, data mining is the extraction or mining of information and knowledge from massive databases [15]. Data mining is mainly a process of extracting useful relationships and patterns from data using algorithms, which usually consists of multiple steps interconnected with each other and repeated human-computer interactions [16]. The task of data mining techniques is to discover valuable patterns from databases. Before selecting the appropriate data mining techniques, it is first necessary to transform the problems in practical applications into appropriate data mining tasks according to the specific problems, and then select a specific mining algorithm or algorithms according to the needs of the specific tasks [17], [18].

In this paper, the computational process of Apriori algo-

rithm under the association algorithm is proposed according to the mechanism of the action of the association rule algorithm and listing the three measures of the association rule. After collecting the sample of subjects, the Apriori algorithm is used to mine the association rules as well as the measurement indexes of the association rules, evaluate the mining results of the association rules, complete the PCA teaching quality assessment model, use the model to calculate the covariance matrix, eigenvalues in turn, select the principal components of the teaching quality assessment, and calculate the principal component load and score. Based on the score, the results of the component matrix are analyzed. In view of the problem of insufficient teaching quality evaluation system, the necessary guidelines for the construction of teaching quality assessment model are proposed. The model is applied to the actual teaching quality assessment work, based on the classroom teaching quality evaluation process, the classroom teaching data and the overall teaching evaluation situation are analyzed separately.

II. Teaching Quality Assessment Modeling and Analysis

A. Rule of Relevance Principles and Metrics

1) Association rules

Data mining has received a lot of attention from today's artificial intelligence and database communities. Among them, association rule mining is an important branch of data mining and an important topic of research in recent years. The main purpose of association rule mining is to find out whether there is some relationship between transaction items in the transaction database. It is driven by an application called shopping basket analysis, which aims to find out whether there is some kind of relationship among the items purchased by customers, i.e., whether the purchase of one item will also stimulate the purchase of another item. For example, a correlation rule can be expressed as "some of the customers who buy computers also buy printers". The decision maker of a shopping mall can optimize the layout of the mall accordingly by placing computers and printers together to stimulate the sale of goods.

2) Correlation rule measures

The three measures of association rules are Support, Confidence, and Lift:

Take transaction A and B as an example to illustrate, respectively, with $Y(A)$ indicates the number of transactions using A, $Y(B)$ indicates the number of users using transaction B, and N indicates the number of all users:

Support indicates the ratio of the number of people using A and B at the same time to the number of all transactions, and its calculation is shown in (1):

$$\text{Support}(A, B) = P(AB) = \frac{Y(A \cup B)}{N}. \quad (1)$$

Confidence indicates the proportion of transactions using A that also use B, which is calculated in (2):

$$\text{Confidence}(A \to B) = \frac{Y(A \cup B)}{Y(A)}. \quad (2)$$

Lift reflects the relevance of transactions A and B, which is calculated in (3):

$$\text{Lift}(A \to B) = \frac{Y(A \cup B)}{Y(A)}/Y(B). \quad (3)$$

B. Analysis of association rule mining algorithms

1) Apriori algorithm

Apriori algorithm was proposed in 1994, as one of the most classic and original algorithms for data mining association rules, it is mainly used to find out all the frequent itemsets (frequency) based on support and then generate association rules (strength) based on confidence on a large database.

2) Apriori algorithm flow

Figure 1 shows the flow of Apriori algorithm, Apriori algorithm uses layer-by-layer iterative search method, the specific steps are as follows:

1) Set the minimum support_min.
2) Scan the candidate_1 item set and calculate its support, keep the item set in the candidate_1 item set that satisfies its support is greater than or equal to support_min, i.e., get the frequent item set_1.
3) Frequent item set_1 is successive to get candidate item set_2, keep the item set in candidate item set_2 that satisfies its support degree is greater than or equal to support_min, that is to get frequent item set_2.
4) Iterate sequentially until it is impossible to find the frequent itemset _k+1, the corresponding set of frequent k itemsets is the output of the algorithm.

3) Association rule mining results

The accurate data is the basis of the analysis of the teaching behavior, and this paper analyzes and studies the teaching behavior data of teachers in the city based on intelligent classroom. In June 2019, the author collected 95,525 teaching behaviors in the intelligent class from March 2019 to June 2022, and obtained 1302 data according to the individual usage of the teachers. In this paper, the total number of teaching, the total number of teachers' teaching, the use of teaching resources, the study of the teaching resources, the arrangement of homework and the approval of 16 indexes were collected.

Figure 2 shows the results of association rule mining, using Apriori algorithm to mine association rules, set the minimum confidence and minimum support for 0.3 and 0.08 respectively.

As can be seen from the figure, the mining results of association rules are greater than the set minimum confidence
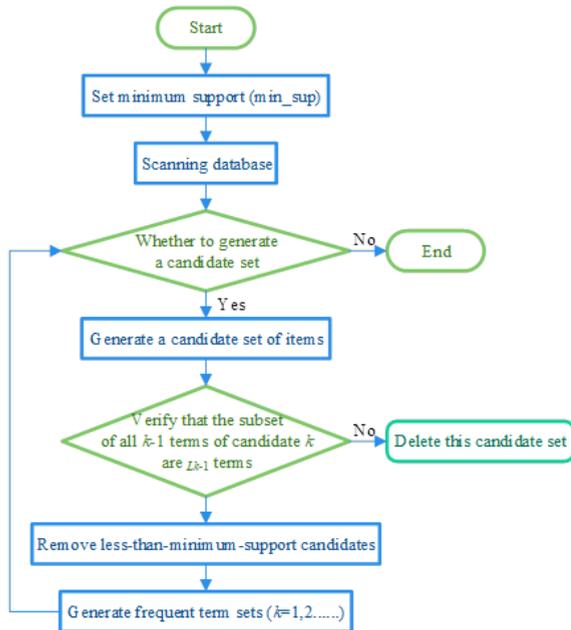
Figure 1: Apriori algorithm process

Figure 2: Association rule mining results

and minimum support, and the support and confidence range is between 0.0836~0.1567 and 0.3148~0.3874, respectively, so the use of this paper's model can be effectively mined for the association rules contained in the evaluation of teaching quality.

C. PCA Teaching Quality Assessment Model

1) Calculating the covariance matrix

Calculate the covariance matrix for the sample data:

$$\Sigma = (s_{ij}) \, p \times p. \tag{4}$$

Among them:

$$s_{ij} = \frac{1}{n-1} \sum_{k=1}^{n} (x_{ki} - \bar{x}_i)(x_{kj} - \bar{x}_j) \, i, j = 1, 2, \cdots, p. \tag{5}$$

2) Calculation of eigenvalues

The first m larger eigenvalues $\lambda_1 \geq \lambda_2 \geq \cdots \lambda > m_0$ of Σ are the variances corresponding to the first m principal components, and i the corresponding unit eigenvectors a_i are the coefficients of the principal components F_i with respect to the original variable, which is then the ith principal component F_i of the original variable:

$$F_i = a_i' X. \tag{6}$$

The variance (information) contribution of the principal components is used to reflect the amount of information, a_i for:

$$a_i = \lambda_i / \sum_{i=1}^{m} \lambda_i. \tag{7}$$

3) Selection of principal components

The final choice of several principal components, i.e. m of $F_1, F_2, \cdots\cdots, F_m$ is determined by the cumulative contribution of variance (information) $G(m)$:

$$G(m) = \sum_{i=1}^{m} \lambda_i / \sum_{k=1}^{p} \lambda_k. \tag{8}$$

When the cumulative contribution is greater than 85%, it is considered sufficient to reflect the information of the original variable, and the corresponding m is the first m principal components extracted.

4) Calculating principal component loadings and scores

Principal component loadings are reflecting the degree of inter-correlation between principal component F_i and the original variable X_j, and the loadings $l_{ij}(i = 1, 2, \cdots, m; j = 1, 2, \cdots, p)$ of the original variable $X_j(j = 1, 2, \cdots, p)$ on the principal components F_i $(i = 1, 2, \cdots, m)$:

$$l(Z_i, X_j) = \sqrt{\lambda_i} a_{ij} (i = 1, 2, L, m; j = 1, 2, L, p). \tag{9}$$

In the results of principal component analysis in SPSS software, the "Component Matrix" reflects the principal component loadings matrix.

Calculate the score of the sample on m principal component:

$$F_i = a_{1i} X_1 + a_{2i} X_2 + \cdots + a_n X_P. \tag{10}$$

5) Component Matrix Results

When the cumulative contribution rate is larger, the less information about the data is lost, i.e., the more information about the original indicator that can be covered. Table 1 shows the indicator eigenvalues, contribution rate and cumulative contribution rate, and the cumulative contribution rate of the first three indicator factors is 33.813%, which indicates that when analyzing the management quality of the school based on the assessment results, the first three factors have the highest degree of influence on the assessment of the teaching quality, as can also be seen from the contribution rate.

Principal component	Index	Eigenvalue	Contribution value %	Cumulative contribution %
1	Content familiarity	3.4517	11.458	11.458
2	Be careful	3.4515	11.569	23.027
3	Proper course	2.9645	10.786	33.813
4	highlight	2.8421	10.345	44.158
5	Content integrity	2.7978	9.462	53.62
6	Reasonable assignment	2.7484	9.345	62.965
7	Content of teaching	2.6458	9.058	72.023
8	Be clear	2.2645	8.645	80.668
9	lecture	2.2645	6.452	87.12
10	Blackboard cleanliness	2.2578	3.155	90.275
11	Mandarin standard	2.2368	2.565	92.84
12	Student interaction	2.0698	2.345	95.185
13	Clear learning	1.4688	1.865	97.05
14	Develop problem-solving skills	0.7856	1.236	98.286
15	On time	0.2459	0.927	99.213
16	Prepare for the time of confusion	0.0647	0.787	100

Table 1: Index characteristics, contribution and cumulative contribution

The model in this paper utilizes the mined association rules to determine the indicators of teaching quality assessment, and the PCA algorithm is used to calculate the contribution rate of the eigenvalues of different indicators, and the results of the cumulative contribution rate calculations show that the first 3 principal components obtained can reflect numerous information of teaching quality assessment. Statistics of the component matrix established by the 3 principal components, the results are shown in Table 2. Based on the results in the table, the linear combination of the 3 principal components is established, and through the weighted average of the coefficients, the final result of the teaching quality assessment of the course is obtained as 8.3145 points, and the experimental results show that the model in this paper can realize the quantitative assessment of teaching quality.

III. Needs and Analysis for Quality Assessment of Teaching and Learning

A. The need for evaluation of teaching quality

In the society of rapid development of knowledge economy, competition has become an eternal theme, and not advancing or retreating teaches us that innovativeness is what needs to be competitive. Therefore, for students educated in higher education institutions, the quality of teaching will greatly affect their competitiveness in society. In the past, the evaluation of teaching quality was measured by the amount of knowledge acquired by the students, but whether the knowledge could be transformed into application in practical work was seldom mentioned, so such evaluation was sometimes not comprehensive. So now the quality of teaching in colleges and universities depends on a number of aspects, such as: the quality and effectiveness of teachers' classroom teaching is mainly evaluated by students, teachers' scientific research and teaching level is evaluated by peers, and teachers' professional ethics and classroom organization ability is evaluated by leaders. Combining the above links to give the corresponding evaluation indexes and weights, you can come up with a relatively fair and impartial results, so that teachers themselves

for reference, and thus improve the quality of teaching, optimize the level of teaching to better serve the students. The quality of teaching and learning has become the top priority of the evaluation of teaching in colleges and universities, and is also an important initiative formulated by the Ministry of Education to improve the quality of teaching in colleges and universities. The role of higher education teaching assessment is to better promote the construction and development of colleges and universities, the assessment of the school to clarify the direction and purpose of the school, to further enhance and optimize the construction of faculty, so as to improve the conditions of schooling and improve the school management system, to improve the quality of education and teaching in higher education. At the same time, the assessment work should be continuously improved and perfected according to the situation of education and the current status of education. The main purpose of evaluation is to promote the effective fulfillment of the responsibilities of higher education institutions and the conscientious implementation of the Party's education policy.

B. Inadequacy of the current teaching quality evaluation system

The evaluation indexes in the teaching quality evaluation system are determined by using different evaluation indexes, weights and percentages occupied by each evaluation system according to the teaching purpose and teaching effect of the specialized courses. Taking the teaching quality evaluation system of Guangwai South China Business School as an example, such an evaluation system is mainly based on student evaluation as the main body, combined with the weighting of mutual evaluation between departmental leaders and colleagues to give the final assessment results.

C. Analysis of the application effect of the teaching quality model

Due to the necessity and urgency of the existence of the teaching quality assessment model at this stage, this paper

Index name	First component	Second main component	Third main component
Content familiarity	0.3458	0.0897	0.0896
Be careful	0.2988	-0.0365	0.1324
Proper course	0.3578	0.0269	0.1678
highlight	0.2978	0.0159	0.0364
Content integrity	0.3795	0.0369	-0.0896
Reasonable assignment	0.3669	0.0169	0.0642
Content of teaching	0.2678	0.3498	0.2644
Be clear	0.3569	-0.2689	0.0652
lecture	0.3789	0.1987	-0.1987
Blackboard cleanliness	0.2657	0.3452	0.2945
Mandarin standard	0.3457	0.4987	0.0462
Student interaction	0.3158	-0.3658	0.2648
Clear learning	0.3436	0.2978	-0.1659
Develop problem-solving skills	0.3498	0.2656	0.0896
On time	0.3458	0.3487	-0.0657
Prepare for the time of confusion	0.2898	0.1366	0.0567

Table 2: Matrix results

applies the designed teaching quality assessment model to the actual teaching quality evaluation.

1) Analysis of the evaluation process of classroom teaching quality

This chapter uses the research tool introduced in the research methodology in Chapter 2, the Classroom Teaching Quality Assessment Indicator Algorithm, to analyze 10 quality lessons in terms of familiarity with the content of the lecture, careful preparation, proper course progression, highlighting of the key points, completeness of the content, reasonable arrangement of the assignments, informative teaching content, clear organization, vivid explanation, neatness of the board, standard of Putonghua, students' Interaction, clear learning objectives, development of problem-solving skills, on-time starting and ending of class, and preparation time for answering questions and solving problems are analyzed in 16 dimensions for 10 quality lessons. Each quality lesson will have an overview of the classroom to understand the general flow and characteristics of classroom activities, as well as a representative selection of 3-4 segments to be analyzed specifically in terms of the 16 dimensions mentioned above, giving the level of observation and assessment and its rationale. Each lesson will also present the situation of each classroom activity fragment at the level of the 16 dimensions, the average classroom level data for each dimension, and the number of fragments at different levels of each dimension, and interpret and analyze them accordingly, and a teacher from University P was randomly selected as the subject teacher of this paper, named C1.

2) Analysis of classroom teaching data

Using the Classroom Teaching Quality Assessment Indicator System, we observed and assessed the performance of each teaching segment in the classroom of C1 teachers in 16 dimensions and calculated the average score of each dimension, Figure 3 shows the performance of C1 teachers in each segment in 16 dimensions, which allows us to have a more intuitive feeling of how the data changes in different dimensions and different teaching segments.
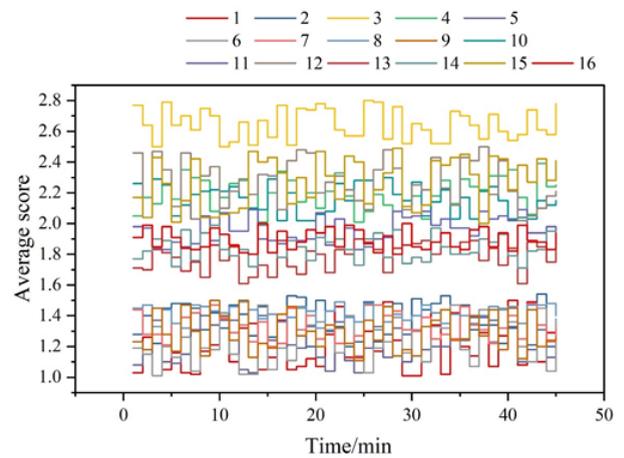

Figure 3: The 16 dimensional performance of teachers in each fragment

The top 5 mean scores for each of the 16 dimensions of the Classroom Teaching Quality Assessment System (CTQAS) for Teacher C1's class, in descending order, were proper course progression, getting to and from class on time, student interaction, highlighting of key points, and neatness of boards, with mean scores of 2.646, 2.269, 2.265, 2.199, and 2.155, respectively, which were all above 2 points.

The score for progressing appropriately from the beginning of the course to the end of the class remained basically above 2.5, fluctuating within the range of 2.5 to 2.8. Compared to the evaluation indicator of appropriate class progress, the score for getting to and from class on time fluctuated more widely, between 2 and 2.5. Scores for student interaction were consistent with those for getting to and from class on time, with a similar range of fluctuation. The range of scores for focus was smaller than for on-time and student interaction, ranging from 2 to 2.4, and the mean and range of fluctuations for neatness of boards was the smallest, with a range of fluctuations of 0.3 points or less.

Through the above analysis, it can be seen that the classroom organization of teacher C1's class was good, with the

teacher being able to control the classroom rhythm well and express the teaching content clearly, and the overall classroom activities of the class had a high degree of participation, with students actively and enthusiastically integrating into the classroom. However, the whole teaching content does not require much cognitive demand from students, and the richness and extensibility of the content needs to be strengthened. Students have fewer opportunities to elaborate and express their own meaningful understanding or make their own suggestions about others' ideas, and teachers should also strengthen their awareness and ability to evaluate in a timely manner, and capture students' valuable ideas or confusing and erroneous questions at the right time, and use this as a "teaching point". Teachers should also strengthen their awareness and ability in timely evaluation to capture valuable ideas or confusing or erroneous questions from students at the right time and use them as "teaching points" to promote the formation and development of students' thinking and abilities.

3) Analysis of the overall teaching evaluation situation

Table 3 shows the comparison of expert and student evaluation of teaching by faculty in the first semester. The basic idea of this paper on the application of teaching quality assessment model is: firstly, applying the empirical approach on the basis of practice, adopting the methods of combining qualitative and quantitative analyses, combining objective observation and subjective feelings, and combining students' evaluations and experts' (peers') evaluations, the results of this study are analyzed and demonstrated to initially establish a college classroom teaching Quality evaluation index system. Secondly, by utilizing the school's midterm teaching inspection, connecting the teacher's classroom teaching quality evaluation index system with the teaching management system, and by means of students' online evaluation of teaching, we will improve the system and method of teacher's classroom teaching quality evaluation, and enhance the operational efficiency of the evaluation process and the statistical efficiency of the evaluation results.

The comprehensive evaluation score is out of 10 points. The grades are, respectively, excellent: 9.00 points and above, good: 8.00 to 8.99 points, qualified: 6.00 to 7.99 points, and unqualified: less than 6.00 points. For teachers who are evaluated as basic qualified or unqualified, the faculty of the teacher should focus on helping them, designate specialists to help and guide them, and urge them to improve and enhance.

Taking the assessment results of the model designed in this paper as a measure, from the comparison of student and expert evaluation of teaching, the rate of student evaluation of teaching excellence is significantly higher than the rate of expert evaluation of teaching excellence, and the proportion of student evaluation of excellence is more than 80%, while the rate of expert evaluation of good is 76.19%. This shows on the one hand that students are highly satisfied with teachers, and on the other hand that the teaching level of teachers still needs to be further improved, and that the basic organizations of teaching still need to continue to organize the teaching work in

strict accordance with the basic laws of teaching, to cultivate and explore the potential of teachers, and to continuously improve the quality of teaching.

Due to the teachers' attention to the evaluation results, the teachers can actively strengthen the communication with the students, try to improve the quality of classroom teaching, and summarize and find out their shortcomings in time. For young teachers whose evaluation results are at the back of the line, students arrange experienced teachers to pass on their teaching experience so that they can improve their teaching level as soon as possible, and the experts have an obvious role in guiding classroom teaching, which provides a basis for the construction of the faculty in private colleges and universities.

To sum up, the evaluation of teachers' classroom teaching must be based on facts, emphasizing that by evaluating the quality of teaching, it objectively, fairly and accurately reflects the real situation of teachers' classroom teaching, brings the baton function of classroom teaching evaluation into full play to maximize the effectiveness of the teaching evaluation, gives full play to the leading role of the evaluation of teaching in the demonstration aspects of strengthening the construction of teaching, advancing the reform of teaching, and improving the quality of teaching, and integrates the teachers' classroom teaching with the cultivation of human beings, to Formation of synergy.

At the same time, we are actively creating conditions to improve the teaching ability of teachers. Actively play the role of "passing on" the role of the old teachers, the old teachers should be in-depth teaching, insist on listening to the lessons, pay attention to the evaluation of the lessons, which is conducive to play a good role in demonstration, but also conducive to the practice of investigating and summarizing the experience of the teaching reform and the problem. For young teachers who are not familiar with the business, after each lesson, they should be given timely instruction and systematic counseling in conjunction with the actual teaching. In addition, veteran teachers can also conduct demonstration classes and teaching reform classes to provide teaching models for improving the teaching ability and skills of young teachers.

Of course, the evaluation system of teachers' classroom teaching quality is not static, and it should be revised in due course according to the adjustment of the school's talent cultivation objectives, and it should be able to adapt to the social development, reflect the quality standards of education and teaching in the current period of time, and better play the role of the evaluation system in supervising and promoting the quality of classroom teaching.

D. Applicability of machine learning algorithm teaching

Machine learning refers to a branch of computer science, which means that computer programs can learn rules by themselves and use and integrate rules. In addition, the improvement of its own performance over time is an important part of the current artificial intelligence application field. The study found that in the field of education, SVM often has more applications, so it is of great significance to predict the

Secondary school	Tie up	Student evaluation	School expert	This model
Business school	Marketing Department	9.235	9.625	9.564
	Department of human resources management	9.321	8.165	8.652
	Department of business administration	9.348	8.985	9.125
	Business management department	7.954	8.154	8.654
Financial accounting institute	Financial system	8.265	8.265	7.845
	Accounting department	9.315	7.985	7.954
International school of economics	International business and trade department	9.265	8.845	9.012
	Foreign language department	9.214	7.789	8.556
Medical institute	Chinese traditional Chinese medicine department	9.451	8.026	8.569
	Medical department	9.465	8.156	8.647
	Oral medical technology department	9.521	8.569	8.978
Information and engineering institute	Electronic information and engineering department	9.248	7.845	7.985
	Department of computer science and technical engineering	9.265	8.365	8.647
	Construction process	9.445	8.065	8.578
The institute of culture and art	Chinese department	9.458	8.126	8.569
	Animation series	9.658	9.488	9.569
	Management department	8.126	8.125	8.057
	Art department	9.265	8.569	8.869
Jewelry academy	Jewelry department	8.265	8.354	8.265
Institute of clothing	Clothing design department	9.365	8.245	8.798
	Clothing Marketing Department	9.254	8.568	8.3665

Table 3: The experts and students are divided into the department classification

students' learning performance by using the support vector regression mechanism of the prediction and diagnostic reliability.

IV. Conclusion

This paper combines the measurement indexes of association mining algorithm, introduces PCA algorithm on the basis of Apriori algorithm, jointly constructs the teaching quality assessment model, and applies the final indexes to the actual teaching quality assessment after analyzing the results of association rule mining as well as the component matrix respectively.

In association rule mining, the support and confidence ranges are between 0.0836 and 0.156 and 0.3148 and 0.3874, respectively, and the constructed model is able to effectively mine the association rules contained in the evaluation of teaching quality.

The results of the cost matrix calculation show that the cumulative contribution value of the factors of the first three indicators is 33.813%, which shows that the first three factors have the highest degree of influence on the assessment of teaching quality. The final result of the teaching quality assessment of the tested course is 8.3145 points, and the model can realize the quantitative assessment of teaching quality.

Applying the model to the actual teaching assessment, 16 teaching quality assessment dimensions were evaluated, and the first five indicators were proper course progress, starting and ending the class on time, student interaction, highlighting the key points, and neatness of the board, with the mean value of more than 2 points. Taking the assessment of the model as the standard, the students' assessment of teaching quality is higher than that of the model, with an excellence rate of more than 80%, while the experts' assessment of teaching quality is slightly lower than the results of the model, with a good rate of 76.19%. The model designed in this paper plays a better auxiliary role in the process of teaching quality assessment.

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