Evaluation Method of Online Education Effect in Colleges and Universities Based on Data Mining

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Abstract. In order to improve the accuracy of online education evaluation results and lay a solid foundation for improving the level and quality of online education, data mining technology is introduced. Based on data mining technology, this paper studies the effectiveness evaluation method of online education in colleges and universities, and puts forward the effectiveness evaluation model of online education in colleges and universities. The decision problem is decomposed into hierarchical structure, the data mining technology is used to analyze the relevant data, and the evaluation table is constructed. The effectiveness of online education is evaluated comprehensively and multi-dimensionally based on association rules. The experimental results show that the method has high feasibility and accuracy, the confidence level is more than 96%, and the response time is less than 10ms, which is superior to the traditional method, proving that the method has significant advantages and potential in practical application.

Keywords: Data mining · Universities · On-line · Education · Effect · Evaluation

1 Introduction

Improving the quality of teaching in colleges and universities is currently the biggest challenge faced by schools due to the wave of higher education popularization. To address this challenge, it's essential for teachers to listen to students' feedback on their teaching methods, course content, and effectiveness. By using student evaluations as a tool to adjust teaching strategies, we can improve the overall quality of education. Ultimately, involving students in monitoring and evaluating the teaching process will ensure that they become active participants in their educational journey.Online education in colleges and universities is a crucial higher education category, providing education to front-line professionals and promoting China's move from elite to mass education. However, the expansion of national college enrollment and a rise in high enrollment rates has led to a need for quality monitoring, particularly for vocational colleges. As education shifts from elite to mass, schools face challenges like resource shortages, declining student quality, and insufficient monitoring of the teaching process. Thus, an effective online education evaluation method is essential [1].

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Due to various reasons, the effect of teaching monitoring and evaluation in colleges and universities is not ideal. Although some colleges and universities have carried out online evaluation, the large amount of data generated has not been effectively used to improve the teaching quality. For example, the design of a teaching effect evaluation system for accounting major based on big data technology was proposed in literature [2]. It uses MySQL database as the management platform to design four modules: basic information of teaching evaluation, setting of teaching evaluation scheme, online teaching evaluation and statistical analysis of evaluation results. Then it adopts fuzzy comprehensive evaluation and key technologies of data mining, and uses Java language and Android system to make the platform run more efficiently. However, there are still some problems in data processing and it is difficult to apply. Another example is the design of college English teaching effect evaluation method based on intelligent algorithm proposed in literature [3]. This method first collects English teaching evaluation data, intelligently selects evaluation indicators within the demarcated range, establishes a multi-functional intelligent algorithm teaching effect evaluation model, and adopts hierarchical goal evaluation method to realize the design, which also has the problem of difficult data processing.

Data mining is the core step of "knowledge discovery", which is a process of discovering hidden rules or valuable information and knowledge by collecting a large number of random original data samples and using a series of mining tools. Association analysis is to discover association rules between data samples by mining frequent item sets in data sets. More appropriate rules can usually be measured and determined through support, feasibility, relevance, etc. [4, 5]. At present, data mining is widely used in many disciplines and fields, but its workflow tends to be consistent, that is, the process of repeatedly predicting, analyzing, modeling and verifying from massive data through various methods to find interesting, valuable and applicable knowledge or patterns[6]. On this basis, this paper introduces the data mining technology, and makes a deep research on the evaluation method of online education in colleges and universities based on data mining technology.

2 Design of Evaluation Method for Online Education Effect in Colleges and Universities

2.1 Build an Online Education Effect Evaluation System Model

According to the actual education and teaching situation in colleges and universities, the online education effect evaluation system model is constructed to lay the foundation for the subsequent education effect evaluation.

First of all, it is necessary to clarify the correct orientation of the construction of the evaluation system model of online education effect in colleges and universities, including two orientations, namely, diversification orientation and differentiation orientation.

Diversified orientation. The personnel involved in the evaluation of teachers' teaching should be diversified so as to make a more comprehensive, objective and scientific evaluation of teachers' teaching activities from multiple aspects and perspectives [7].Diversified teaching evaluation should be composed of the following parts: first,

expert evaluation; Second, peer evaluation; Third, the evaluation of students; Fourth, the evaluation of teaching management personnel; Fifth, teachers' self-evaluation.

Differentiation oriented. The so-called micro differentiation means that the evaluation content of teaching should have a high degree of clarity, which should be easy to master standards and collect information. The first level indicators of the teaching evaluation content of university teachers generally include: teaching attitude, teaching design, teaching content, teaching methods, teaching effects, teaching characteristics and other major aspects, while the contents of the second level indicators and the third level indicators must be differentiated and refined according to the actual situation of the university and the differences in the course.

Through the research of practical problems, the decision-making problems are decomposed into different hierarchies according to the overall evaluation objectives, and a hierarchical structure is constructed to represent the characteristics and functions of the system. Secondly, using the same method as the judgment solution matrix vector, the judgment matrix of each element at each level to the related elements at the previous level is constructed to determine the weight of each element. For the decision problems whose target value can only be qualitatively described and the target system with hierarchical and staggered evaluation indicators, it is more appropriate to use the analytic hierarchy process [8].The process steps of constructing the model of online education effect evaluation system in colleges and universities based on analytic hierarchy process are as follows.

1. Establishment of evaluation system (index system).

   To realize the establishment of the evaluation system, it is necessary to carry out a systematic analysis, including the scope of the system, the factors involved and the relationship between these factors. Through this analysis, the system objectives, evaluation criteria and index system are established, and the corresponding hierarchical structure is established. The hierarchy structure required by AHP usually consists of three levels: the highest level is the target set of the problem -- the target level; The middle level is the standard level which affects the realization of the goal. The lowest level is the measure that promotes the realization of the goal - the measure level. As shown in Fig. 1, this is a hierarchical diagram.

   The application of analytic hierarchy process has different purposes, and the hierarchy can be selected and adjusted accordingly. For example, when selecting the evaluation index system to determine the ranking of index weights, the first two or three hierarchies can be used, and the alternative scheme layer should also be added when selecting the decision scheme.
2. Construct judgment matrix.

   This paper constructs the judgment matrix according to the hierarchical structure. The specific method to construct the judgment matrix is to take the criterion, that is, each element with downward subordinate relationship as the first element of the judgment matrix, place it in the upper left corner, and then arrange the elements belonging to it in the first column and the first row [9] in order.

   Usually, the method used to fill in the judgment matrix is to repeatedly ask the experts who fill in the judgment matrix; According to the criteria of the judgment matrix, compare the elements in pairs, select the important elements, evaluate their

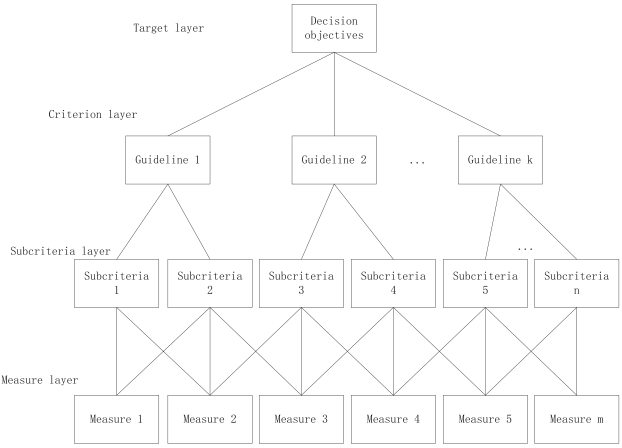

Fig. 1. Hierarchy Diagram of AHP Decision Analysis Method

importance, and use the importance scale value table to assign the importance by 1–9.The importance scale values are shown in Table 1.

Table 1. Importance Scale Values

Factor ratio factor	Quantized value
Equally important	1
Slightly important	3
Strongly important	5
Strongly important	7
Extremely important	9
Intermediate value of two adjacent judgments	2,4,6,8

3. Computational weight vector

To calculate the weight vector, appropriate mathematical methods should be used. The essence of single-layer hierarchical ranking is to compute the weight vector that indicates the relative weights of each factor in its standard under each judgment matrix. The computation of the weight vector includes methods such as sum method, power method, and root method. The sum method principle is to normalize each column in a consistent judgment matrix to obtain the required weights. In an inconsistent judgment matrix, the results obtained by normalizing each column only approximate the corresponding weights. The arithmetic mean of the column vectors is taken as the final weight:

$$W_i = \frac{1}{n} \sum_{i=1}^{n} \frac{a_{ij}}{\sum_{k=1}^{n} a_{k1}} \tag{1}$$

Among them, a_{ij} represents the elements in the judgment matrix under the criteria; a_{k1} represents the lower level element of the judgment matrix. In some special cases, the judgment matrix can be consistent and transitive. In general, this property does not require the judgment matrix to be strictly satisfied. However, a correct judgment matrix importance ranking requires certain logical rules from the perspective of human cognition rules. For example, if A is more important than B and B is more important than C, A comparison can be made between A and C. [10] Therefore, in practice, the judgment matrix generally meets the requirements of consistency, and consistency inspection is required. Only if the judgment matrix passes the test can it be explained that it is logically reasonable, and then continue to analyze the results.

4. Verify consistency. First, CI (consistency index) is calculated according to the one-time index, and the calculation formula is:

$$CI = \frac{\lambda_{\max} - n}{n - 1} \tag{2}$$

Among them, $\lambda_{\max}$ represents the maximum eigenvalue of the judgment matrix. According to the judgment, different orders in the matrix can be obtained. Again, the consistency ratio of the evaluation index CR (consistency ratio) is calculated and judged. The formula is:

$$CR = \frac{CI}{RI} \tag{3}$$

where, RI is the average random consistency index corresponding to the evaluation index. When $CR \prec 0.1$, the judgment matrix consistency meets the requirements; When $CR \succ 0.1$, the judgment matrix is unacceptable and does not meet the consistency requirements, the judgment matrix should be modified.

2.2 Data Mining for Online Education Effect Evaluation

After building the online education effect evaluation system model based on the above, next, use data mining technology to comprehensively mine and analyze the relevant data of online education effect evaluation of colleges and universities. The data mining system is generally composed of various databases, mining pre-processing modules, mining operation modules, pattern evaluation modules, and knowledge output modules. The achievements of these modules constitute the architecture of data mining, as shown in Fig. 2.

As shown in Fig. 2, the data mining architecture of online education effect evaluation for colleges and universities designed in this paper. The data mining process is as follows:

1. Define the problem.

The primary factor to realize data mining is to clarify the problems that users need to solve. However, we do not know what kind of pattern structure the knowledge data to be mined is, but we can know the specific objects that users want to mine. Because we do not know what is meaningless to mine, we must understand users' mining needs, combine specific needs, and study the feasibility of data implementation to finally determine users' business problems.

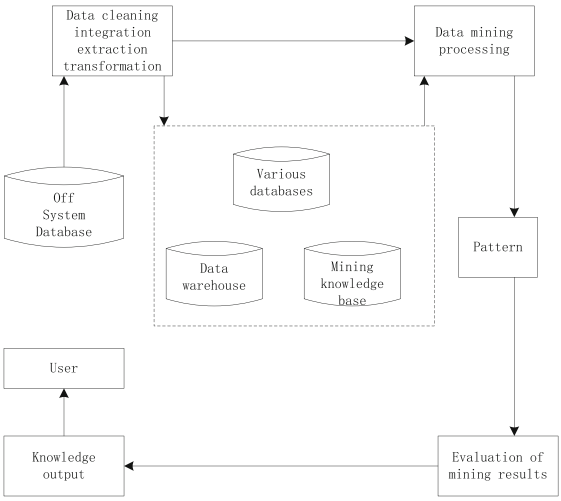

Fig. 2. Data Mining Architecture

2. Prepare data.

   Data exists in different ways, and can be distributed in the same database or under different departments of the enterprise. Because different storage media often have inconsistent data formats, and a large number of erroneous data will accompany. Therefore, it is necessary to properly delete or complete data at a stage, then smooth the noisy data, and then convert the data format into a unified format to facilitate data processing; Finally, all the data are put together to find useful potential data in the integrated data, and then generate useful test data sets. In the actual teaching evaluation process, it is inevitable that due to the influence of personal subjective emotions, the evaluation data is not credible. Therefore, it is necessary to screen out the teaching evaluation data that deviates excessively from the actual situation for data cleaning to ensure the objectivity of the subsequent model construction. In data cleaning, regression uses a function to fit data to smooth data and identify noise; However, the density based outlier detection method has a good effect on anomaly data detection for data sets with uneven distribution.
3. Browse data.

   The purpose of browsing data is to test and evaluate the dataset generated in the previous step to determine whether the dataset meets the user's requirements. However, data correction cannot be successful once. It requires repeated experimental correction until the tested data set can map out the real data.
4. Generate model.

   Select a mathematical model that can match the data mining algorithm. The adaptability of the model and algorithm is an important factor for success. If the adaptability is high, then the model is successful. The design model of this paper is the entity relationship model of education effect evaluation, as shown in Fig. 3.

As shown in Fig. 3, it is an individual for teachers and a whole for schools. When building the entity relationship model of teaching evaluation, we can only build it for a single teacher, thus improving the matching degree of the model.

5. Browse and verify the model.

   Before bringing the above model to the user environment, relevant tests should be carried out on the model, and the evaluation should be carried out according to relevant data indicators. If the model can be used, it can be directly used in the user environment; If it is not good, it needs to be modified repeatedly until the model produces the best data results.

6. Deploy and update models.

   After the model is established, the new data will be described under the new model, and the data model that is least difficult to understand will be used to realize visual expression for users. At the same time, the model will be adjusted and changed immediately according to the specific effects or needs in the actual process.

   After the completion of data mining for online education effect evaluation of colleges and universities, the evaluation table for online education effect of colleges and universities is constructed based on the above weight calculation results, and the corresponding weight distribution is divided, as shown in Table 2.

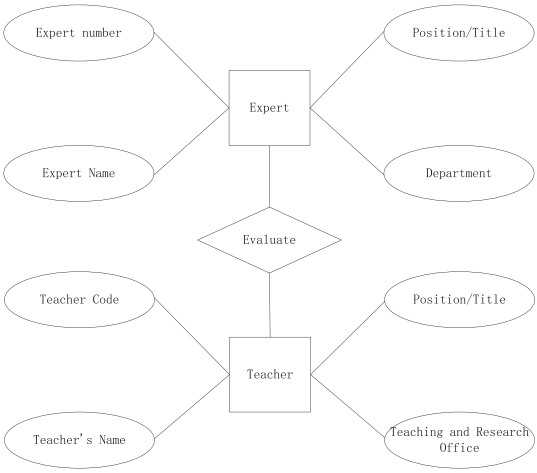

Fig. 3. Entity relationship model of education effect evaluation

For the above five first level indicators, the corresponding second level indicators have the same weight. In data mining, data preparation includes all activities of constructing the final dataset from the original data. These data will be input values to the model. Because the data stored in the computer system database has problems such as noise, missing and redundancy, it is not suitable for direct data analysis and mining. Therefore, it is necessary to further preprocess the original data. In the data preprocessing stage, data cleaning, integration, reduction, transformation and other steps need to be carried out. The final data after preprocessing should be accurate, complete and consistent. The

Table 2. Evaluation of online education effect in colleges and universities

Primary indicators	Secondary indicators	Weight distribution
Teaching quality U1	U11	0.05
	U12	0.03
	U13 (well prepared, skilled in teaching, patient in answering questions)	0.04
	U14 (Reasonable teaching design, clear organization and sufficient teaching preparation)	0.07
	U15	0.01
Teaching Methods U2	U21 (Rational use of modern information technology and digital teaching resources such as the Internet and artificial intelligence)	0.09
	U22 (pay attention to the cultivation of students' ability and encourage innovation)	0.04
	U23 (pay attention to individual differences of students and give guidance to students' learning methods)	0.08
	U24 (active classroom atmosphere, good interaction between teachers and students)	0.06
	U25 (pay attention to the cultivation of students' practical ability and innovative consciousness)	0.017
Teaching content U3	U31 (clear teaching purpose and reasonable time arrangement)	0.15
	U32 (earnestly practice the teaching plan to make it meet the requirements of the syllabus)	0.03
	U33 (brief explanation, prominent key and difficult points, and standard demonstration operation)	0.08
	U34 (organic integration of cultural education, curriculum ideological and political, professional ideological and political, professional and creative integration and other elements)	0.07
	U35 (combine and extend classroom knowledge and extracurricular knowledge)	0.09
Teaching effect U4	U41 (student participation in class)	0.23
	U42 (improvement of students' practical ability)	0.16
	U43 (Student Quality Development)	0.19
Teaching Features U5	U51 (innovative teaching mode, both scientific and artistic)	0.11

values of the five first level indicators are equal to the sum of the scores of each second level indicator. After conversion, we converted the scores of the secondary indicators into the relevant data of the five primary indicators, and sorted out the collected data as the original data samples to cluster the five primary indicators. After data collection, preprocessing and transformation, data samples for data mining can be obtained.

In the clustering analysis of data mining, we use K-Means algorithm, which usually selects K data from n data as the initial cluster center. Then, the remaining objects are allocated to the corresponding clusters according to the similarity with the selected initial cluster center. Finally, the corresponding average value of each cluster center is obtained through calculation, and the task is completed by repeating this process to obtain the final convergent standard measure function. In the actual operation process, we divide the sample data into three clusters, and randomly select three data as the center point of the initial cluster analysis. Then the number of three clusters represents the clustering results of "excellent", "qualified" and "unqualified" teaching evaluation results respectively.

2.3 Evaluating the Effect of Online Education in Colleges and Universities

After the above data mining of online education effect evaluation is completed, the initial clustering evaluation results of online education effect are obtained. On this basis, the effect of online education in colleges and universities is evaluated comprehensively and multi-dimensionally based on association rules.

The data of the five primary indicators in Table 1 are converted through data discretization. In this paper, we convert the five first level indicators in the above table into four levels: "excellent", "good", "medium" and "poor". See Table 3 for the specific conversion criteria.

Table 3. Discrete conversion standard of primary indicators

Primary indicators	excellent	good	in	difference
Teaching quality	Score $\geq$ 22	19 $\leq$ score $<$ 22	16 $\leq$ score $<$ 19	Score $<$ 16
teaching method	Score $\geq$ 22	19 $\leq$ score $<$ 22	16 $\leq$ score $<$ 19	Score $<$ 16
content of courses	Score $\geq$ 26.5	23 $\leq$ score $<$ 26.5	19.5 $\leq$ score $<$ 23	Score $<$ 19.5
teaching effectiveness	Score $\geq$ 13	11 $\leq$ score $<$ 13	9 $\leq$ score $<$ 11	Score $<$ 9
Teaching characteristics	Score $\geq$ 4.5	4 $\leq$ score $<$ 4.5	3.5 $\leq$ score $<$ 4	Score $<$ 3.5

According to the data discretization conversion standard in Table 3, the primary evaluation indicators are converted to obtain the evaluation table of online education effect of colleges and universities shown in Table 4.

Table 4. Evaluation of online education effect in colleges and universities

Teaching quality	teaching method	content of courses	teaching effectiveness	Teaching characteristics	Evaluation grade
excellent	excellent	excellent	excellent	good	excellent
excellent	excellent	good	good	good	excellent
excellent	excellent	excellent	excellent	excellent	excellent
good	in	In	in	good	qualified
good	good	In	good	good	qualified
excellent	good	good	good	good	qualified
good	in	difference	difference	difference	unqualified
in	in	difference	difference	difference	unqualified
…	…	…	…	…	…

Through the online education effect evaluation table in Table 4, we can obtain the education effect evaluation grade, and then achieve the goal of online education effect evaluation of colleges and universities based on data mining.

3 Experimental Analysis

3.1 Experiment Preparation

The above content is the whole design process of the online education effect evaluation method for colleges and universities based on data mining technology proposed in this paper. Before putting forward the method for online education effect evaluation in colleges and universities, the feasibility and effectiveness of the method need to be objectively tested to avoid abnormal problems in direct use, which is not conducive to improving the level and quality of online education in colleges and universities.

In order to verify the effectiveness of relevant algorithms, the course Fundamentals of Computer Application for the automobile maintenance specialty of X University is selected as the experimental object, and the first 497 (38250 in total) data extracted from the data set are used as the data source for example analysis. Each record contains 35 attributes, The data mining algorithm in this paper is analyzed by observing the change of the algorithm execution time and the time required under different minimum support states from the fixed minimum support. The software and hardware environment of the experiment is shown in Table 5.

According to the software and hardware environment configuration shown in Table 5, the online education effect evaluation test environment of colleges and universities was built. The online education effect evaluation index system used in this experiment consists of multiple sub indicators. In view of the needs of X university teachers and students for online education, as well as the various factors that affect the education effect, the rating indicators are mainly divided into two parts: teacher quality indicators and teaching

Table 5. Software and Hardware Environment Configuration for Experimental Test

Environmental Science	project	to configure
Hardware	CPU	Intel (R) Core (TM), 17
	Memory	4G
	Hard disk	500G
Software	CPU	WindowsServer 2019
	Memory	SQL SERVER 2019
	Hard disk	/

quality indicators. Among them, teacher quality indicators include teacher's education background, professional title, teaching achievements, etc. The teaching quality indicators are divided into four items: classroom driving, classroom participation, curriculum difficulty and comprehensive teaching evaluation. In the whole data evaluation indicator system, the data information of teachers' quality indicators is reflected, as shown in Table 6.

Table 6. Data Information of Teacher Quality Indicators

Field Name	Field Description	Field Type	length
JS-GH	Teacher ID	INT	8
JS-MM	password	VARCHAR	64
JS-XM	full name	VARCHAR	20
JS-ZGXL	Highest education	VARCHAR	20
JS-ZC	title	VARCHAR	20
JS-XB	Gender	VARCHAR	20
JS-GL	working years	DATETIME	20
JS-NL	Age	INT	4

The above table shows the composition of teachers' basic information, from which the irrelevant items, such as gender, age, reserved job number, educational background and other attribute items that are closely related to teaching work, are excluded. Among them, each attribute item corresponds to several different attribute sectors. For example, the education level includes four levels: junior college, bachelor, master and doctor. The rating information of teaching quality comes from the students' evaluation and rating of each teacher on the school system after each semester. It is also the main part of the data set in this teaching evaluation system. Different attributes of teaching evaluation are also divided into different rating levels. For example, classroom driving includes four levels: excellent, good, medium and poor. There are also Boolean variables, such as whether comprehensive evaluation has two attribute levels: yes and no. In the scoring system,

different attribute levels correspond to different score ranges. The teaching evaluation information table is shown in Table 7.

Table 7. Evaluation Information of Online Education Effect

Field Name	Field Description	Field Type	length
PJ-ID	Course No	INT	8
PJ-JSGH	Teacher ID	VARCHAR	8
PJ-KTDDX	Driving power of online classroom	VARCHAR	20
PJ-KTHDX	Online classroom interaction	VARCHAR	20
PJ-KCJSD	Online classroom acceptance	VARCHAR	20
PJ-YYBDNL	Online classroom expression ability	VARCHAR	20
PJ-XSCYD	Student participation in online classes	VARCHAR	20
PJ-KHFS	Online classroom assessment method	VARCHAR	20
PJ-ZHPJ	Comprehensive evaluation of online classroom	VARCHAR	20

The teacher education evaluation information is obtained through the online education effect evaluation information of colleges and universities in Table 7. On this basis, According to the online education effect evaluation method designed in this paper, the online education effect of X University is objectively evaluated. The flow of this experimental analysis is shown in Fig. 4.

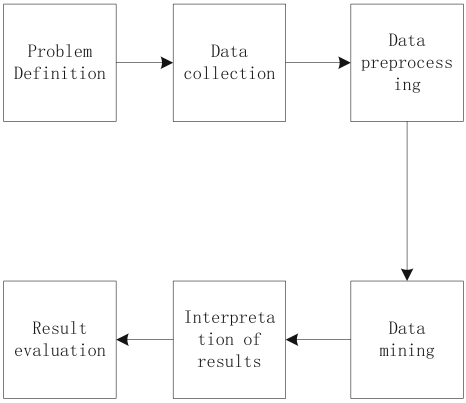

Fig. 4. Schematic Diagram of Experimental Analysis Process

According to the experimental analysis process shown in Fig. 4, the online education effect evaluation test of colleges and universities was carried out to test the feasibility and application effect of the proposed evaluation method.

3.2 Result Analysis

In order to make the experimental analysis results more intuitive and clear, the method and principle of comparative analysis are introduced. Set the above online education effect evaluation method based on data mining proposed in this paper as the experimental group, and set the traditional online education effect evaluation method as the control group, and compare and analyze the evaluation effects of the two methods respectively. The credibility of the evaluation results of online education in X colleges and universities is selected as the evaluation index of this experimental analysis. The higher the confidence of the evaluation results, the higher the feasibility of the online education effect evaluation method, the higher the accuracy of the evaluation results, and vice versa.

Randomly select some items in the online education effect evaluation information table, and map the centroid to the score table of the percentile system. Starting from five dimensions of online education quality, online education content, online education method, online education effect, online education management, the above two methods are used to evaluate the online education effect of X university from five different dimensions. SPSS statistical analysis software was used to measure the confidence of the results of the two methods and compare them. The results are shown in Fig. 5.

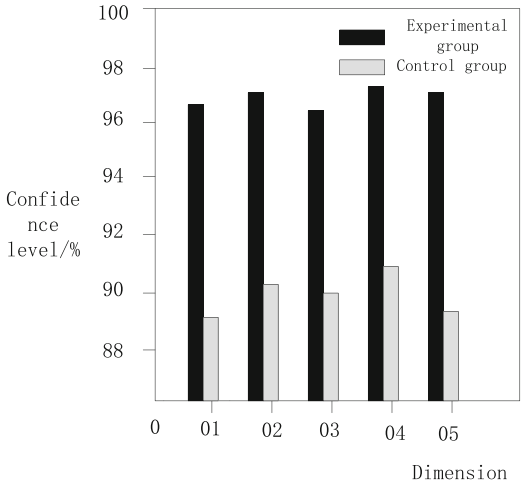

Fig. 5. Comparison Diagram of Evaluation Results Confidence

It can be seen from the comparison results of evaluation indicators in Fig. 5 that after the application of the online education effect evaluation method for colleges and universities based on data mining proposed in this paper, the confidence level of evaluation results is significantly higher than that of traditional methods, reaching more than 96%.It is not difficult to see that the online education effect evaluation method proposed in this paper has high feasibility, high accuracy of evaluation results, significant advantages in application effect, and can be put into practical use.

Next, the evaluation time of the two methods is compared, and the comparison results are shown in Fig. 6 below.

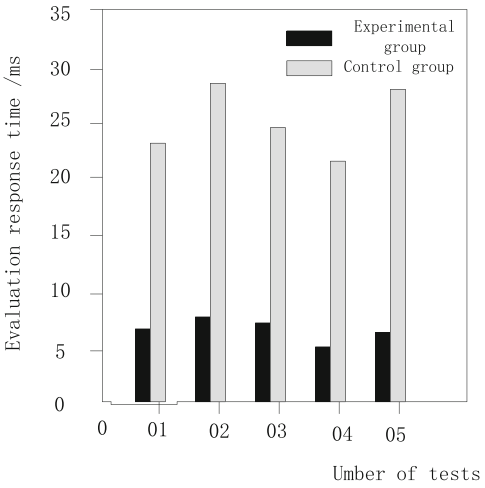

Fig. 6. Evaluation response time comparison

As shown in Fig. 6, the evaluation response time of the proposed data mining based online education effectiveness evaluation method for universities is less than 10ms, while the evaluation response time of traditional methods is above 20ms. Therefore, the proposed method is better and can be better applied to online education effectiveness evaluation.

4 Conclusion

In view of the problems of low accuracy and poor effect of traditional online education evaluation methods in practical application, this paper introduces data mining technology and puts forward an online education evaluation method based on data mining technology. This method establishes the evaluation model of the effectiveness of online education in colleges and universities, decomposes the decision-making problem into a hierarchical structure, analyzes the relevant data by using data mining technology, constructs an evaluation table, and evaluates the effectiveness of online education comprehensively and multidimensional based on association rules. The experimental results show that compared with the traditional method, the evaluation results obtained by the proposed method are more than 96% confident, the evaluation response time is less than 10ms, and the performance is better. It can improve the technical level of teaching evaluation, science, objectivity and justice, and improve the teaching quality in colleges and universities.

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