Teaching Quality Evaluation Model of a Flipped Classroom in Colleges and Universities Based on Support Vector Machine

Jin Feng Fu¹ and Jun Li²

¹School of Marxism, Heilongjiang University of Science and Technology, Harbin, China 150022
²Office of Teaching Construction in Chengdu Technological University, Chengdu, Sichuan Province, China 611730

Correspondence should be addressed to Jun Li; ljun1@cdtu.edu.cn

Received 21 March 2022; Revised 8 April 2022; Accepted 20 April 2022; Published 30 June 2022

The systematic evaluation of teaching quality in colleges and universities is an important factor, which makes the systematic evaluation of teaching quality in colleges and universities very complex and makes the systematic evaluation of teaching quality in colleges and universities unable to describe a variety of teaching quality directly or indirectly. Therefore, a quality evaluation model of flipped classroom teaching in colleges and universities based on support vector machine is proposed. Through the selection of teaching quality evaluation indicators from three aspects of experts, teachers, and students, the evaluation system of flipped classroom teaching quality in colleges and universities is established. The evaluation indicators are used as the input of support vector machine for learning, and the evaluation model of flipped classroom teaching quality in colleges and universities is established. The experimental results show that this method can effectively evaluate the quality of flipped classroom teaching in colleges and universities, the relative error of the evaluation results is low, and it has certain practicability.

1. Introduction

With the continuous in-depth reform of education in China, a flipped classroom has become a more popular teaching form in current teaching. Compared with the traditional classroom teaching mode, this new type of classroom breaks the rigid mode of traditional teaching, subverts the limitation of time and space in classroom teaching, and gives students more space for autonomous learning [1]. It not only improves students’ interest in learning but also effectively improves the quality of teachers’ teaching. In order to continuously improve the teaching quality of the flipped classroom, it is very important to effectively evaluate its classroom quality [2, 3]. Teaching evaluation requires multiangle, multidimensional, and dynamic evaluation based on relevant quality and results. At present, the evaluation of teaching quality mainly depends on the attitudes of teachers and students, and there is often a certain degree of subjectivity in the evaluation process [4]. Therefore, researchers in this field have conducted a lot of research into the evaluation methods of classroom teaching quality and have achieved certain results.

Reference [5] studies and implements an interactive light augmented reality teaching system for numerical optimization teaching. The system uses the Aruco algorithm for multitarget tracking and recognition, realizes the simulation and visualization of the numerical optimization process based on JavaScript technology, and designs and develops a prototype augmented reality system, which can effectively improve the learning efficiency of learners. Reference [6] constructs a comprehensive college English quality evaluation system based on big data analysis to obtain high-precision English teaching quality evaluation results. Reference [7] uses the mixed evaluation method to evaluate the effect of demand support teaching on girls’ daily moderate intensity sports activities in physical education teaching. Reference [8] proposes a new method to evaluate teachers’ teaching skills under the application of a flipped classroom based on probabilistic semantic evaluation information.

Machine learning in artificial intelligence algorithm, represented by support vector machine, can show many unique advantages in solving small sample and nonlinear
and high-dimensional pattern recognition [9] and can be extended to other machine learning problems such as function fitting. At the same time, the support vector machine method is an efficient method widely used in the field of evaluation. It has high advantages for non-linear and high-dimensional evaluation problems [10, 11]. At present, the evaluation methods of classroom teaching quality in colleges and universities are mainly aimed at the traditional offline classroom. There is less research on the evaluation of teaching quality of a flipped classroom, or there are problems with strong subjectivity. Therefore, this paper proposes the evaluation method of flipped classroom teaching quality in colleges and universities based on support vector machine. On the basis of constructing the evaluation system of flipped classroom teaching quality in colleges and universities, the support vector machine method is applied to the evaluation of flipped classroom teaching quality in colleges and universities, so as to avoid the defects that the evaluation is easy to fall into local optimization and overlearning and improve the effectiveness of the evaluation.

2. Construct the Evaluation System of Flipped Classroom Teaching Quality in Colleges and Universities

Traditional teaching quality evaluation methods evaluate the flipped classroom teaching quality according to the subjective cognition of experts and teachers, ignoring students’ opinions, which is quite different from the real teaching results. At the same time, the pertinence of teaching quality evaluation methods is weak, and the accuracy of evaluation results is low. Therefore, this paper analyzes the evaluation indexes of flipped classroom teaching and constructs the evaluation system of flipped classroom teaching quality in colleges and universities.

2.1. Flipped Classroom. A flipped class model (FCM) is also known as flipped classroom [12]. The application field of the flipped classroom has relevant empirical research from basic education to higher education. In the flipped classroom teaching method, students are listed as the main unit of the learning process. Students can actively complete learning tasks before, during, and after class and can promote effective communication between teachers and students during the teaching process. And it can also increase the communication opportunities between students. The use of this teaching mode can fully mobilize students to participate in the classroom and participate in the whole process of learning [13, 14], cultivate students’ autonomous learning ability, inquiry ability and cooperative learning ability, and mobilize the enthusiasm of students in class.

2.2. Selection of Evaluation Indicators. In order to ensure the accuracy of flipped classroom teaching quality evaluation in colleges and universities, the evaluation indexes are divided into several different levels of indexes, which are divided layer by layer. The more the levels of index evaluation, the higher the effectiveness of the indexes. The hierarchical structure of indicators is shown in Figure 1.

Considering that students and teachers are the direct receivers of flipped classroom teaching and experts are the objective evaluation subjects, the evaluation indicators are selected from three aspects: experts, students, and teachers according to the hierarchical model shown in Figure 1.

2.2.1. Selection of Expert Evaluation Indicators. According to the selection principle of evaluation indicators, the expert evaluation indicators are determined, which are composed of four primary indicators and nine secondary indicators, as shown in Table 1.

2.2.2. Selection of Student Evaluation Indicators. After analyzing the student indicators of flipped classroom teaching, the indicators that occupy a small proportion are screened out, and the remaining part is the student evaluation indicators needed in this paper. The determined student evaluation indicators are shown in Table 2.

2.2.3. Selection of Teacher Evaluation Indicators. Through the evaluation of teaching planning, teaching means, classroom setting, teaching attitude, and classroom performance, the teacher evaluation indicators [15, 16] are obtained, as shown in Table 3.

2.3. Constructing the Quality Evaluation System of Flipped Classroom Teaching in Colleges and Universities. An analytic hierarchy process is more suitable for decision-making problems with hierarchical and staggered evaluation indexes, and the target value is difficult to describe quantitatively. The expert scoring method is also a qualitative description and quantitative method. It first selects several evaluation items according to the specific requirements of the evaluation object, then formulates the evaluation criteria according to the evaluation items, hires several representative experts to give the evaluation scores of each item according to the evaluation criteria based on their own experience, and then aggregates them. Therefore, this paper combines the above two algorithms when constructing the flipped classroom teaching quality evaluation system in colleges and universities.

Based on the above selected evaluation indicators, the evaluation system of flipped classroom teaching quality in colleges and universities is established by using the analytic hierarchy process [17, 18] and expert evaluation method [19]. Firstly, the main level model of flipped classroom teaching quality evaluation in colleges and universities is determined, as shown in Figure 2.

The main hierarchical factors determined by the analytic hierarchy process are compared with each other to establish the main factor comparison matrix [20], as shown in Table 4.

The importance of different indicators in Table 4 is represented by 1, 2, and 3, respectively, indicating that the two elements are equally important, relatively important, and very important [21]. It is established that the maximum eigenvalue of the matrix is 5.9865 and the order of the matrix is 5. The consistency test formula for the order and
The eigenvalue of the matrix is as follows:

\[ CR = \frac{CI}{RI} \]  

(1)

In formula (1), CR represents the consistency ratio of the comparison matrix [22] and RI and CI, respectively, represent the average random consistency index and the inconsistency degree of the pairwise comparison matrix.

The weights of different evaluation indexes are obtained according to the eigenvalues of the comparison matrix [23, 24], and the construction of the flipped classroom teaching quality evaluation system in colleges and universities is completed.

### 3. Evaluation of Flipped Classroom Teaching Quality Index under the Support Vector Machine Algorithm

According to the selection results of the above flipped classroom teaching quality evaluation indicators, the indicators of experts, students, and teachers cannot be studied.

---

![Figure 1: Hierarchical model of the evaluation index.](image)
quantitatively. Therefore, the support vector machine method [25] is used to evaluate the quality of flipped classroom teaching. The evaluation results are basically consistent with the actual situation, and the process is simple and convenient for practical application.

3.1. Principle of the Support Vector Machine Algorithm. Support vector machine is based on statistical theory. Support vector machine is often applied to machine learning in the case of small samples [26]. Support vector machine uses the optimization method to obtain the global optimal solution, effectively avoiding local optimization and overlearning [27], which can be applied to regression and classification problems.

The support vector machine (SVM) algorithm is proposed under the condition of linear separability [28, 29]. For $n$ linearly separable observation samples, $(x_1, y_1), \ldots, (x_n, y_n)$, as shown in Figure 3.

According to the support vector machine learning algorithm shown in Figure 3, the linear discriminant function is $g(x) = ax + b$, and there are two types of education modes between the positions of solid points and hollow points. $H$ is the optimal classification line, $H_1$ and $H_2$ are the points closest to the classification hyperplane and parallel to the classification line, and the distance between $H_1$ and $H_2$ is called the classification margin [30].

Let the formula of the hyperplane be $ax + b = 0$. $a$ is the vector perpendicular to the hyperplane, $b$ is the hyperplane offset, and a hyperplane can be completely determined by its parameter $(a, b)$. Define the conditions met:

$$\min |ax_i + b| = 1, \quad i = 1, 2, \ldots, n. \quad (2)$$

The hyperplane calculated by formula (2) is the canonical hyperplane. At this time, the linearly separable sample set meets the following constraints:

$$y_i(ax_i + b) \geq 1, \quad i = 1, 2, \ldots, n. \quad (3)$$

At this point, margin = $2/|a|$. The training samples are correctly separable, meet the sample points of $ax_i + b = 1$, and have the smallest distance from the classification line. They determine the optimal classification line, which is called support vector.

Using the Lagrange multiplier optimization method [31], the above problem is transformed into a dual problem; that is, there are constraints:

$$\begin{cases} \sum_{i=1}^{n} y_i \beta_i, & i = 1, 2, \cdots, n. \\ \beta_i \geq 0, & i = 1, 2, \cdots, n. \end{cases} \quad (4)$$

Solve the maximum value of the following function for $\beta_i$ based on formula (4):

$$W(\beta) = \sum_{i=1}^{n} \beta_i - \frac{1}{2} \sum_{i,j} \beta_i \beta_j y_i y_j x_i x_j. \quad (5)$$
where $\beta_i$ is the Lagrange multiplier corresponding to each sample. If the solution of this formula is not zero, the corresponding sample is the support vector, and the final optimal classification function is

$$ f(x) = \text{sgn} \ (\alpha x + b) = \text{sgn} \left\{ \sum_{i=1}^{n} \beta_i^* y_i K(x_i, x) + b^* \right\}. \quad (6) $$

The category to which $x$ belongs is obtained by formula (6). When the linearity is inseparable, many relaxation variables and penalty coefficients can be added to the conditions to reduce the restrictions and obtain the generalized linear classification.

In the case of nonlinearity, $x$ is transformed into high-dimensional feature space through nonlinearity, so as to find the optimal classification surface. In the high-dimensional space, the inner product operation is carried out by using the function of the original space, and the nonlinear problem in the linear space [32] is mapped to the high-dimensional feature space, so as to fundamentally solve the nonlinear problem. Therefore, assuming that the kernel function satisfying the Mercer condition is $K(x_i, x_j)$, the linear classification can be obtained through nonlinear transformation without increasing the computational complexity. At this time, the corresponding classification function is

$$ f(x) = \text{sgn} \ (\alpha x + b) = \text{sgn} \left\{ \sum_{i=1}^{n} \beta_i^* y_i K(x_i, x) + b^* \right\}. \quad (7) $$

Choosing different kernel functions can form different algorithms. Commonly used kernel functions mainly include the following two types:

Radial basis function (RBF):

$$ K(x_i, x_j) = \exp \left\{ -\frac{|x_i - x_j|^2}{\sigma^2} \right\}, \quad \sigma > 0. \quad (8) $$

Polynomial kernel function:

$$ K(x_i, x_j) = [(x_i \times x_j) + 1]^q, \quad q \in \mathbb{N}^*, \quad (9) $$

where $q$ represents the degree of the polynomial.

3.2. Construction of the Teaching Quality Evaluation Model of a Flipped Classroom in Colleges and Universities. When the support vector machine is applied to the regression problem, the support vector machine method assumes that the number of independent and identically distributed observation samples $S = \{x_i, y_i\}$ is $n$, where $i = 1, 2, \ldots, n$. Assuming that the sample exists in the function set $F$, the regression problem is to obtain the optimal function $f(x)$ and use this function to minimize the expected risk $R(f) = \int L(x, y, f(x)) dxdy$. To solve the regression learning problem through the principle of empirical risk minimization, the following formula needs to be minimized:

$$ R_{\text{emp}}(f) = \frac{1}{n} \sum_{i=1}^{n} L(f(x_i) - y_i), \quad (10) $$

where $L(f(x_i) - y_i)$ is the loss formed by predicting $y$ through the regression function $f(x)$.

Solving formula (10) to obtain the best regression function $y = f(x)$ can solve the regression problem.

According to the statistical theory, the actual risk is not affected by the empirical risk minimization. The support vector machine method adopts the structural risk minimization principle as the learning method, which can minimize the complexity and empirical risk [33], so that when the number of samples is limited, it still has high output function smoothness and generalization ability.
The formula of the support vector machine method is as follows:

\[ f(x) = \sum_{i=1}^{n} (\alpha^* - \alpha_i) K(x_i, x) + b \]

\[ = \sum_{i=1}^{n} (\alpha^* - \alpha_i) \varphi(x_i) \cdot \varphi(x) + b = w \cdot \varphi(x) + b. \]  

(11)

In formula (11), \( \alpha^* \) and \( \alpha_i \) are Lagrange multipliers and \( \alpha^* \geq 0, \alpha_i \geq 0 \), and \( K(x_i, x) \) represent kernel functions, which are used to map nonlinear problems to high-dimensional feature space and present them as linear problems, and \( K(x_i, x) \equiv \varphi(x_i) \cdot \varphi(x) \) and \( w \) and \( b \) represent hyperplane weight vectors and offset constants, respectively [34, 35].

When the insensitive function \( \varepsilon \) is used as the loss function [36], the following can be obtained:

\[ L(x, y, f(x)) = \max \{0, |y - f(x)| - \varepsilon\}. \]  

(12)

Transform the support vector machine problem into an optimization problem, that is,

\[
\begin{align*}
\min &\quad \frac{1}{2} \|w\|^2 + C \sum_{i=1}^{n} (\xi_i + \xi_i^*) \\
\text{s.t.} &\quad w \cdot x_i - b - y_i \leq \varepsilon + \xi_i \\
&\quad y_i - w \cdot x_i - b \leq \varepsilon + \xi_i.
\end{align*}
\]

(13)

In formula (13), \( \xi_i > 0, \xi_i^* > 0 \), and \( \varepsilon > 0 \), \( i = 1, 2, \cdots, n \).
and $\xi^*$ are the introduced relaxation variables, C represents the penalty factor, and the penalty factor is used to reflect the penalty degree beyond the error sample.

Lagrange multipliers $\alpha^*$ and $\alpha_i$ are introduced into the above optimization problem, and the dual problem is used to solve the optimization problem. The formula is as follows:

$$\max W(\alpha^*, \alpha) = -\varepsilon \sum_{i=1}^{n} (\alpha_i + \alpha_i^*) + \sum_{i=1}^{n} (\alpha_i + \alpha_i^*)y_i^i$$

$$- \frac{1}{2} \sum_{i,j=1}^{n} (\alpha_i^* - \alpha_i) (\alpha_j^* - \alpha_j) K(x_i, x_j)$$

s.t. $\sum_{i=1}^{n} (\alpha_i - \alpha_i^*) = 0$, $\alpha_i^* \in \left[0, \frac{C}{n}\right]$, $\alpha_i \in \left[0, \frac{C}{n}\right]$.  

(14)

Solve formula (14) to obtain the optimal $\alpha^*$ and $\alpha_i$, and select the KKT condition to obtain the offset value, that is,

$$b = \begin{cases} 
    y_i^i - \varepsilon - \sum_{i=1}^{n} (\alpha_i^* - \alpha_i) K(x_i, x_j), & \alpha_i \in (0, C), \\
    y_j + \varepsilon - \sum_{i=1}^{n} (\alpha_i^* - \alpha_i) K(x_i, x_j), & \alpha_i^* \in (0, C). 
\end{cases}$$  

(15)

By substituting the coefficients obtained from the above solution into formula (15), the quality evaluation of flipped classroom teaching in colleges and universities based on a support vector machine can be realized.

4. Experimental Analysis

4.1. Test Environment. In order to analyze the performance of the design evaluation model, it was tested. The parameter settings of the test environment are shown in Table 5.

4.2. Test Object. Flipped classroom teaching quality evaluation consists of expert evaluation, teacher evaluation, and student evaluation.

(1) Expert evaluation: evaluate teachers’ teaching and students’ learning through class listening

(2) Teacher evaluation: evaluate the teaching quality of teachers and students by listening, evaluating, and discussing classes

(3) Student evaluation: students need to evaluate the teaching quality of teachers in this semester every semester. At the same time, the evaluation of teachers’ teaching quality in each semester is basically arranged before the final examination

The experiment selects the first 4000 groups of 4500 groups of data as training samples, the remaining 500 groups as experimental detection data, and the corresponding
evaluation target as the output expected value, and the evaluation error of teaching quality is 0.0001.

4.3. Result Analysis

4.3.1. Teaching Quality Analysis. In order to verify the improvement of teaching quality in colleges and universities after the application of this method, this paper analyzes four aspects: the transformation of teaching methods, the abundance of teaching resources, the change of students’ learning initiative, and the evaluation of flipped classroom teaching quality.

(1) Changes in Teaching Methods. This paper investigates the changes to teaching methods in the university in the past three academic years. The survey results are shown in Figure 4.

As can be seen from Figure 4, teachers’ teaching method is no longer a single classroom teaching, but on the basis of traditional classroom teaching, combined with diversified teaching methods such as online analysis resources and encouraging group cooperation, change the single teaching mode, so as to prove the application quality of information technology in teaching.

(2) Abundant Teaching Resources. The sources of teaching resources in the three academic years of the university were investigated. The survey results are shown in Figure 5.

As can be seen from Figure 5, the teaching resources of colleges and universities are no longer only from textbooks and books, but from a wider range of open sources. They can be obtained remotely through the information platform across geographical constraints or by visiting other schools at home and abroad to request resource sharing and enrich teaching resources.

(3) Changes in Students’ Learning Initiative. This paper investigates the changes to students’ learning initiatives in the past three academic years. The survey results are shown in Figure 6.

As can be seen from Figure 6, in the first academic year, students’ learning initiative is higher than 70%. With the increase in grades and the decrease in the number of courses, their learning initiative is gradually decreasing, but it is always higher than 50%. Therefore, with the application and implementation of the flipped classroom teaching strategy, students’ learning initiative has been greatly improved, which can improve the teaching quality to a great extent.

(4) Flipped Classroom Teaching Quality Evaluation. The teaching quality of the flipped classroom is evaluated by teachers and students, respectively, and the evaluation results are shown in Table 6.

As can be seen from Table 6, more than 66.4% of the students agree with the evaluation indicators of flipped
classroom teaching quality, which proves the quality of flipped classroom teaching.

4.3.2. Method Performance Comparison. In order to better show the good performance of this method, the experiment takes the big data analysis method in Reference [6] and the mixed evaluation method in Reference [7] as the control group of this method, and the results are shown in Table 7.

According to Table 7, the reference method needs at least 21 s to evaluate the teaching quality, while the method in this paper can evaluate the teaching quality at only 18 s. Because the norm method is used to control the loss function of support vector machine training, it can effectively reduce the training times, shorten the evaluation time, and ensure the evaluation accuracy. Therefore, the accuracy is more than 99.70%.

Comparing the training results of flipped classroom teaching quality evaluation between this method and the reference method, the results are shown in Table 8.

Through the evaluation and comparison of 500 sample data in Table 8, it can be seen that the maximum error of the evaluation results of this method is 0.04, which is less than the evaluation error of the literature method. This is because the literature method does not adopt the method of gradient descent back propagation, so it cannot update the weight in real time, and there is a large error in the evaluation of teaching quality. Therefore, the evaluation results obtained by this method are closest to the real evaluation results.

In the experiment, the accuracy of flipped classroom teaching quality evaluation under the methods of this paper, Reference [6], and Reference [7] is analyzed. The higher the precision value, the higher the quality of the evaluation. In order to improve the accuracy of the experiment, two groups of precision analysis are carried out, respectively. The results are shown in Figure 7.

It can be seen from Figure 7 that there are some differences in the accuracy of this method, Reference [6] method, and Reference [7] method in the evaluation of flipped classroom teaching quality in the two experiments. Among them, from the curve trend, the evaluation quality of this method is better than that of the other two methods. And the evaluation accuracy of this method is always more than 90%. It can be seen that the performance of the proposed method is better. This is because the evaluation index of classroom teaching quality is evaluated from three aspects: experts, teachers, and students, which makes the evaluation results comprehensive. Support vector machine uses a gradient descent backpropagation method to select the appropriate gradient of training samples in each iterative calculation, so as to reduce the error of actual teaching quality evaluation results.
5. Conclusion

At present, improving the teaching quality of the flipped classroom has become a key task in current education. Teaching quality evaluation is the most direct and effective method to improve teaching. The support vector machine method in the artificial intelligence algorithm is used to realize the teaching quality evaluation of the flipped classroom in colleges and universities, and it is verified by example analysis that this method can effectively evaluate the teaching quality of the flipped classroom in colleges and universities, and the evaluation quality is good. The support vector machine method has high evaluation accuracy and wide application range. It has better application prospects in evaluation problems. It can improve the evaluation performance by selecting a reasonable loss function and kernel function. Colleges and universities use research methods to clarify the problems existing in the flipped classroom and can improve the teaching quality of the flipped classroom by improving the comprehensive teaching ability, improving the traditional teaching concept, enriching the teaching mode, and so on.

Data Availability

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.
Conflicts of Interest

The authors declared that they have no conflicts of interest regarding this work.

Acknowledgments

This work is supported by the Teaching and Research Project of Heilongjiang University of Science and Technology in 2022 (2021 ideological and political theory teaching research project in Heilongjiang universities: Research on integrating jinyuan cultural resources into ideological and political teaching in universities (SJGSX2021017)); 2021 ideological and political theory teaching research project in colleges and universities in Heilongjiang Province: Research on the teaching practice of integrating party history education into ideological and political theory courses in colleges and universities (SJGSX2021017)).

References


