

Research on Student Learning Attitude Evaluation Model Based on TOPSIS Comprehensive Evaluation Algorithm

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Abstract. In order to ensure the quality of teaching in universities, this article uses the TOPSIS comprehensive evaluation algorithm to help analyze the learning attitude of school students, as well as the class atmosphere and academic atmosphere of the college. At the same time, a list of five classes with the best academic atmosphere, three colleges, and sixty students with positive and negative learning attitudes were selected. Firstly, this article conducts a quantitative analysis of the scores and participation in the tests of 9048 students. The article identifies three factors that reflect students' learning attitudes: average test score, standard deviation, and participation rate in the tests. Then, based on student test data, an evaluation model reflecting the academic atmosphere, class atmosphere, and student enthusiasm of the college was established based on student performance information. The model results were ranked to obtain the ranking of model scores for each college, class, and student. By studying student data and quantifying the characteristics that reflect their learning attitudes, three indicators that can effectively reflect student attitudes and enthusiasm were established by analyzing the attached data. When assigning weights to factors, it is necessary to consider the importance of the factor in describing student attitudes, and make judgments and trade-offs based on specific situations. In response to this situation, although the standard deviation can reflect the stability of students' grades, it is greatly limited by the number of tests, while test completion and average score can better reflect students' learning attitude and performance. Therefore, subjective weighting method can be considered to assign weights to these three indicators, which are average score, standard deviation, and test participation rate, respectively; 0.3, 0.2, 0.5. By using the TOPSIS method and combining three indicators, establish an evaluation model for the academic atmosphere of the college, a class atmosphere evaluation model, and a student motivation evaluation model. Finally, evaluate the academic atmosphere of each college, class atmosphere, and the learning enthusiasm of each student. Based on the evaluation results of the model, this article selected a list of five classes with the best academic atmosphere, three colleges, and sixty students with positive and negative learning attitudes.

Keywords: TOPSIS, Evaluation model, Data preprocessing, learning attitude, Learning style.

1. Introduction

In order to evaluate the learning attitude and status of students in a certain university, it is recommended that teachers of core basic courses conduct a test of the teaching content of the previous class before class, including advanced mathematics, probability and statistics, college physics, linear algebra, and other courses^[1,2].

Students may choose different courses within the scope of core basic courses, with some students taking multiple courses and others only taking one course; Some students may have done homework that was not posted by their class teacher; Some students did not participate in every test due to some

reasons; The frequency of pre class tests released by teachers of the same course is not entirely the same^[3].

Quantitative analysis of test participation can reflect the performance level of students throughout the entire exam period, and the average score is a good reference indicator. The standard deviation indicates the distribution of exam scores and can reflect differences in student learning performance^[4]. If the standard deviation is large, it indicates a significant difference in the abilities of the candidates, which may have an impact on their learning attitude and performance. The participation rate of the test reflects students' attendance in class and their attitude and behavior towards exams^[5]. If a student does not attend classes or take tests, it reflects their attitude towards learning, attending classes, and taking exams. This article identifies three factors that reflect students' learning attitudes: test average score, stability (standard deviation), and test participation rate^[6].

This article constructs a mathematical model that can reasonably evaluate the academic and class atmosphere of the college. As it evaluates the academic and class atmosphere of the college, the factor of standard deviation is not considered. Using the average score of each college and the participation rate in college tests, the TOPSIS comprehensive evaluation algorithm is used to model and solve the problem, and the academic style scores and rankings of each college are given. Using the class average score and class test participation rate as two factors, the TOPSIS comprehensive evaluation algorithm is used to model and solve, and the academic atmosphere scores and rankings of each college are given. Select the list of 5 classes and 3 colleges with the best academic atmosphere and provide reasons (data sources:math.tust.edu.cn).

2. Establishment and solution of the model

2.1. Descriptive analysis of data

According to statistical analysis, the total number of data is 118431, with 9048 students, 15 colleges, 80 majors, 542 classes, 22 courses, 89 classes, 21 teachers, and 294 tests. Among them, only one student with the highest number of tests conducted 37 times, and the least number of tests conducted only once.

(1) In terms of colleges, there are a total of 15 colleges, among which the college with the college code 308821 conducted the most tests, with 12808 times.

(2) In terms of majors, there are a total of 80 majors, among which the major with code 308917 has conducted the most tests, with 6350 times.

(3) Class aspect: There are a total of 542 classes, among which the class with class code 16110928 conducted the most tests, with 1069 times.

(4) In terms of courses, there are a total of 22 courses, among which the course code 216658109 has taken the most tests, with 55743 times.

(5) In terms of classes, there are a total of 89 classes, among which the class with class code 72091439 conducted the most tests, with 3407 times.

(6) In terms of classroom teachers, there are a total of 21 classroom teachers, among which the teacher with code 92963 has the highest test data, which is 55743. Corresponding to the course code 216658109.

(7) In terms of test names, there are a total of 294 tests, among which the test named "In class Test 3" has the most records, with 2191.

(8) In terms of normalized scores, a total of 118431 test scores were obtained. The highest score is 100, and the lowest score is 6.92. The overall average score is 87.03.

(9) The number of students in each college: The college with the college code 308854 has the highest number of students, at 1009. The college with the fewest number of students is only one. (10) Number of students in each class: There are four classes with the highest number of students, which is 41. The class with the fewest number of students is only one person.

Descriptive analysis of the given data reveals that a course can have multiple classes, and one class corresponds to the same course; Only one teacher teaches two courses, and the other course subjects correspond one-to-one with the teaching teacher.

2.2. Factors that reflect students' learning attitudes

The average score of a student's overall test level can be analyzed from the "normalized score" information as one factor, and the standard deviation that reflects the stability of a student's grades as the second factor^[7]. The test participation rate is an important indicator that reflects their learning attitude and is also the third factor.

(1) Average score

The average score can reflect the performance level of students throughout the entire exam period and is a good reference indicator.

$$A_i = \frac{S_i}{n_i}, i = 1, 2, 3, \dots \quad (1)$$

(2) Standard deviation

The standard deviation indicates the distribution of exam scores and can reflect differences in student learning performance. If the standard deviation is large, it indicates a significant difference in the abilities of the candidates, which may have an impact on their learning attitude and performance.

$$\sigma_i = \sqrt{\frac{\sum_{j=1}^{n_i} (s_j - A_i)^2}{n_i}} \quad (2)$$

(3) Test participation rate

The participation rate of the test reflects students' attendance in class and their attitude and behavior towards exams. If a student does not attend classes or take tests, it reflects their attitude towards learning, attending classes, and taking exams.

$$R_i = \frac{p_i}{\sigma_i} \quad (3)$$

2.3. Verify and analyze the given data

If it is not an assignment published by the teacher of this class, a course that does not fall within the scope of core basic courses, a grade that is empty or exceeds the normal range, etc., use principal component analysis to reduce the dimensionality of the data and extract the principal components that can represent most of the information in the original data^[8].

Assuming there are $n(n \leq 9049)$ samples and $p(p \leq 4)$ indicators, a sample matrix x of size $n \times p$ can be formed:

$$x = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1p} \\ x_{21} & x_{22} & \cdots & x_{2p} \\ \vdots & \vdots & \ddots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{np} \end{bmatrix} = (x_1, x_2, \dots, x_p) \quad (4)$$

According to the calculation of mean $\bar{x}_j = \frac{1}{n} \sum_{i=1}^n x_{ij}$ and standard deviation $S_j = \sqrt{\frac{\sum_{i=1}^n (x_{ij} - \bar{x}_j)^2}{n-1}}$,

the standardized data $X_{ij} = \frac{x_{ij} - \bar{x}_j}{S_j}$ is obtained, and the original sample matrix is normalized to:

$$X = \begin{bmatrix} X_{11} & X_{12} & \cdots & X_{1p} \\ X_{21} & X_{22} & \cdots & X_{2p} \\ \vdots & \vdots & \ddots & \vdots \\ X_{n1} & X_{n2} & \cdots & X_{np} \end{bmatrix} = (X_1, X_2, \cdots, X_p) \quad (5)$$

Calculate the covariance matrix of standardized samples.

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1p} \\ r_{21} & r_{22} & \cdots & r_{2p} \\ \vdots & \vdots & \ddots & \vdots \\ r_{p1} & r_{p2} & \cdots & r_{pp} \end{bmatrix} \quad (6)$$

Eigenvalue: $\lambda_1 \geq \lambda_2 \geq \cdots \geq \lambda_p \geq 0$ (R is a semi positive definite matrix, and

$tr(R) = \sum_{k=1}^p \lambda_k = p$), Contribution rate $\sigma = \frac{\lambda_i}{\sum_{k=1}^p \lambda_k} (i=1, 2, \cdots, p)$ Accumulated contribution rate

$$\varepsilon = \frac{\sum_{k=1}^i \lambda_k}{\sum_{k=1}^p \lambda_k} (i=1, 2, \cdots, p).$$

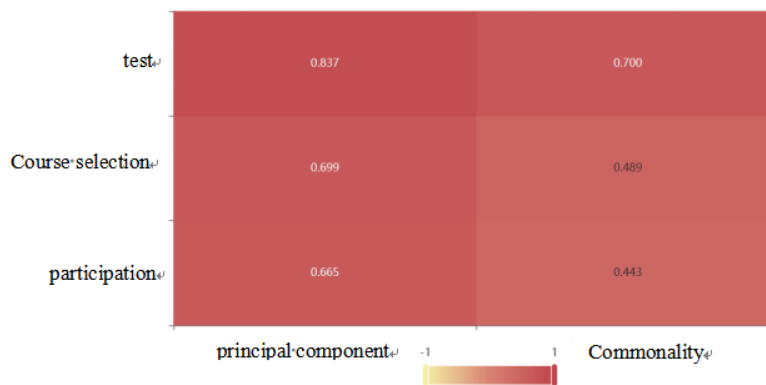


Fig 1 Heat map of factor load matrix

As can be seen from Fig 1, for the first, second,..., m ($m \leq p$) principal components corresponding to eigenvalues with a general cumulative contribution rate exceeding 80%, and the i -th principal component: $F_i = a_{1i}X_1 + a_{2i}X_2 + \cdots + a_{pi}X_p$, for a certain principal component, the larger the coefficient in front of the indicator, the greater the impact of the indicator on that principal component, as shown in Table 1.

Table 1 Results of Contribution Rate Calculation

component	Eigenvalue	Contribution rate (%)	Accumulated contribution rate (%)
Number of tests	2.186	54.659	54.859
Average score	0.991	24.773	83.432
Test attendance rate	0.712	17.482	94.924
Number of course selections	0.123	3.076	100

Therefore, according to the principal component analysis method, this article establishes three principal component influencing factors: average score, test attendance rate, and number of elective courses^[9]. Then, SPSS is used to calculate the average score, test attendance rate, average number of

elective courses, median, mode, standard deviation, variance, percentile, etc. within this group, as shown in Fig 2.

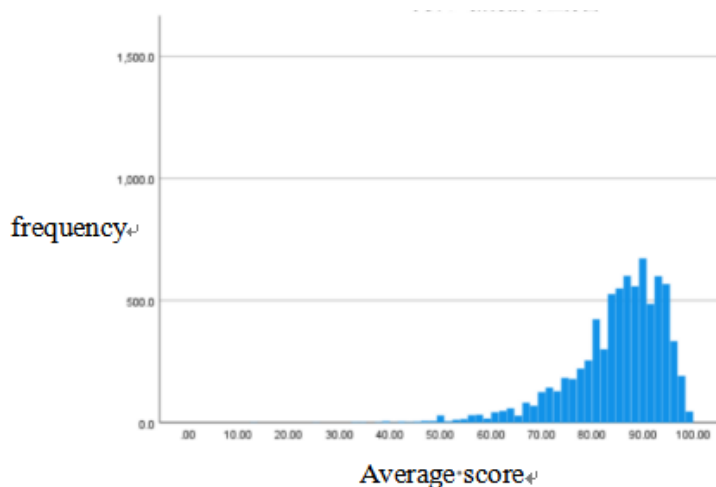


Fig 2 Histogram of the distribution of average grades among students

Simultaneously, use Excel to conduct descriptive analysis on average grades, test attendance rates, and course selection data. Calculate indicators such as mean, quartile, standard deviation, and standard score, which can be used for data frequency analysis, data concentration trend analysis, data dispersion analysis, and data distribution^[10].

To quantify learning attitudes, this article uses the independence weight coefficient method to calculate weights. Assuming there are a total of $p(p=3)$ indicators, the larger the complex correlation coefficient between indicator x_k and other indicators, the stronger the collinearity relationship with other indicators, and the easier it is to have linear combinations of other indicators represented. The more repetitive information there is, the smaller the weight of this indicator, where.

$$R_j = \frac{\sum_{j=1}^p (x_j - \bar{x})(x - \bar{x})}{\sqrt{\sum_{j=1}^p (x_j - \bar{x})^2 (x - \bar{x})^2}} \quad (j = 1, 2, 3) \quad (7)$$

Select the reciprocal of the complex correlation coefficient:

$$R = \left[\frac{1}{R_1}, \frac{1}{R_2}, \frac{1}{R_3} \right] \quad (8)$$

The final weight value is calculated after standardization:

$$\omega_j = \frac{\frac{1}{R_j}}{\sum_{j=1}^p \frac{1}{R_j}} \quad (9)$$

Table 2 Calculation of Weights by Independence Weight Coefficient Method

term	Multiplier R	Reciprocal of complex correlation coefficient 1/R	Weight (%)
Average score	0.11	9.122	58.298
attendance	0.312	3.206	20.489
Unified course selection	0.301	3.319	21.213

As can be seen from Table 2, this article identifies average grades, test attendance rates, and the number of elective courses as factors that can reflect students' learning attitudes. At the same time, the independence weight coefficient method is used to calculate weights and quantify students' learning attitudes, resulting in new data - learning attitude scoring.

Among them:

$$\tau = \sum_{i=1}^p \omega_i \times x_{ij} \quad (10)$$

To verify and analyze the given data, this article uses paired sample t-test to obtain a heatmap of the correlation coefficients between average score, test attendance rate, number of elective courses, and learning attitude scoring, as shown in Fig 3.

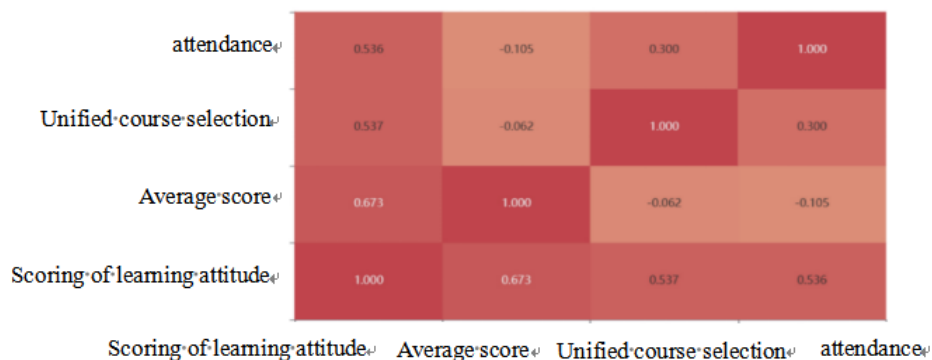


Fig 3 Thermal diagram of correlation coefficient

In the end, the average score, test attendance rate, and number of elective courses in this article are factors that can reflect students' learning attitudes and have been verified to have a strong correlation through paired sample t-tests.

3. Conclusions

In conclusion, this study employed the TOPSIS comprehensive evaluation algorithm to assess the quality of teaching in universities, focusing on analyzing the learning attitudes of students, as well as evaluating the class and academic atmosphere within the college. Through a quantitative analysis involving 9048 students, three key factors were identified to reflect students' learning attitudes: average test score, standard deviation, and participation rate in tests. These factors were then utilized to establish an evaluation model that gauges the academic atmosphere, class atmosphere, and student enthusiasm within the college.

To effectively reflect student attitudes and enthusiasm, three indicators were established: average score, standard deviation, and test participation rate. A subjective weighting method was employed, considering the significance of each factor in describing student attitudes. The weights assigned were 0.3, 0.2, and 0.5 for average score, standard deviation, and test participation rate, respectively.

The TOPSIS method was applied to rank colleges, classes, and students based on the evaluation model scores. Consequently, an assessment was made regarding the academic atmosphere of each college, the class atmosphere, and the learning enthusiasm of individual students. The findings led to the identification of five classes with the best academic atmosphere, three exemplary colleges, and sixty students characterized by positive and negative learning attitudes.

This comprehensive approach not only facilitated the identification of key factors influencing the learning environment but also provided a systematic and quantitative method for evaluating and ranking colleges, classes, and students. The results offer valuable insights for enhancing the quality of teaching in universities and promoting a positive and conducive learning atmosphere.

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