Research on the Management System of College Student Union Based on Analytic Hierarchy Process

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Abstract

At present, the evaluation of student union management in colleges primarily hinges on subjective judgments, which lack quantifiable indicators and generalized models. Consequently, there is an urgent need for colleges to develop a quantifiable management evaluation model that converts subjective assessments into objective evaluations based on data. This paper employs the Analytic Hierarchy Process (AHP) to construct a quantifiable evaluation model for student council management. An expert scoring card based on the AHP is designed to evaluate these ten indicators, leading to the creation of a weighted evaluation model. The model's accuracy is verified through the calculation of the Consistency Indicator (CI) and Consistency Ratio (CR) values, The experimental results conform to a Gaussian Distribution, substantiating the validity of the experimental conclusions. Based on this evaluation system, among the six student departments, the Organization Department achieved the highest score, indicating it as the most efficiently managed department.

Keywords: student council management, Analytic Hierarchy Process, Evaluation system.

Introduction

This study is grounded in the 2023 directive issued by the Central Committee of the Communist Youth League and the Ministry of Education of the People's Republic of China, titled "Several Measures to Consolidate the Reform Achievements of Student Unions (including Graduate Student Unions) in Higher Education Institutions." The directive mandates higher education institutions to further deepen reforms and construction of student unions in the new era, continuously improving satisfaction, overall contribution, and social recognition. the Analytic Hierarchy Process (AHP) is notably effective in evaluation and decision-making. Therefore, our research focuses on the application of AHP.

The Analytic Hierarchy Process (AHP), a structured and systematic method of decision analysis, was introduced by the American operations researcher Thomas L. Saaty in the early 1970s (Saaty T.L., 2008). This method is primarily used for complex decision-making problems that are difficult to quantify. AHP has been widely applied. Feng's team (Feng Y.L., et al., 2019) used AHP to determine the weights of various dimensions and factors based on expert questionnaires. Considering the limitations of AHP, fuzzy theory and fuzzy AHP are introduced to address related issues. Abrahamsen, et al. (2020) discussed using AHP as a basis for prioritizing investments in safety measures in the chemical industry. Wang, et al. (2021) introduced variable weight factors into the traditional AHP, allowing the weights assigned by experts to sustainable development indicators to change over time or space, and proposed a new improved method of weight allocation, known as variable weight AHP. Díaz, et al. (2022) employed the Monte Carlo simulation method to determine the confidence of various solutions using AHP, applying this method to a marine wind farm in Spain to rank the most suitable locations for turbines.

AHP and linear regression models can be combined to solve complex decision-making problems, especially in forecasting and evaluation scenarios. For instance, Elwakil, et al. (2013) proposed a new organizational performance evaluation model, which combines AHP and Multiple Linear Regression Analysis (MLR) to help identify areas for potential improvement, leading to better performance. Pourghasem, et al. (n.d.) conducted a detailed study on landslide susceptibility mapping using binary logistic regression, AHP, and a statistical index model, and evaluated their performance. Thus, this paper employs AHP and linear regression models, selecting ten relevant quantitative indicators to construct an evaluation system for student unions in higher education institutions.

Objectives

The establishment of a scientific student union management evaluation system in higher education institutions is intended to set clear evaluation metrics. Through this system, universities can better understand and assess the quality and effectiveness of their student unions, Enhancing Decision-Making with Scientific Accuracy and Effectiveness, Increasing Transparency and Fairness in Management, Facilitating Rational Allocation and Utilization of Resources, Emphasizing Goal Orientation and Outcome Assessment, Developing Students' Data Analysis Skills and Critical Thinking, Enhancing the Attractiveness and Participation in Activities. In summary, This is crucial for improving the overall quality of student union work, meeting student needs, and providing better services and experiences for students.

Research scope

Taking the student union of a university in Kunming as the research object, 6 departments were selected for the investigation, and 47 questionnaires were distributed to collect relevant scoring data.

Methodology

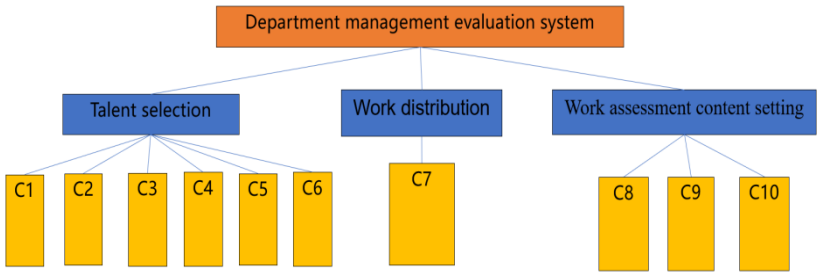

Figure 1: Department management evaluation system

As illustrated in Figure 1, we based our quantitative indicators on three main categories: talent selection, work allocation, and work content assessment. These indicators were further subdivided into ten aspects: sense of responsibility, cooperation ability, quick mastery of basic work skills, amiability, attention to detail, understanding of work content, work distribution, task completion, execution ability, and participation in activities. These were respectively named C1 to C10. We combined the Analytic Hierarchy Process (AHP) with linear regression, treating C1 to C10 as independent variables to construct our evaluation system. The formula is as follows:

$$y = \sum_{i=1}^{n} w_i * b_i * C_i \quad i = 1,\ldots 10$$

Here, w_i represents the weights derived from the AHP matrix, b_i are the coefficients of the independent variables, and y is the comprehensive score of a department. We distributed 47 questionnaires, setting up 30 questions to score the comprehensive capabilities of six departments, and finally verified the accuracy of our model through calculation. The experimental steps are as follows:

Identifying Decision Factors and Objectives: Firstly, it is essential to clarify the objectives of the decision and the various factors influencing it.

Determining Factor Weights Using AHP: A hierarchical structure model is constructed using AHP to categorize the factors influencing the decision and determine their relative importance through pairwise comparison, thus calculating the weights of each factor.

Data Collection and Preprocessing: Data related to decision objectives and influencing factors are collected. We distributed surveys to collect scores for each department in areas such as responsibility, execution ability, cooperation ability, etc.

Constructing a Linear Regression Model: Utilizing the collected data, a linear regression model is built, where the weights of the factors are used as coefficients of the independent variables in the regression model.

Model Validation: The scores of departments calculated by the model were compared with the original scores collected for the departments. Model parameters were adjusted to enhance the accuracy of the model's calculations.

Interpretation and Application of Results: The results of the linear regression model were analyzed to understand the impact of different factors on the predictive target. These insights were then applied in practical decision-making.

Results

Table 1: Judgment matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
C1	1.00	0.33	0.33	0.20	0.11	3.00	0.11	0.20	0.14	0.33
C2	3.00	1.00	1.00	0.60	0.33	9.00	0.33	0.60	0.43	1.00
C3	3.00	1.00	1.00	0.60	0.33	9.00	0.33	0.60	0.43	1.00
C4	5.00	1.67	1.67	1.00	0.56	15.00	0.56	1.00	0.71	1.67
C5	9.00	3.00	3.00	1.80	1.00	27.00	1.00	1.80	1.29	3.00
C6	0.33	0.11	0.11	0.07	0.04	1.00	0.04	0.07	0.05	0.11
C7	9.00	3.00	3.00	1.80	1.00	27.00	1.00	1.80	1.29	3.00
C8	5.00	1.67	1.67	1.00	0.56	15.00	0.56	1.00	0.71	1.67
C9	7.00	2.33	2.33	1.40	0.78	21.00	0.78	1.40	1.00	2.33
C10	3.00	1.00	1.00	0.60	0.33	9.00	0.33	0.60	0.43	1.00

Table 1 illustrates the construction of a 10x10 judgment matrix. The judgment matrix does not compare all factors simultaneously but rather compares them in pairs. Subsequently, it is necessary to perform a consistency test on the constructed matrix. The consistency indicators include CI (Consistency Index), RI (Random Index), and CR (Consistency Ratio). In defining the consistency index CI, where λ is the largest eigenvalue and n is the count of unique non-zero eigenvalues, a CI of 0 indicates perfect consistency; the closer CI is to 0, the more satisfactory the consistency. Larger CI values signify greater inconsistency. The specific formula for CI is as follows:

$$\mathrm{CI} = \frac{\lambda - \mathrm{n}}{\mathrm{n} - 1}$$

To measure the magnitude of CI, the Random Consistency Index (RI) is introduced. Table 2 shows the fixed results for RI. The specific formula for RI is as follows:

$$RI = \frac{CI_1 + CI_2 + \ldots + CI_{500}}{500} = \frac{\frac{\lambda_1 + \lambda_2 + \ldots + \lambda_{500}}{500} - n}{n-1}$$

Table 2: Consistency indicator RI

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Finally, in the consistency test, the Consistency Ratio (CR) is calculated using the following formula:

$$\mathrm{CR} = \frac{\mathrm{CI}}{\mathrm{RI}}$$

When the consistency ratio CR is less than 0.1, the inconsistency level of the judgment matrix is considered within an acceptable range, indicating satisfactory consistency, and the matrix passes the consistency test. In such cases, the normalized eigenvector is used as the weight vector. Otherwise, the judgment matrix needs to be reconstructed and adjusted. Our calculations yielded a CI value of 0.0113 and a CR value of 0.0023, indicating

satisfactory consistency and adherence to the quantitative standards of the AHP model. Consequently, we can determine the weights and geometric means of the relevant parameters C1 to C10, as shown in Table 3.

Table 3: Geometric mean values and weights

	Geometric mean values	weights
C1	0.31	0.02
C2	0.93	0.07
C3	0.93	0.07
C4	1.47	0.11
C5	2.55	0.19
C6	0.1	0.01
C7	2.55	0.19
C8	1.65	0.12
C9	2.24	0.16
C10	1.04	0.08

We put the above data into the model to calculate the final result, as shown in Table 5.4, The experimental outcomes are as follows: the Publicity Department scored 94.99, the Broadcasting Station 92.95, the Volunteer Department 93.97, the Organization Department 96.23, the Etiquette Team 94.28, and the Student Art Troupe 93.11. Upon comparing the values calculated by our model with the actual values, it was observed that the discrepancies between the calculated values and the actual values are minimal. Furthermore, the comprehensive capability ranking of departments as determined by our model aligns with the scoring order of the original data. This indicates that our model is capable of accurately quantifying the overall capabilities of the departments.

Table 4: Compare the Model value with the true value

	Publicity Department	Broadcasting Station	Volunteer Department	Organization Department	Etiquette Team	Art Troupe
Model value	94.99	92.95	93.97	96.23	94.28	93.11
True value	94.77	92.64	93.54	96.11	94.26	92.9
Error value	0.22	0.31	0.42	0.12	0.02	0.21

Conclusion and discussion

By combining analytic hierarchy process (AHP) and linear regression model, we can deal more effectively with complex decision problems that require both consideration of multiple influencing factors and quantitative analysis. However, the effectiveness of this method is highly dependent on the accuracy of the factor weights in the initial analytic hierarchy and the quality of the data in the linear regression model. In the quantitative evaluation of student union management in colleges and universities, the model we put forward has remarkable effect. This transformation is not only beneficial for enhancing the specificity and efficacy of college management tasks but also aids in the advancement of students' self-education and self-management abilities.

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