Research on Evaluation Model of College Students' Mathematical Modeling Ability Based on Hierarchical Clustering Method

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Abstract: In order to make the evaluation of mathematical modeling ability more in line with the actual ability of college students, it is necessary to establish a scientific and objective evaluation method. Therefore, based on the hierarchical clustering method, this paper establishes the evaluation criteria of College Students' mathematical modeling ability. Through the test, the application of this method can make a fair judgment on the mathematical modeling ability of college students, make the evaluation of the mathematical modeling ability of students more based on educational institutions, and also help students to provide useful guidance for personal learning progress. In addition, this method can guide teachers and researchers to carry out the work of mathematical modeling, and help them to cultivate more mathematical modeling talents.

1. Introduction
At present, mathematical modeling has been fully practiced in many fields. Many colleges and universities take mathematical modeling as an important aspect of students' ability training. Mathematical modeling is not only a test to cultivate college students' ability to solve abstract mathematics, but also a judgment to college students' comprehensive quality and ability to solve practical problems by using compound knowledge. Therefore, it is necessary to evaluate the mathematical modeling ability of college students, because it is of great practical significance to establish a scientific evaluation model.

2. Evaluation model of college students' mathematical modelling ability based on hierarchical clustering method
We studied n students, of whom n were marked as $A=\{x_1, x_2, ..., x_n\}$, students have m categories, we mark $B=\{y_1, y_2, ..., y_m\}$, the vector of each object corresponds to the values taken by these indicators, expressed as:

$$X_i = \{x_{i1}, x_{i2}, ..., x_{im}\} \quad (i=1, 2, ..., n),$$

(1)

First, each class contains only one data. The distance between classes is the same as the distance between data. There are n classes. The distance between N data of each two classes is calculated, and the distance matrix between data is calculated.

The class with the smallest distance between the two classes is merged into a new class, in which case the number of classes is reduced by one.

There are three advantages of Mahalanobis distance: firstly, Mahalanobis distance makes the indexes no longer interfere with each other. Secondly, the index dimension does not interfere with Mahalanobis distance. Third, it has the advantage of not being affected by the linear transformation of the original data. In the specific implementation process, if the class i and j are merged into the class r,
the distance formula between the new class and other old classes is 
\[ d_{rk} = \text{Max} \{ d_{ik}, d_{jk} \}, \ (k \neq i, j), \]
where \( d_{ik} \) and \( d_{jk} \) represent the distance between the class \( i \) and \( j \) contained in the new class and the class \( k \) not merged into the new class.

3. Case analysis of mathematical modelling ability evaluation

3.1. Establishing evaluation index system of mathematical modelling ability
The primary goal of mathematical modeling ability index evaluation is to establish a set of accurate, scientific, objective and fair evaluation criteria. The characteristics of the evaluation criteria are shown in Figure 1. First of all, the evaluation index system must cover all students, that is to say, it has universality, which is a point to be considered in the design of the scheme. Secondly, the evaluation criteria must be scientific and objective, that is to say, it can reflect the real level of students' mathematical modeling and avoid over evaluation and missing evaluation. Third, the evaluation criteria should be helpful to the healthy development of mathematical modeling of college students, and play a correct leading and guiding role. Finally, the criterion can be measured scientifically and reflect the real law and current situation of things.

3.2. Establishing evaluation index system of mathematical modelling ability
According to the above evaluation criteria and standards, the evaluation system of mathematical modeling ability of large number students is determined as shown in Figure 2. The system includes five aspects: innovative thinking, teamwork, knowledge base, problem-solving ability and computer application ability. After determining the evaluation criteria, the next step is to construct a matrix, which is also called comparison matrix. By calculating the eigenvalues and eigenvectors of the comparison matrix, it is suggested to test the correlation between the data. Whether the structure is scientific is judged according to whether the parameters such as the correlation degree meet the requirements of the standard and the situation.

In order to investigate the students' ability of mathematical modeling, the five abilities of the selected students are evaluated in the survey, including innovation, mutual cooperation, basic knowledge mastery, and problem analysis and solution, and computer application. Score the assessed ability in percentage form. In order to evaluate the mathematical modeling ability of college students scientifically and accurately, let them do test questions or solve modeling problems, through this way, to evaluate their personal ability. Because of the combination of qualitative and quantitative evaluation criteria, the scientificity and objectivity of evaluation can be guaranteed. The evaluation of the supervisor problem is judged by the tester. The clustering results and the average connection tree are obtained by spass20 software, as shown in Figure 3.
Mathematical Modeling Ability

Innovation ability
Collaboration ability
Mastery of basic knowledge
Ability to analyze and solve problems
Computer Application Ability

All students

Figure 2. Evaluation system of mathematical modelling ability

Through the above methods, the results are classified as follows:

Case 3
Case 5
Case 11
Case 14
Case 7
Case 8
Case 13
Case 4
Case 15
Case 2
Case 9
Case 12
Case 1
Case 10
Case 6

Figure 3. Average join tree graph

The first category: case 1, 2, 4, 8, 9, 10, 12, 13, 15; class II: case 3, 5, 7, 11, 14; class III: case 6. Among them, case 6 is very outstanding in cooperation ability, basic knowledge mastery and computer application ability, showing a high level. Case 6 shows its high level of innovation and problem-solving ability. The second kind of students shows that they have good mathematical foundation, and have high innovative thinking and computer application skills. For example, case 7 shows outstanding performance in mastering basic knowledge, while case 11 shows obvious advantages in collaboration ability and problem solving.

It can be seen from Figure 3 that students' innovation ability and thinking ability are not positively related to their ability to analyze and solve problems. For example, although the first type of students' innovation ability is not good enough, their ability to solve problems is strong. At the same time, the
first kind of students’ cooperation ability is more outstanding than their personal quality. For example, case 1, case 2, case 12 and case 13 are relatively single in their perspectives and aspects; lack of innovative thinking, lack of divergent thinking ability compared with other students, and need to focus on cultivating their ability to express their views. Although the second kind of students have a certain foundation of mathematical modeling, their modeling level still needs to be further improved, and they need to receive more guidance, so that they can show greater and better growth potential in the future.

4. Conclusions
Using the hierarchical clustering method to evaluate the mathematical modeling ability of college students can make the evaluation more scientific, help to select more excellent mathematical modeling talents, and provide useful guidance for the selection of such students. Compared with other evaluation methods, it has two outstanding advantages. First of all, AHP combines qualitative and quantitative analysis to make the evaluation more objective and scientific. Secondly, the evaluation method is highly operable, simple and practical. Finally, it is precisely because of the high operability of the evaluation system that it has a wider applicability and versatility. This method can be used in the selection of students; the clustering results are scientific and reasonable, more in line with the actual situation. The model can evaluate the mathematical modeling ability of college students scientifically and objectively, show the actual state of students, and help them to play their strengths and improve their shortcomings. Therefore, it can be said that the application of hierarchical clustering method in the evaluation of college students’ mathematical modeling ability is not only helpful to provide correct guidance for the further improvement of students, but also can provide more comprehensive and specific reference for educators to carry out mathematical modeling training. In addition, if the evaluation method is applied to educational institutions, it will help to ensure the accuracy of the research results, so as to ensure the selection of more outstanding talents.

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