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Analysis of the Pass Rate Factors of "Probability Theory and Mathematical Statistics" Based on Fuzzy Comprehensive Evaluation

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Abstract: *In view of the phenomenon of high probability and mathematical statistics examination failure rate in local colleges in recent years, this paper analyzes and investigates the positive influencing factors of probability theory and mathematical statistics passing rate and makes a questionnaire survey.Then, the fuzzy comprehensive evaluation is used to establish the evaluation model of the influencing factors of probability theory and mathematical statistics pass rate, and the weight of each factor of probability theory and mathematical statistics pass rate evaluation is obtained by AHP. Thus, the evaluation results are more objective and scientific.*

Keywords: *Analytic hierarchy process, fuzzy comprehensive evaluation,influence factors of pass rate, probabil ity theory and mathematical statistics*

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I. Introduction

In real life, a thing is often influenced by many factors. Therefore, when evaluating a thing, we should consider all kinds of relevant factors synthetically, and then give a reasonable decision, which is usually referred to as a comprehensive evaluation problem [1]. However, people's evaluation of things is often unclear, but some vague language (such as good, poor, etc.) as different levels of comments. Therefore, it is very important to use fuzzy set theory to judge things synthetically.

As one of the core courses of science and engineering majors, "probability theory and mathematical statistics" plays an important role in the cultivation of higher education talents. However, due to its high degree of abstraction, "probability theory and mathematical statistics" has always been a difficult course for students.In recent years, some students in our school have poor academic performance and poor pass rate, and even some classes fail more than 20%. Therefore, it is the primary task to fully understand the influencing factors of the passing rate of probability theory and mathematical statistics. At present, some scholars have discussed the influencing factors of college students' achievement in probability theory and mathematical statistics. Zhang et al. [2] used cluster analysis, factor analysis and regression analysis to analyze the influence degree and type of probability theory and mathematical statistics. Hao and Hong set up a multivariate linear regression model in [3], and then quantitatively analyzed the correlation between the results of the two courses in higher mathematics, probability theory and mathematical statistics. The papers [4,5] used the fuzzy comprehensive evaluation to discuss the factors affecting the pass rate of college students and the evaluation of academic performance.

In the current literature, it is rare to evaluate the influencing factors of pass rate in probability theory and mathematical statistics, especially the research on the factors affecting pass rate of probability theory and mathematical statistics by using fuzzy mathematics is almost blank. Therefore, combined with fuzzy mathematics knowledge such as fuzzy comprehensive evaluation, the factors influencing the pass rate of probability theory and mathematical statistics are comprehensively evaluated in order to obtain the reasons that affect the pass rate.

II. Mathematical Model of Fuzzy Comprehensive Evaluation

Fuzzy comprehensive decision making is a very effective method for making comprehensive evaluation of things affected by many factors. Its basic idea is to make use of the principle of fuzzy linear transformation and the principle of maximum membership degree. Take into account the factors related to the preparation and evaluation of things, and make a reasonable comprehensive evaluation of them.

In recent years, some students have had poor learning effects on "probability theory and mathematical statistics" and the test pass rate is not ideal. By using the method of fuzzy comprehensive evaluation, an

evaluation model of the influencing factors of passing rate of "probability theory and mathematical statistics" is given, and the main influencing factors of pass rate of probability and mathematical statistics are revealed fairly, which provides theoretical support for the reform of probability theory and mathematical statistics curriculum. Follow the principles of science, feasibility and reasonableness, we extensively seek the opinions of relevant experts and teachers, and determine to conduct investigations from three levels: individual, teacher, and school. The evaluation index system of the model and the grade standard are established (see Table 1). The evaluation set is $V=\{v_1,v_2,v_3,v_4\}$, where v_1 is perfect, v_2 is good, v_3 is general and v_4 is bad. Questionnaires were sent out to students majoring in probability theory and mathematical statistics in Anyang Normal University. The subjects were 2015 and 2016 students majoring in mathematics, physics, computer, and so on, and a total of 200 questionnaires were distributed. 200 valid questionnaires were collected, and the recovery rate was 100. Specific information can be found in the following table 1:

Table 1 Factors of passing rate and evaluation results of probability theory and mathematical statistics

Classify	First level index	Secondary index	Order of evaluation			
			Perfect	Good	General	Bad
Individual level	Learning foundation U_1	Entrance achievement u_{11}	28	50	71	51
		Advanced Mathematics u_{12}	41	73	79	7
		Linear algebra u_{13}	43	86	67	4
	Attitude to learning U_2	Subject opening attitude u_{21}	96	75	25	4
		classroom status u_{22}	115	30	53	2
		Pre-class preparation u_{23}	17	19	125	39
		Working condition u_{24}	64	95	29	12
Teacher level	Classroom mode U_3	Teaching method u_{31}	97	68	29	6
		Interaction u_{32}	70	89	36	5
		Teaching contentu_{33}	16	124	54	6
		Exam questions easy u_{34}	72	89	37	2
School level	School ethos U_4	learning atmosphere u_{41}	44	117	19	20
		Invigilation system u_{42}	23	30	66	81
		Scholarship system u_{43}	43	80	58	19
		School atmosphere u_{44}	44	71	70	15

The steps of establishing fuzzy comprehensive evaluation model are as follows:

(1) Determine the factor set. The factor set U is divided into four groups:

$$U_1=\{u_{11},u_{12},u_{13}\},\ U_2=\{u_{21},u_{22},u_{23},u_{24},u_{25},u_{26}\},$$
$$U_3=\{u_{31},u_{32},u_{33},u_{34}\},\ U_4=\{u_{41},u_{42},u_{43},u_{44}\},$$

where U_1 is the learning foundation, U_2 is the attitude to learning, U_3 is the classroom mode, and U_4 is the school ethos.

(2) Determine the fuzzy evaluation matrix. Let $r_{ij}=\dfrac{T_{ij}}{200}$ be the degree of membership of evaluation factors to comments at all levels, the single factor evaluation matrixes are as follows:

$$R_1=\begin{bmatrix}0.14 & 0.25 & 0.355 & 0.255\\ 0.205 & 0.365 & 0.395 & 0.035\\ 0.215 & 0.43 & 0.335 & 0.02\end{bmatrix},\ R_2=\begin{bmatrix}0.48 & 0.375 & 0.125 & 0.02\\ 0.57 & 0.15 & 0.265 & 0.01\\ 0.085 & 0.095 & 0.625 & 0.195\\ 0.32 & 0.475 & 0.145 & 0.06\end{bmatrix},$$

$$R_3=\begin{bmatrix}0.485 & 0.34 & 0.145 & 0.03\\ 0.35 & 0.445 & 0.18 & 0.025\\ 0.08 & 0.62 & 0.27 & 0.03\\ 0.36 & 0.445 & 0.185 & 0.01\end{bmatrix},\ R_4=\begin{bmatrix}0.22 & 0.585 & 0.095 & 0.11\\ 0.115 & 0.15 & 0.33 & 0.405\\ 0.215 & 0.4 & 0.29 & 0.095\\ 0.22 & 0.25 & 0.35 & 0.075\end{bmatrix}.$$

(3) Determining the index weight set. In this paper, the analytic hierarchy process (APH) is used to find the weights of various factors in the evaluation of probability factors and mathematical factors. Due to the use of multiple evaluation systems, the importance of the evaluation system can be compared at the lower level first, and then rise to the higher level to carry on the similar treatment step by step, so the comparability degree of the evaluation system can be enhanced. Finally, consistency can be verified by calculating the maximum eigenvalue to ensure the feasibility of the evaluation mechanism.According to the advice of relevant experts and teachers, we compare the importance of each index on the same level by using "1-9 scale method" to form a judgment matrix. Further determine the weight of each index in the concentration of factors.

The judgment matrix C corresponding to the pass rate factor indicators of "probability theory and mathematical statistics" is:

	Learning foundation U_1	learning attitude U_2	Course mode U_3	School ethos U_4
Learning foundation U_1	1	1/3	1/2	1/3
learning attitude U_2	3	1	2	4
Course mode U_3	2	1/2	1	2
School ethos U_4	3	1/4	1/2	1
Weights	0.1058	0.4714	0.2483	0.1745
Note:	λmax=4.2072, CI= 0.0691, CR=0.0767＜0.1, which meets the requirements for consistency			

Therefore, the weight of the "probability theory and mathematical statistics" pass rate factor indicator is: $A=(0.1058, 0.4714, 0.2483, 0.1745)$.

The judgment matrix C_1 corresponding to the learning basic indicators is:

	Entrance score u_{11}	Advanced mathematics u_{12}	Linear algebra u_{13}
Entrance score u_{11}	1	1/3	1/3
advanced mathematics u_{12}	3	1	2
Linear algebra u_{13}	3	1/2	1
Weights	0.1396	0.5278	0.3325
Note:	λmax=3.0536, CI= 0.0268, CR=0.0462＜0.1,which meets the requirements for consistency		

Therefore, the weight of the "probability theory and mathematical statistics" pass rate factor indicator is: $A_1=(0.1396, 0.5278, 0.3325)$.

The judgment matrix C_2 corresponding to the learning attitude index is as follows:

	Subject opening attitude u_{21}	Class status u_{22}	Pre-study u_{23}	Working condition u_{24}
Subject opening attitude u_{21}	1	1/4	1	1/2
Class status u_{22}	4	1	2	4
Pre-study u_{23}	1	1/2	1	2
Working condition u_{24}	2	1/4	1/2	1
Weights	0.1314	0.4963	0.2168	0.1555
Note:	λmax=4.1855, CI= 0.0618, CR=0.0687＜0.1, which meets the requirements for consistency			

Therefore, the weight of the learning attitude indicator is $A_2=(0.1314, 0.4963, 0.2168, 0.1555)$.

The judgment matrix C_3 corresponding to the classroom mode indicator is

	learning atmosphere u_{41}	Invigilation system u_{42}	Scholarship system u_{43}	School atmosphere u_{44}
learning atmosphere u_{41}	1	1/7	0.25	1/3
Invigilation system u_{42}	7	1	5	4
Scholarship system u_{43}	4	0.2	1	1
School atmosphere u_{44}	3	0.25	1	1
Weights	0.5734	0.0547	0.1024	0.2695
Note:	λmax=4.0665, CI= 0.0222, CR=0.0246＜0.1, which meets the requirements for consistency			

Therefore, the weight of the school-level indicators is $A_4 = (0.5734, 0.0547, 0.1024, 0.2695)$.

According to the above analytic results, the weight distribution of each evaluation index of the balanced scorecard performance management can be obtained, as shown in the following table 2:

Table 2 Weight distribution of pass factor indexes of "probability theory and mathematical statistics"

Target layers	Weights	Primary indicators	Weights	Secondary indexes	Weights	Total weights
Probability Theory and Mathematical system and Lattice rate Facto	1	Learning foundation U_1	0.1058	Entrance score u_{11}	0.1396	0.0148
				advanced mathematics u_{12}	0.5278	0.0558
				Linear algebra u_{13}	0.3325	0.0352
		Learning attitude U_2	0.4714	Entrance score u_{11}	0.1314	0.0619
				advanced mathematics u_{12}	0.4963	0.2340
				Linear algebra u_{13}	0.2168	0.1022
				Entrance score u_{11}	0.1555	0.0733
		Course mode U_3	0.2483	Subject opening attitude u_{21}	0.4886	0.1213
				Class status u_{22}	0.1125	0.0279
				Pre-study u_{23}	0.2193	0.0544
				Working condition u_{24}	1797	0.0446
		School ethos U_4	0.1745	learning atmosphere u_{41}	0.5734	0.1001
				Invigilation system u_{42}	0.0547	0.0095
				Scholarship system u_{43}	0.1024	0.0179
				School atmosphere u_{44}	0.2695	0.0470

(4) Two-layer fuzzy comprehensive evaluation. Using the weighted average type $M(\cdot,+)$ to perform a layer of fuzzy evaluation $B_i = A_i * R_i = (b_{i1}, b_{i2}, \cdots, b_{in})$, the following evaluation results can be obtained:

$B_1 = (0.1992, 0.3705, 0.3694, 0.0607), B_2 = (0.4166, 0.2182, 0.3060, 0.0592),$

$B_3 = (0.3586, 0.4321, 0.1836, 0.0258), B_4 = (0.0373, 0.0838, 0.0343, 0.0191).$

Construct two-level fuzzy comprehensive evaluation matrix of U as

$$R = \begin{bmatrix} B1 \\ B2 \\ B3 \\ B4 \end{bmatrix} = \begin{bmatrix} 0.1992 & 0.3705 & 0.3694 & 0.0607 \\ 0.4166 & 0.2182 & 0.3060 & 0.0592 \\ 0.3586 & 0.4321 & 0.1836 & 0.0258 \\ 0.0373 & 0.0838 & 0.0343 & 0.0191 \end{bmatrix}.$$

Since the weight index set $A=(0.1058, 0.4714, 0.2483, 0.1745)$ of $U=\{U_1,U_2,U_3,U_4\}$, then the model of the total single factor evaluation matrix is evaluated by fuzzy comprehensive evaluation

$$B=A*R=(0.3130, 0.2640, 0.2349, 0.0441).$$

According to the principle of maximum membership degree, it is concluded that the influence factors of probability theory and mathematical statistics curriculum have a perfect influence on the pass rate of students.

III. Conclusions and recommendations

In this paper, with the help of fuzzy comprehensive evaluation model and analytic hierarchy process (AHP), the weight of the index of influencing pass rate is determined, and the investigation of 200 students in Anyang normal College is carried out. It is concluded that the influencing factors of probability theory and mathematical statistics can promote the achievement of the course of probability theory and mathematical statistics of college students. At the same time, it also shows that the factors affecting the passing rate of probability theory and mathematical statistics selected in this paper are suitable. According to Table 2, in the total weight of pass factor index of probability theory and mathematical statistics, the significant factors are as follows: class status U_{22}, teaching mode U_{31}, pre-class study U_{23}, study atmosphere U41, homework status u_{24}.According to the order of overall weight from strong to weak, in order to improve the results of probability theory and mathematical statistics of college students, the following suggestions are put forward to students, teachers and schools:

(1) Student level: Students should be aware of the importance of learning “probability theory and mathematical statistics” and master the correct learning methods. In the process of learning, students should give full play to their subjective initiative, pre-study before class, listen carefully to class, and complete homework independently. Students should pay attention to the difference and connection between the probability of middle school and the probability of university. Grasp the knowledge of advanced mathematics and linear algebra, and learn the probability theory and mathematical statistics to understand the gradual process from concrete to abstract, from special to general.

(2) Teacher level: Teachers pay attention to accumulating teaching methods in practice, and constantly explore new teaching methods and means to better complete the teaching of probability theory and mathematical statistics. Interact with students as much as possible during the lectures, stimulate students' interest in learning, and increase their attention to the probability of probability and mathematics statistics.

(3) School level: Probability and mathematical statistics have their own unique disciplinary methods. Deterministic mathematical thinking is not suitable for its learning. Students' differences are not obstacles to teaching. "Respecting studentsundefined differences" should be the basic principle of teaching design.

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