

Sustainable Development of Higher School based on Competition Mathematical Model

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Abstract: With the development of the economy, higher school in China has become a new force in the higher education system. In the new historical period, the development of higher school faces both opportunities and challenges. How to improve the education quality and broaden the development space is an urgent problem to be solved for the higher school. Sustainable development is a new model of development and has been recognized by the world. It is very necessary to examine the development of higher school with the concept of sustainable development, which is of great practical significance. If we want to improve the competitiveness of higher school and achieve their sustainable development, we must recognize the problems and their causes in the sustainable development of higher school, and take targeted measures to solve them. Therefore, a method of evaluating sustainable development ability of higher school based on competition mathematical model is proposed in this paper. By using data collection, analytic hierarchy process and empirical method, the sustainable development ability and evaluation index system of higher school are researched. It is found that the dialectical unity relation of scale, structure, quality and benefit is reflected in the construction of the evaluation index system of the sustainable development ability of higher school. The weight of the evaluation index is determined by the analytic hierarchy process and the expert investigation method, and the effective evaluation of the sustainable development ability of higher school has been realized. The relevant data of an empirical research are carried out through a questionnaire on a university. Based on customer satisfaction theory and service quality theory, a questionnaire survey is carried out to investigate the satisfaction degree of teachers and students in a university. Through data statistics and data analysis, the problem of the internal development of a higher school is obtained, and the corresponding countermeasures and suggestions are given.

Keywords: Competition mathematical model; Higher school; Sustainable development

1. Introduction

How to continue and coordinate the development of higher education and how to provide more resources for the sustainable development of our economy and society in the process of higher education from elite education to mass education is a question of great concern to the whole society. Therefore, it is of great significance to research and analyze the survival and sustainable development of higher education [1, 2].

The current research on international education research is mainly focused on basic education, vocational education, higher education, and neglect of adult education and preschool education. Attach importance to the study of successful experience in education in developed countries, despise the problems existing in the development of education in developing and less developed countries, and pay close attention to such issues as investment in education, policies, quality, equity, and so on. Finally, The reform of inclusive education, civic education and education need to be strengthened, and the contradiction

between diversity and simplification of research methods needs to be resolved. In the process of the transformation of higher education from elite to mass in China, higher education has made great development. As a new force in China's higher education system, higher education not only plays a role in meeting the different needs of society for higher education, but also plays an important role in promoting the reform and development of higher education in China. However, it cannot be denied that there are also a series of contradictions and problems at the same time of the rapid development of higher school. These problems have led to a considerable gap between the higher education and the social requirements. Therefore, studying the current situation of the development of higher school, analyzing the existing problems and causes, forecasting their development prospects and exploring their new strategies for sustainable development are of great significance for the sustainable development of higher school [3-6].

Sustainable development is a major long-term subject for the development of human society. The sustainable de-

velopment of higher school is also a dynamic and macroscopic topic for the development of higher school [7,8]. It is the main purpose of this research to combine empirical research and theoretical research with the quantitative and qualitative methods, and provide theoretical and practical basis for the sustainable development of higher school in China [9].

2. Literature Review

Through the analysis of the research literatures, it is found that the previous research on higher education is more serious from the macro point of view. The methods of prescribing prescription, description, and analysis are used in these researches. There are few empirical researches, most of which are empirical research reports based on the theory of satisfaction. It is not well combined with the empirical evidence and the theory. In the research of the factors affecting the internal development of education, the analysis is not profound and specific and it cannot effectively solve the problems encountered in the higher education. In this paper, empirical analysis and comparative analysis are used. Through a survey of the status of a university, more specific problems in the development of higher school are found and some operable suggestions are given. With the successful experience of foreign countries in the external development of higher school, combining theory with practice, the way of sustainable development of higher school in China is discussed [10,11].

3. Methods

3.1. Construction of evaluation index system of sustainable development ability of higher school

According to the design principle of evaluation index of sustainable development ability of the higher school,

combined with the actual situation of the development of higher school, with reference to the ministry of education "Evaluation Index of Talent Training Level in higher Colleges" and research results of the sustainable development of higher school evaluation index system, the evaluation index system of sustainable development of higher school is formulated. This evaluation system is designed as a two level evaluation index system. The first level evaluation index consists of five indexes, such as condition for running schools, personnel training, scientific research level, school management, and financial fund. The second level index consists of four indexes, such as scale index, structure index, quality index, and benefit index. Each second level index is subdivided into several items [12, 13].

3.2. Determination of index weight

The size of the weight value reflects the position of a certain index in the evaluation index system. The purpose of determining the weight is to rating some evaluation indexes. Because the target value of the evaluation index does not completely belong to the quantitative target value, it cannot be deduced directly by the mathematical analytic method. Therefore, the methods of analytic hierarchy process and expert investigation are used to determine the weight relation of each index in the evaluation system [14,15]. The specific steps are as follows [16]. The judgment matrix is established. The value of the matrix reflects the understanding of the decision-makers on the importance of each index. Experts compare the indexes based on the data provided by the decision-makers and provide the comparison results. Assume that the indexes are compared, and comparison results are represented by the 0.1-0.9 scale, as shown in Table 1.

Table 1. Meaning of 0.1-0.9 scale of judgment matrix

Scale value	Meaning	Scale value	Meaning
0.1	The index B is extremely superior to the index A	0.6	The index A is slightly better than the index B
0.2	The index B is strongly superior to the index A	0.7	The index A is obviously superior to the index B
0.3	The index B is obviously superior to the index A	0.8	The index A is strongly superior to the index B
0.4	The index B is slightly better than the index A	0.9	The index A is extremely superior to the index B
0.1	The index B is extremely superior to the index A	0.6	

Assume the evaluation index set and the expert set are P and E , respectively, which are given by

$$P = \{P_1, P_2, P_3, \dots, P_n\} \tag{1}$$

$$E = \{E_1, E_2, E_3, \dots, E_n\} \tag{2}$$

where n and m are the number of the indexes of the evaluation index set and the expert set, respectively.

According to the above analysis, the index of E are compared with one of P . As the comparison results are complementary, score result of the importance of each

index can be obtained from $n(n-1)/2$ comparisons, as shown in Table 2 [17].

Table 2. Score table of comparisons of importance of each index by experts

Comparison object	E1	E2	...	Ek	...	Em
P1-P2	t121	t122	...	t12k	...	t12m
...
P1-Pn	t1n1	t1n2	...	t1nk	...	t1nm
P2-P3	t231	t232	...	t23k	...	t23m
...

Pi-Pj	t(n-1)n1	t(n-1)n2	...	t(n-1)nk	...	t(n-1)nm
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Note: t_{ijk} represents the score result of comparison of the importance of higher school sustainable development ability index i and j by E_k .

The results shown in Table 3 are given by experts according to their own subjective judgment. So the results are generally not the same. Therefore, the method of average is used to integrate the opinion of the experts. The comprehensive result is shown as the complementary judgment matrix F , which is given by

$$F = \begin{bmatrix} t_{11} & t_{12} & \dots & t_{1n} \\ t_{11} & t_{12} & \dots & t_{1n} \\ \dots & \dots & \dots & \dots \\ t_{11} & t_{12} & \dots & t_{1n} \end{bmatrix} \quad (3)$$

$$t_{ij} = \frac{1}{n} \sum_{k=1}^m t_{ijk}, 1 \leq i \leq j \leq n, t_{ij} = 1 - t_{ji} \quad (4)$$

3.3. Calculation of sorting vector

The sorting vector of the matrix is calculated by using the least square method of weight. Assume the sorting vector of the matrix F is Y , which is given by

$$Y = (y_1, y_2, \dots, y_n)^T \quad (5)$$

where T denotes transpose. When the matrix F satisfies the consistency condition,

$$t_{ij}y_j = t_{ij}y_i \quad (6)$$

When the matrix F does not satisfy the consistency condition,

$$t_{ij}y_j \neq t_{ij}y_i \quad (7)$$

According to the above calculation, the deviation function is constructed with the minimum deviation of $t_{ij}y_j$ and $t_{ij}y_i$ as the objective, which is expressed by

$$\min f(y) = \sum_{i=1}^n \sum_{j=1}^n (t_{ij}y_j - t_{ij}y_i)^2 \quad (8)$$

Assume λ is the eigenvalue of the complementary judgment matrix, $\sum_{i=1}^n y_i = 1, y_i > 0, i \in P$, Construct Lagrangian function, which is given by

$$f(y, \lambda) = \sum_{i=1}^n \sum_{j=1}^n (t_{ij}y_j - t_{ij}y_i)^2 + 2\lambda(\sum_{i=1}^n y_i - 1) \quad (9)$$

Assume $\partial f / \partial y_k = 0$, then

$$\sum_{j=1}^n (t_{kj}y_j - t_{jk}y_k) \times (-t_{jk}) + \sum_{i=1}^n (t_{ki}y_i - t_{ik}y_k)t_{ik} + \lambda = 0, k \in P \quad (10)$$

If $\partial f / \partial \lambda = 0$, then

$$\sum_{j=1}^n y_j = 1 \quad (11)$$

Sorting vector can be obtained by solving the above $n+1$ equations.

The sorting result is checked for consistency. According to the transformation relation of complementary judgment matrix and reciprocal judgment matrix, the consistency index equation of complementary judgment matrix can be obtained, which is given by

$$CI = 1 / (n-1) \sum_{1 \leq i \leq j \leq n} [t_{ij} / t_{ji} \times y_j / y_i \times y_{ji} / y_{ij} \times y_j / y_i - 2] \quad (12)$$

According to the obtained ratio of random consistency is less than 0.1, it can be considered that the complementary judgment matrix meet the requirement of consistency. The ratio is the weight value of the index. If the ratio of random consistency is greater than 0.1, it is necessary to reevaluate the matrix until it meets the requirement of consistency [18].

According to the hierarchical analysis and consistency check of the above sorting by layer, the weight values of each layer and each index can be obtained. According to the survey data, the first and second level index weight data of the sustainable development ability index system of higher schools in Fuzhou are obtained and the judgment matrix synthetically is formed. After calculation and consistency check, the weights of all levels of indexes are obtained. The final value of the fourth level index is obtained by multiplying the weight of each fourth level index by the weight of the index. Then the final values of all fourth level indexes under the same third level index are added to obtain the initial value of the third level index. The final value of the third level index is obtained by multiplying the initial value of each third level index by its corresponding weight. The final values of all third level indexes under the same second level index are added to obtain the initial value of the second level index. The final value of the second level index is obtained by multiplying the initial value of each second level index by its corresponding weight. The final values of all second level indexes under the same first level index are added to obtain the initial value of the first level index. The final value of the first level index is obtained by multiplying the initial value of the two first level indexes by the corresponding weight. The final values of the two first level indexes are added to obtain the final value of the sustainable competition advantage and achieve evaluation of the sustainable development ability of higher school [19, 20].

4. Results

The analysis of the factors influencing the internal sustainable development of higher school in China is mainly through the satisfaction survey. The influence of some basic characteristics on satisfaction of teachers and students is analyzed from satisfaction survey. Therefore, the basic characteristics of some demography and other aspects that affect the sustainable development of higher school are found out.

According to the above theory analysis and the constructed evaluation index system, in order to achieve the purpose of the investigation, a university teacher and student satisfaction questionnaire is designed. The characteristics of the design of the questionnaire are as follows. The teacher questionnaire and the student questionnaire are composed of three parts of the introduction, the personal information and the questions. The teacher questionnaire is divided into 6 subscales and a total of 36 questions. The student questionnaire is divided into 5 subscales and a total of 38 questions. There are two questions for each item in the questionnaire, which are the importance of the question and the satisfaction of the question. The design of the two dimensional scale is not

only able to assess the expectations of the respondents, that is, the importance, but also to assess the current satisfaction of the respondents.

4.1. Analysis of the influencing factors of teacher satisfaction

Influence of sex on satisfaction. In terms of the distribution of the satisfaction of male teachers and female teachers, the proportion of male teachers and female teachers of all kinds of satisfaction is basically the same. None of the male and female teachers is very dissatisfied with the school, and the overall satisfaction of most of the schools is "general", as shown in Table 3.

Table 3. Satisfaction distribution of teachers with different sexes

		Overall satisfaction of higher						Total
		Very dissatisfied	Dissatisfied	General	Satisfied	Very satisfied		
Sex	Male	Number	0	1	37	18	3	61
		Proportion %	0	1.5	63.3	32.1	4.8	100
	Female	Number	0	2	74	24	2	102
		Proportion%	0	2.1	71.5	20.5	2.2	100
Total	Number	0	4	112	43	43	163	
	Proportion %	0	1.8	69.3	25.8	3.1	100	

Based on the data obtained from the above survey, the test method is used to check whether sex has an impact on school satisfaction. The results obtained by T test are $t = 1.583$ $p = .116 > 0.05$, which represents that there is no significant difference between the two groups of data. It shows that sex has no significant effect on satisfaction,

and the overall satisfaction of teachers is not different because of sex.

Influence of part-time situation on satisfaction. According to the distribution of part-time teachers, as shown in Figure 1, the satisfaction distribution of part-time teachers and full-time teachers is basically the same.

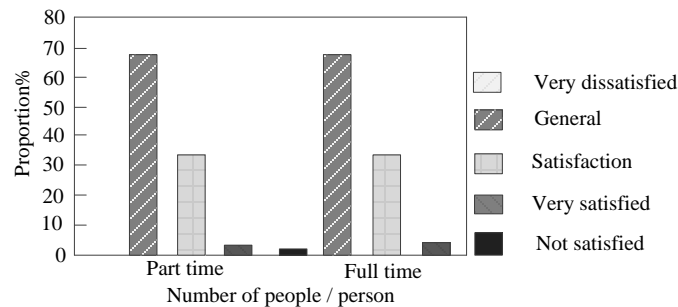


Figure 1. Satisfaction distributions of part-time teachers and full-time teachers

Based on the data obtained from the above survey, the test method is used to check whether part-time situation has an impact on school satisfaction. It is obtained that $t = -.856$, $p = .393 > 0.05$, which represents that there is no significant difference between the two groups of data. It shows that part-time situation has no significant effect on satisfaction, and the overall satisfaction of teachers is not different because of part-time situation.

Influence of professional title on satisfaction. From the distribution of professional titles, as shown in Figure 2,

the higher the professional title of the teacher group, the higher the proportion of teachers' satisfaction.

Single factor variance analysis is used to detect the impact of professional titles on teachers' satisfaction. It is found that the satisfaction of teachers is not different from the different professional titles.

Influence of educational background on satisfaction. According to the distribution of teacher's educational background in Figure 3, the proportion of postgraduate's satisfaction is the highest and the proportion of undergraduate's satisfaction is the highest.

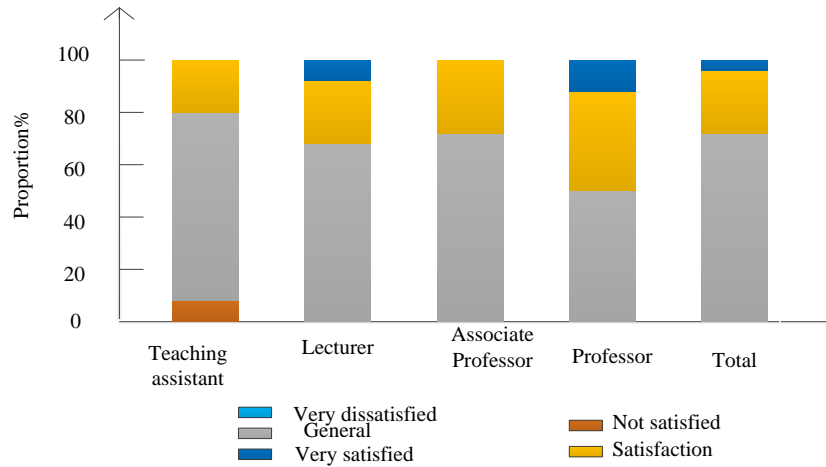


Figure 2. Satisfaction distributions of teachers with different professional titles

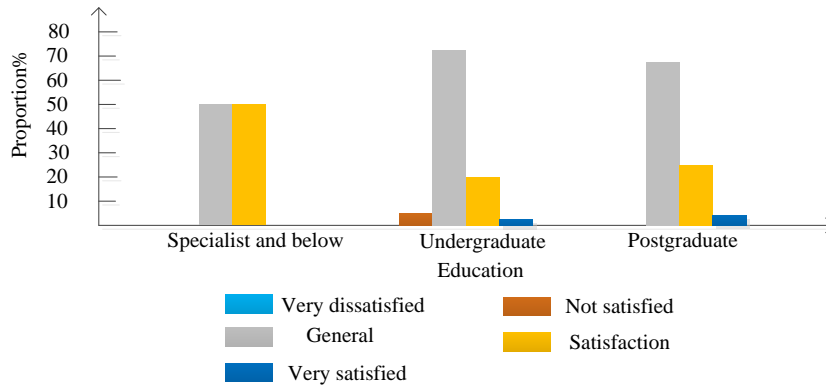


Figure 3. Satisfaction distributions of teachers with different educational background

Single factor variance analysis is used to detect the impact of educational background on teachers' satisfaction. It is found that the satisfaction of teachers is not different from the different educational background.

Influence of working time on satisfaction. According to the distribution of teachers' working time, as shown in

Figure 4, the proportion of satisfaction of teachers working for more than 10 years at school is the highest. The proportion of satisfaction of teachers working for 4-6 years is the highest. Others are different from each other.

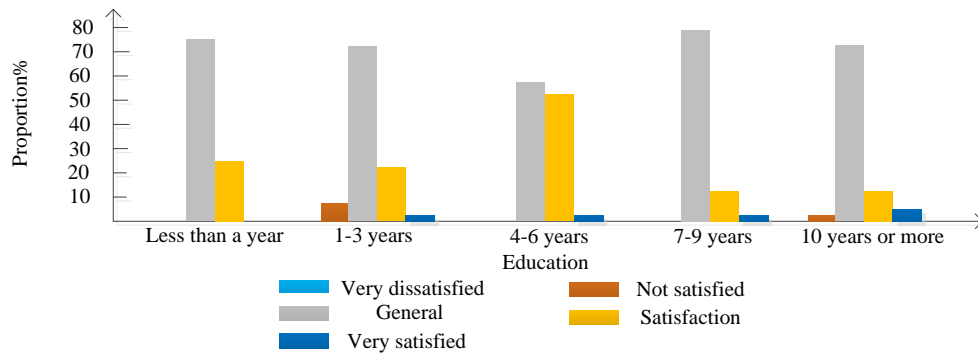


Figure 4. Satisfaction distributions of teachers with different working time at school

Single factor variance analysis is used to detect the impact of working time on teachers' satisfaction. It is found that the satisfaction of teachers is not different from the different working time.

5. Discussion

The following conclusions can be obtained from the survey data from the perspective of a university teacher. Sex has no significant impact on teachers' satisfaction. Part-time situation has no significant impact on teachers' satisfaction. Professional title has no significant impact on teachers' satisfaction. Educational background has no significant impact on teachers' satisfaction. Working time has no significant impact on teachers' satisfaction.

The above analyzed factors include demographic characteristics and the factor of higher working time, which do not have a greater impact on teachers' satisfaction. For higher school, these factors are uncontrollable and have little influence on school satisfaction, so these are not the main factors that influence teachers' satisfaction. Higher schools must rely on their own conditions, start with some controllable factors of internal factors and greater influence on satisfaction, so as to improve teachers' satisfaction and ensure the sustainable development of higher schools.

Analysis of factors affecting students' satisfaction is carried out and the corresponding conclusions are as follows. Sex has no significant impact on students' satisfaction. Home location has a significant impact on students' satisfaction. The satisfaction of students from "county town", "township", "city", "rural", "provincial capital" and "municipality directly under the central government" declines in turn. Educational level of parents has no significant effect on students' satisfaction. Aspiration has a significant impact on students' satisfaction. The "first aspiration" student has the highest overall satisfaction with the school. The rest of the students are generally the lowest in the dispensing group, and the "first aspiration", "second aspiration", "obeyed aspiration" and "other" students' satisfaction gradually decrease. The degree of understanding of the specialty has a significant impact on students' satisfaction. Students with "know", "understand", "general", "do not understand", "do not know", have gradually reduced the overall satisfaction. The above analyzed factors include demographic data and other basic characteristics, which have different effects on students' satisfaction. For higher school, these factors are not the factors that the school can grasp, and they are not operable. Based on their specific development conditions, higher school must start from the internal operational factors to improve the indexes of problems existing in the development of the school, and students' satisfaction, so as to ensure the sustainable development of the school.

6. Conclusion

From the above analysis of survey data of higher school, the related factors of the existing problems are obtained. This paper tries to propose a proposal for the internal sustainable development aiming at the above factors. Meanwhile, based on the American and Japanese experience, the relevant countermeasures for the development of the external environment of higher school in China are proposed as follows:

Relevant countermeasures for the development of internal environment are paying attention to the teacher construction, improving the situation of teaching service, creating the benefit of logistics service, enriching the campus culture, and so on.

Countermeasures for external sustainable development. Legislation embodies the will of the state in the course of the development of higher education. It not only helps to guarantee the emergence and development of higher education institutions, clarify its status and function, but also gradually standardizes the running activities of higher education. It is one of the important measures for the development of higher education in many countries to grant necessary funding to higher schools and the amount of this kind of funding is still increasing. The construction of government management level is needed to strengthen.

Finally, the internal and external factors are linked, and the theory of sustainable development of China's higher school is further improved.

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