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The Innovative Path of Changing the Management Mode of Colleges and Universities in the Context of Education Informatization

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SUMMARY: *This paper establishes the index system for evaluating the maturity of university management capability, constructs the two-by-two comparison matrix through hierarchical analysis, and determines the weight coefficients of each index for maturity evaluation. Finally, the maturity evaluation is carried out with different faculties of University H as a case study, and the results of teaching quality management maturity of different faculties are obtained through self-assessment, and then one of the faculties is selected for fuzzy evaluation. Based on the fuzzy evaluation method, the prioritization matrix of the management capacity improvement program of the faculty was derived and the current problems of the faculty were pointed out. The results of the study show that the faculties in the case study show great variability in different dimensions of teaching quality management, and the difference between faculties with high maturity scores and those with low scores can be as high as 1.66, which indicates that a "one-size-fits-all" management approach should not be adopted even within the university. The College of Media and Design, with a total maturity level of 52.36, is at the defined stage, and there is still a lot of work to be done to standardize and institutionalize its management capabilities. At the same time, this study also gives the strategies and paths for colleges and universities to improve their management maturity.*

KEYWORDS: *structural equations; fuzzy evaluation method; hierarchical analysis; maturity evaluation*

1 Introduction

Higher education is the key stage of talent cultivation, which is related to the improvement of students' social adaptability and employment competitiveness [1]. In the era of knowledge economy, the social development of talent requirements continue to improve, especially the new round of scientific and technological revolution and industrial change, so that the demand for high-quality composite talents in various industries continues to expand, urging the management of universities to change [2-4]. Education management is an important part of the work of colleges and universities, and the quality of education management directly affects the overall healthy development of colleges and universities, and by analyzing the strategies of change and innovation of the management mode of colleges and universities under the background of education informatization, it promotes the improvement of the quality of education management in colleges and universities, as well as deeply promotes deeper reform of education [5-7]. Fatoni et al [8] pointed out that good school management can optimize the efficiency of school operations, make full use of human resources, college finances, educational

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facilities, etc. to create a better teaching environment for students, thus improving the quality of education.

Promoting the informatization of educational management in colleges and universities, creating an informatized teaching management platform, and innovating the means and methods of educational management are conducive to promoting the modernization and development of the management mode of colleges and universities, and also have an important practical significance in promoting the improvement of the efficiency of the management of colleges and universities [9-11]. Under the background of informationization, enhancing the openness and transparency of educational management data in colleges and universities and improving the ability to integrate educational management information resources have become the focus of educational management reform in many colleges and universities [12-14]. Currently, the university education management mode is deficient in informationization application awareness, informationization education data, informationization standard construction, informationization technology operation, management team construction, and management mechanism, which cannot meet the needs of improving the quality of teaching and cultivating high-quality talents in colleges and universities, and affects the quality of education management in colleges and universities [15-19]. Embedding informatization literacy into the practice of education management in colleges and universities, innovating traditional education management methods, and exploring more efficient education management modes have become an inevitable trend [20].

And in the context of education informatization, education management is undergoing digital transformation through technologies such as artificial intelligence, big data, and the Internet of Things. Siminto et al [21] point out that artificial intelligence promotes the optimization of resource management and administrative processes in universities through paths such as improving the efficiency of course management, establishing student performance assessment, and meeting students' individualized learning needs, which leads to an innovative management model. Garanin and Krasnova [22] proposed a university management system and an educational program management model that separates managerial and administrative functions, promotes in-depth interaction between the board of trustees and supervisory committees, and provides theoretical support for a management innovation model. Wu [23] created a framework for a university teaching management system, which employs IoT devices to collect and process teaching data, introduces data mining and big data analysis algorithms mining teaching data comprehensive information, and classify students' academic activities through K-mean clustering algorithm, combined with the principal component analysis method to explore the relationship between the number of students' visits to the library and students' grades, so as to better carry out the teaching management and promote the innovation of university management informatization. Dong and Xie [24] used OpenFlow's cloud computing technology to optimize the university teaching management informatization's network security mechanism, which makes the response efficiency of cloud management system when it suffers from network attack increased by 30% and the risk reduced by 40%. Liang [25] emphasized the need to make full use of education big data in teaching management of colleges and universities to optimize the teaching management decision and improve the level of teaching management, and gave the teaching management innovation strategy given cloud computing and education big data. Chang [26] reported the big data technology and algorithmic optimization model in university management to monitor teaching quality, optimize educational resources and improve teaching quality through data such as classroom teacher-student interactions, student evaluations, teachers' teaching facility usage rate, teachers' class hours, etc., thus promoting the innovative development of teaching management. Zhang and Fang [27] analyzed the problem of information silos in the informatization of university management with

the help of data mining algorithm and developed a heterogeneous information resource integration platform, which can promote cross-sectoral contribution of student information and optimize the efficiency of student information management. Liu [28] created an intelligent teaching management platform for colleges and universities using resource clustering algorithms, through which students and teachers can realize the docking of management services and functions and promote the design of teaching management from multiple perspectives, avoiding the duplication of management. These research practices show that technology-assisted college management can weigh the management of multiple perspectives issues and open up a path of change and innovation for college management models through educational data.

By combing the research on university management and reviewing the relevant literature in recent years, the main factors affecting the management capability of universities are deeply excavated and analyzed and studied by using structural equation modeling, with a view to revealing the correlation between the influencing factors and the management capability of universities, and to provide a strong basis for the construction of the evaluation indexes and the determination of the weights of the indexes. After determining the influencing factors of university management capability, this study establishes a management maturity evaluation model. The model adopts the fuzzy evaluation method method and combines the hierarchical analysis method to give the corresponding index weights, so as to more accurately assess the management capability of colleges and universities. Through the case analysis of the management capability of University H, the constructed evaluation index system is used to determine the advantageous and disadvantageous parts of the management capability of each department of the university, so as to put forward a series of improvement strategies in a targeted manner. At the same time, it is verified that the evaluation indexes and evaluation model constructed in this paper are feasible and effective in the evaluation of management capacity of colleges and universities.

2 Analysis of factors affecting management capacity in higher education

2.1 Research hypothesis

There are so many factors affecting the quality of higher education that it is impossible to include all the complex factors, and this is also unrealistic. Therefore, a good indicator system is not a big and comprehensive system, but should be a standard that can reflect the evaluation objectives and quality connotations to the greatest extent possible. According to the evaluation indexes of qualified assessment and audit assessment of undergraduate teaching work in ordinary institutions of higher education issued by the Ministry of Education, this paper combs through the key activities concerning the management capability of colleges and universities, identifies eight potential variables, namely, positioning and objectives, student development management, curriculum management, graduation management, faculty management, scientific research management, resource management, and continual improvement, and then refines these eight potential variables again into 31 measurement variables as the college and university key activities of management competence, and establish the index system of factors influencing management competence of universities as shown in Table 1. Based on this, research hypotheses are proposed and all hypotheses are summarized as shown in Table 2.

Table 1: The influence factors of college management ability

Potential variable	Measuring variable
Positioning and objectives M1	Target positioning M11
	Talent training plan M12
Student development management M2	Source construction M21
	Admissions M22
	Academic guidance M23
	Career planning guidance M24
	Employment guidance M25
	Party activity M26
	Student funding M27
Course management M3	Course teaching M31
	Textbook construction M32
	Course assessment M33
	Practical teaching M34
Graduation management M4	Graduate evaluation M41
	Graduation thesis (design) M42
Teacher management M5	Introduce teachers M51
	Job evaluation M52
	Teaching work input M53
	Teacher culture M54
Scientific management M6	Scientific research planning M61
	Scientific policy M62
	Resultant transformation M63
	Academic communication M64
Resource management M7	Human resources M71
	Site equipment M72
	Information resources M73
	Financial protection M74
	External relation M75
Continuous improvement M8	Evaluation of training goals M81
	Evaluation of teaching quality M82
	Teaching reform M83

Table 2: Research hypothesis summary

Serial number	Content
H1	Positioning and goals can significantly affect the management effect of universities
H2	Student development management can significantly affect the management effect of universities
H3	Curriculum management can significantly affect the management effect of universities
H4	Graduation management can significantly affect the management effect of universities
H5	Teacher management can significantly affect the management effect of universities
H6	Scientific research management can significantly affect the management effect of universities
H7	Resource management can significantly affect the management effect of universities
H8	Continuous improvement can significantly affect the management effect of universities

2.2 Theoretical modeling and data collection

2.2.1 Structural equation modeling

Structural Equation Modeling (SEM) is widely used in the fields of psychology, economics, sociology, behavioral sciences, etc. It is a comprehensive application and improvement of statistical methods such as exploratory factor analysis (EFA), validation factor analysis (VFA), path analysis (PA), multiple regression (MRA) and analysis of variance (ANOVA), etc. It is a new development in the field of statistical analysis. Structural equation modeling (SEM) is a new field of development in statistical analysis, and has established a high reputation in the field of statistical applications, and has been regarded by many famous scholars as the "second-generation multivariate statistics" method [29].

Structural equation modeling can be divided into measurement equations and structural equations, and structural equation modeling consists of two parts: measurement equations and structural equations. The structural model mainly reflects the relationship between latent variables, which include exogenous latent variables (X) and endogenous latent variables (Y), that is to say, it mainly verifies the relationship between exogenous variables and endogenous variables, and usually applies the method of path analysis; the measurement model mainly reflects the relationship between latent variables and observational variables, and in order to test the validity of the measurement tool, it usually applies the validation factor analysis.

The main software applications for structural equation modeling analysis are AMOS, LISREL, and EQS. In this study, LISREL version 8.70 is used. In structural equation analysis, the following steps are generally taken: hypothetical modeling based on relevant literature, model identification, parameter estimation, model evaluation and further modification, and so on.

Based on the previous literature organization and theoretical assumptions, this study is to explore the factors influencing the managerial competence of colleges and universities, and a total of 8 latent variables and 33 measured variables are constructed. To conduct structural equation analysis, the key is to establish structural equation modeling, based on the principle of structural equation modeling analysis, the structural model and measurement model of this study are as follows:

(1) Structural model

$$\eta = \beta\eta + \Gamma\xi + \zeta \tag{1}$$

The meanings of the variables in the structural model are as follows:

$\eta = (\eta_1, \eta_2, \ldots..\eta_{\mathrm{m}})^T$, endogenous latent variables

$\xi = (\xi_1, \xi_2, \ldots\ldots\xi_n)^T$, Exogenous latent variable

$B = (\beta_{ij})_{m\times m}$, Path coefficient matrix of endogenous latent variable η

$\Gamma = (\gamma_{ij})m \times n$, Path coefficient matrix of exogenous latent variable ξ and endogenous latent variable η

(2) Measurement model

$$\mathrm{x} = \wedge_x \xi + \delta \tag{2}$$

$$y = \wedge_y \eta + \varepsilon \tag{3}$$

The meanings of the variables in the measurement model are as follows:

x - exogenous latent variable ξ of the observed variables

y - Observed variable of endogenous latent variable η

$\wedge_x$ - Regression coefficient of observed variable x on exogenous latent variable ξ

$\wedge_y$ -- Regression coefficient of observed variable y on endogenous latent variable η

δ - Measurement Error of x

ε - Measurement error of y

2.2.2 Questionnaire design and survey

The questionnaire of this paper on managerial competence in colleges and universities is divided into two sections: firstly, it confirms the five basic elements of the respondents' gender, age, occupation, education and their affiliation to private colleges and universities. Secondly, it involves questions related to management competence in colleges and universities. According to the Likert scale, the level of influence of the factors influencing the management ability of colleges and universities is categorized into five levels: very correct, quite correct, uncertain, not quite correct and very incorrect, so as to assess the level of management ability of private colleges and universities. Based on the factors influencing management competence in colleges and universities, a preliminary questionnaire was set up to explore the factors influencing management competence in colleges and universities.

The sample data collection of this paper is mainly done through the platform of "Questionnaire Star", and this study has collected a large amount of data by using various means of social communication, such as WeChat, Weibo, and Jitterbug. The questionnaires were mainly distributed among teachers and students of Hangzhou universities. After this survey, a total of 715 valid responses were received, and in order to ensure the reliability and accuracy of the responses, we deleted the responses that took too short a time, or all the options were the same, and the final total number of valid responses used for analysis reached 709. The statistical results of the individual distribution of the samples are shown in Table 3, which shows that the gender ratio of the survey samples is basically balanced, and the distribution of individual characteristics such as age, occupation, and education is reasonable, which is suitable for the next step of the study.

Table 3: Sample individual characteristics distribution

Statistical term		Proportion %	Number
Gender	Man	44.85	318
	Female	55.15	391
Age	18-30	53.17	377
	31-40	24.12	171
	41-50	18.62	132
	Aged 51 and above	4.09	29
Occupation	Student	54.16	384
	Teacher	37.66	267
	Others	8.18	58
Educational background	College degree	1.13	8
	Undergraduate degree	58.53	415
	Master degree and above	40.34	286

2.3 Empirical analysis

2.3.1 Reliability test

The reliability test allows the correlation between the items to be assessed, thus ensuring the accuracy and trustworthiness of the test. It is generally accepted that a Clonbach coefficient greater than 0.6 and a combined reliability coefficient greater than 0.7 would indicate that the questionnaire's reliability is relatively satisfactory and that it can continue to be analyzed later. Validity is a measure of the validity and accuracy of the scale. The results of the reliability and validity analysis of the questionnaire are shown in Table 4, and the discriminant validity test is shown in Table 5, the Clonbach coefficients and the combined reliability coefficients in this study meet the requirements, which indicates that the reliability of the scale is good. After the KMO value and Bartlett sphericity test, we found that the Bartlett significance of all latent variables is lower than 0.001, which proves that the data has a strong factor analysis ability, which can be used to carry out more in-depth research. All the indicators in this study met the requirements, which means that the scale has good convergent and discriminant validity. Overall, the level of reliability and validity of the data in this study is satisfactory and suitable for further structural equation modeling analysis.

Table 4: Reliability and validity of questionnaire

Variable	Dimension	Cronbach's Alpha	CR	Factor load	AVE	KMO	The significance of bartlett's spherical test
M1	M11	0.818	0.779	0.87	0.775	0.833	0.000
	M12			0.752			
M2	M21	0.746	0.759	0.741	0.777	0.729	0.000
	M22			0.725			
	M23			0.793			
	M24			0.849			
	M25			0.776			
	M26			0.738			
	M27			0.782			
M3	M31	0.879	0.843	0.819	0.756	0.882	0.000
	M32			0.779			
	M33			0.819			
	M34			0.783			
M4	M41	0.793	0.864	0.741	0.719	0.724	0.000
	M42			0.876			
M5	M51	0.785	0.725	0.739	0.782	0.867	0.000
	M52			0.878			
	M53			0.872			
	M54			0.798			
M6	M61	0.736	0.78	0.861	0.736	0.805	0.000
	M62			0.84			
	M63			0.822			
	M64			0.76			
M7	M71	0.846	0.743	0.772	0.771	0.829	0.000
	M72			0.717			
	M73			0.736			
	M74			0.739			
	M75			0.831			
M8	M81	0.754	0.737	0.738	0.788	0.796	0.000
	M82			0.851			
	M83			0.713			

Table 5: Differential validity test

Variable	M1	M2	M3	M4	M5	M6	M7	M8
M1	0.73							
M2	0.799***	0.883						
M3	0.815***	0.795**	0.778					
M4	0.776**	0.817***	0.836***	0.732				
M5	0.752***	0.875***	0.862**	0.831***	0.728			
M6	0.737**	0.743***	0.788***	0.774**	0.757***	0.846		
M7	0.782***	0.744***	0.744***	0.877***	0.892***	0.867**	0.712	
M8	0.883***	0.878**	0.807***	0.798**	0.829**	0.866***	0.819**	0.746

2.3.2 Model fit test

The constructed structural equation model of the frame was analyzed using the AMOS program, and Table 6 shows the fitting effect of this modeling. It can be seen that for the absolute fit index, the chi-square degree of freedom ($\chi 2/df$) is 1.754, which is in the ideal interval of 1 to 3, the root mean square of the approximation error (RMSEA) is lower than 0.05, the root mean square of the residuals (RMR) is lower than 0.08, and the goodness-of-fit index (GFI) and the modified goodness-of-fit index (AGFI) are 0.984 and 0.976, respectively, which indicate that the modeling has good fitting performance. All the indices exceeded 0.80 and these indices meet the requirements for modeling the structural equations of the frame. The regular fit index (NFI), relative fit index (RFI), incremental fit index (IFI), comparative fit index (CFI), and non-canonical fit index (TLI) of the value-added fit indices exceeded 0.80.After evaluating the parsimony fit indices, the parsimony fit index (PGFI) and parsimony canonical fit index (PNFI) of the parsimony fit indices exceeded 0.6, which indicated that they had good fitting ability and therefore can meet the evaluation criteria.

Table 6: Structure equation model fitting index

Exponential category	Fit index	Value	Reference standard	Index evaluation
Absolute fitting index	$\chi 2/df$	1.754	1~3	Pass
	RMSEA	0.028	<0.05	Pass
	RMR	0.070	<0.08	Pass
	GFI	0.984	>0.80	Pass
	AGFI	0.976	>0.80	Pass
Value-added fitting index	NFI	0.922	>0.80	Pass
	RFI	0.958	>0.80	Pass
	IFI	0.981	>0.80	Pass
	CFI	0.959	>0.80	Pass
	TLI	0.937	>0.80	Pass
Integrated fitting index	PGFI	0.728	>0.60	Pass
	PNFI	0.746	>0.60	Pass

2.3.3 Model hypothesis testing

After validation, we found that the structural equation model constructed in this paper for analyzing the influencing factors of managerial competence in universities can explain the latent variables well. Table 7 shows the standardized path coefficients between latent variables or between latent variables and observed variables. Among the 8 paths between latent variables,

4 reached the significance level test of 0.001 and 4 exceeded the significance level test of 0.01. Therefore all 8 hypotheses are supported.

Table 7: Model validation results

Original hypothesis	Path	Normalization factor	Standard deviation	Significance level	Test result
H1	M1→College management effect	0.13	0.069	**	Pass
H2	M2→College management effect	0.59	0.062	***	Pass
H3	M3→College management effect	0.51	0.060	***	Pass
H4	M4→College management effect	0.12	0.055	***	Pass
H5	M5→College management effect	0.56	0.049	**	Pass
H6	M6→College management effect	0.37	0.086	**	Pass
H7	M7→College management effect	0.45	0.152	**	Pass
H8	M8→College management effect	0.22	0.117	***	Pass

Note: * denotes $p<0.05$, ** denotes $p<0.01$, and *** denotes $p<0.001$.

It can be concluded from the analysis of structural equation modeling of the factors affecting the management ability of universities that the results of path analysis show that orientation and goals, student development management, curriculum management, graduation management, faculty management, research management, resource management, and continuous improvement all have a positive effect on the management ability of universities. The influence coefficients of student development management, curriculum management, faculty management, and resource management on management effectiveness are 0.59, 0.51, 0.56, and 0.45, respectively, indicating that each 1% increase in each competency increases the influence on the management effectiveness of colleges and universities by 59%, 51%, 56%, and 45%.

3 Evaluation of the maturity of university management capacity

In order to obtain a more accurate perception, based on the results of the previous analysis of the factors influencing the management capacity of colleges and universities through questionnaire survey and structural equation modeling. This chapter constructs the index system for evaluating the maturity of university management capability and determining the weights carried by individual indexes, will determine the weights of the maturity evaluation index system with the help of hierarchical analysis, and introduces the fuzzy comprehensive evaluation method as the maturity evaluation method. We choose University H as a case study object to show how to diagnose teaching quality management maturity with the help of maturity evaluation scale, and analyze how model universities can use maturity evaluation to improve teaching quality management in practice through the discussion of evaluation results.

3.1 Maturity model of university management capacity

Capability Maturity Model (CMM) incorporates the idea of Total Quality Management, which is not only a model and a tool, but also represents a management philosophy.CMM classifies the maturity of management processes into five levels, namely, Initial, Repeatable, Defined, Manageable and Optimized, with each of the lower levels being the basis for reaching a higher level [30]. In each level, by defining the key problems and key processes that should be solved to reach a higher level of process management, it provides an actionable methodological path for management organizations to test their practices, identify gaps, and transform from a blind, disorganized, and immature state of management to a purposeful, orderly, and mature aspect, which will in turn make the process of management more standardized, standardized, and scientific. College management maturity is a measure of management ability and level, is a kind of ability indicators, and all emphasize the continuous improvement and enhancement of the process. Therefore, CMM principles and related research results can be borrowed, combined with the content and characteristics of university management capabilities to build a grouping model of university management capability maturity, which can be applied to the optimization and improvement of university management capability and level.

Therefore, the university management capability maturity model is to take the university management capability and level as the research object, around the key factors related to it, outlining the degree of maturity of the university management capability at different stages from low to high, and taking the university's management capability enhancement and improvement as the benchmark for measurement at each stage, so as to change an uncontrollable and disordered process into a controllable, measurable and orderly process. It can provide a tool for universities and external assessment organizations to evaluate the level of quality management, to identify the current status of quality management in universities and to find out the direction of quality improvement.

Referring to the framework structure of CMM, according to the characteristics of the process of university management capability and the operation mode of quality management related departments, the maturity model of university management capability can be constructed preliminarily as shown in Figure 1. Vertically, the model describes five maturity levels of university management capability from low to high in the form of a ladder, and the lower level of the ladder is the basis for realizing the higher level of the ladder. Horizontally, the model defines competencies, criteria, and key process domains (KPAs) that correspond to when HEI management competencies are at a given maturity level. Each KPA contains a set of objectives for management competencies that can only be achieved before progressing to a higher level. The objectives of the Key Process Domains are achieved through a number of specific Key Activities (KPs). The purpose of establishing this model is to help the relevant management to compare the current management capability with the predetermined objectives, so as to find out the gaps, discover the problems, and carry out reform, adjustment and improvement in time, so as to provide directional guidance for the improvement of the management capability level from chaos and disorder up to optimization.

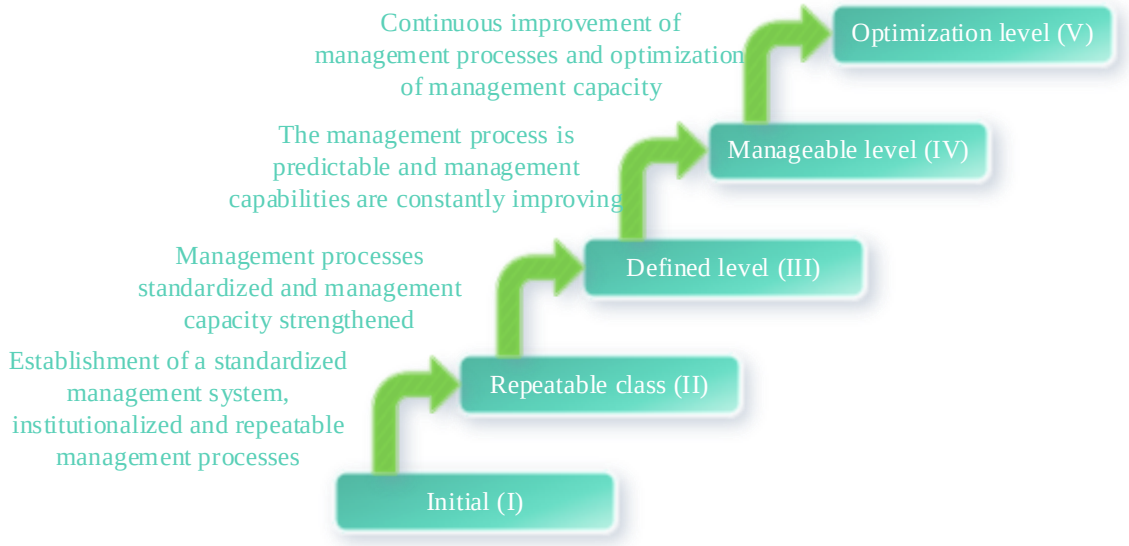

Figure 1: Framework for maturity model

3.2 System of evaluation indicators

3.2.1 Determination of evaluation indicators

In order to ensure the scientificity and effectiveness of the evaluation system of management capability maturity of colleges and universities, on the basis of following the analysis of the influencing factors in the previous section, this paper believes that the design of the evaluation index system about the maturity of management capability of colleges and universities should also follow the five principles of comprehensiveness, systematicity, importance, comparability and operability.

First, we considered the factors influencing the management capacity of universities in section 2.1 as initial evaluation indicators. Second, according to the structural equation modeling, we found that the factor loadings of each measured variable exceeded 0.45. Therefore, we kept the original data analysis conclusions and did not delete the initial evaluation indicators. The final system of evaluation indicators established is the same as the evaluation indicators in the initial Table 1. Among them, the first-level indicators contain 8 aspects, i.e., orientation and goals, student development management, curriculum management, graduation management, faculty management, research management, resource management, and continuous improvement. The second-level indicators contain 31 aspects, i.e., goal orientation, talent cultivation program, student source construction, enrollment, academic guidance, career planning guidance, employment guidance, party and group activities, student financial aid, course teaching, textbook construction, course assessment, practice teaching, graduate evaluation, thesis (design), introduction of teachers, title evaluation, input of teaching and learning, faculty cultivation, scientific research planning M61, scientific research policy, Achievement Transformation, Academic Exchange, Human Resources, Venue and Equipment, Information Resources, Funding Security, External Relationships, Evaluation of Achievement of Cultivation Objectives, Evaluation of Teaching Quality, Teaching Reform.

3.2.2 Determination of indicator weights

Hierarchical analysis, or AHP for short, is a systematic, hierarchical analysis method that combines quantitative and qualitative analysis by breaking down the evaluation objectives layer

by layer, fine-tuning the indicators, and multiplying the evaluation results of the relevant indicators by the appropriate weights to arrive at a conclusion. In the process of multi-objective decision-making, through this method, the various factors in the complex problem will be divided into orderly levels with each other, so that it is organized, according to a certain objective reality of the competent judging body (mainly two by two comparison) to the results of the objective evaluation of the direct and effective combination of the degree of importance of the elements of a level into a quantitative description of the language. After that, the mathematical calculation method is used to calculate the weights of all elements for specific analytical support [31].

The hierarchical analysis process decomposes the solution problem into various hierarchical structures based on the internal logic of the system, in the order of the eigenvectors of the objective level, the criterion level, the sub-criteria level and the indicator level, and the evaluation matrix, which are used to obtain the values of each level. The priority of each element over the elements of the previous level and the final weight of each element of the final indicator level over the target level are recursively combined using a weighted summation method. The scoring matrix compares scores at the same level, and the scale method is used to quantitatively compare the importance of the two in terms of their impact on goals to obtain a two-by-two comparison matrix $A=\left(a_{ij}\right)n\cdot n$, with factor a_{ij} indicating the importance value of factors a_i and a_j compared to the goal, and with matrix A satisfying the following conditions: $a_{ij}>0, a_{ij}=1/a_{ji}, a_{ii}=1(i,j=1,2,\ldots,n)$. Hierarchical analysis hierarchically breaks down the research problem in a qualitative way, and then quantitatively specifies the affiliation between the indicators at the upper and lower levels. Each factor is compared in pairs, and the results of the comparison are expressed in terms of a scale, and the interpretation of the scales in the Satie scale is shown in Table 8.

Table 8: Saatyscale table

scale	meaning
1	It means that the two factors have the same importance
3	It indicates that when comparing two factors, one factor is slightly more important than the other
5	It indicates that one factor is significantly more important than the other when comparing two factors
7	It indicates that when comparing two factors, one factor is more strongly important than the other
9	It indicates that when comparing two factors, one factor is extremely important than the other
2, 4, 6, 8	The median of the two adjacent judgments
reciprocal	If factor i and j compare the judgment of a_{ij}, the judgment of j and i is compared $a_{ji}=1/a_{ij}$

(1) Compute the product of the elements of each row of the judgment matrix A:

$$Mi=\prod_{j=1}^{n}a_{ij} \tag{4}$$

The subscript $i=1,2,\ldots,n$, n in the equation is the matrix order.

(2) Calculate the root of the n th power of each row Mi , i.e., the geometric mean of the i-th row:

$$\bar{Wi} = \sqrt[n]{M_i} \tag{5}$$

(3) Conversion to standard rows:

$$Wi = \frac{\overline{W}_i}{\sum_{i=1}^{n} \overline{W}_i} \tag{6}$$

The equation Wi is the weight of the ith evaluation index on the evaluation object.

(4) Calculate the maximum characteristic root of the judgment matrix A:

$$\lambda_{\max} = \sum_{i=1}^{n} \frac{(AW)_i}{nW_i} \tag{7}$$

In the equation, A is the judgment matrix vector, and W is the weight vector derived by the root method.

(5) The consistency test is performed on the judgment matrix, and the consistency index is:

$$CI = \frac{\lambda_{\max} - n}{n-1} \tag{8}$$

The average R_i of the stochastic consistency metrics increases as the matrix order increases and gives R_i values in a different order as shown in Table 9.

Table 9: Value table of RI

N	1	2	3	4	5	6	7	8	9
RI	0	0	0.58	0.9	1.12	1.24	1.38	1.4	1.46

If $CR = CI / ri < 0{,}1$, the judgment matrix is assumed to pass the tests for consistency and good agreement. If the CR value is greater than 0.1, the judgment matrix is inconsistent and further adjustment of the judgment matrix is required until it passes the consistency test.

We follow the above method and finally calculate the weights of the indicators for evaluating the maturity of university management capacity, as shown in Table 10. From the point of view of the weights carried by the first-level indicators, faculty management has the largest weight index. It is followed by resource management, student development management and curriculum management respectively.

Table 10: Index weight of college management ability

Primary indicator	Index weight	Secondary indicator	Index weight	Total weight factor
M1	0.0758	M11	0.4729	0.0358
		M12	0.5271	0.0400
M2	0.191	M21	0.1026	0.0196
		M22	0.1053	0.0201
		M23	0.3939	0.0752
		M24	0.1705	0.0326
		M25	0.1040	0.0199
		M26	0.0528	0.0101
		M27	0.0709	0.0135
M3	0.0947	M31	0.4383	0.0415
		M32	0.1479	0.0140
		M33	0.1716	0.0163
		M34	0.2422	0.0229
M4	0.0427	M41	0.2127	0.0091
		M42	0.7873	0.0336
M5	0.2734	M51	0.1918	0.0524
		M52	0.0930	0.0254
		M53	0.3815	0.1043
		M54	0.3337	0.0912
M6	0.0758	M61	0.1561	0.0118
		M62	0.2899	0.0220
		M63	0.4557	0.0345
		M64	0.0983	0.0075
M7	0.2148	M71	0.2732	0.0587
		M72	0.1641	0.0352
		M73	0.0986	0.0212
		M74	0.4136	0.0888
		M75	0.0505	0.0108
M8	0.0318	M81	0.2940	0.0093
		M82	0.5409	0.0172
		M83	0.1651	0.0053

3.3 Evaluation model of the maturity of university management capacity

Fuzzy evaluation method is a multi-factor objective decision-making method based on modal mathematics. For some difficult to quantify and opaque problems, this method is widely used [32]. It can be well applied to the research object and reasonably convert qualitative evaluation into quantitative evaluation. Therefore, this paper selects the fuzzy comprehensive evaluation method to establish the evaluation model, and its application process is as follows.

Factor set is a collection of various factors that have influence on the evaluation object, namely:

$$U = \{U_1, U_2, U_3, \cdots, U_n\} \tag{9}$$

where $U_i (i = 1, 2, \ldots, n)$ is the evaluation factor and n is the number of individual elements at the same level that make up the basic assessment framework.

The maturity model described in this paper consists of five maturity levels corresponding to the maturity levels “Optimized”, “Managed”, “Defined”, ‘Repeatable’ and “Initial”, “Repeatable” and “Initial”, with the specific evaluation set:

$$V = \{V_1, V_2, V_3, V_4, V_5\} = \begin{Bmatrix} \text{Optimization level, management level, defined level,} \\ \text{repeatable level, initial level} \end{Bmatrix} \tag{10}$$

Fuzzy evaluation method is a method to make systematic evaluation of complex objects using fuzzy mathematical theory, in the membership theory of fuzzy mathematics, it transforms qualitative evaluation into quantitative evaluation, which is suitable for solving complex and difficult to quantify problems. The single factor evaluation matrix is $R_i = \{r_{ij}\}, i = 1, 2, \ldots, N;\ j = 1, 2, \ldots, n$.

Where r_{ij} indicates the degree to which the ith factor has V_j. $0 < r_{ij} < 1$. When a comprehensive evaluation of the n elements has been carried out, the result of the evaluation is a n-row n-column matrix known as the members R_i, R_i are a set of unique elements that are a set of fuzzy sub-elements. Each row in the matrix is the result of a single element, which contains all the information obtained by evaluating the set of evaluation factors U according to the set of evaluation criteria V. Expanding the amount of information allows the evaluation number to be increased and the evaluation conclusions to be more credible. Considering the importance of the degree of affiliation to the evaluation results, this paper uses the expert scoring method to determine the degree of affiliation of the qualitative indicators, which makes the evaluation results more objective and more in line with the actual situation by virtue of the professional experience of the experts.

The single-factor comprehensive evaluation, i.e., the comprehensive evaluation of the sub-criteria layer, is given by the formula:

$$B_i = A_i \cdot R_i \tag{11}$$

A higher level matrix R_j is formed from B_i of the sub-criteria level of integrated evaluation to find the matrix B_j of the guideline level of integrated evaluation, and then B_j to form the matrix of the higher level matrix R to obtain the final evaluation matrix B, i.e:

$$B = A \cdot R \tag{12}$$

$$E = B \cdot H^T \tag{13}$$

H^T is the implementation of H transposition matrix. the size of E reflects the level of management capability of the university, which results in the maturity level of management capability of the university, points out the aspects of management capability of the university that need to be improved, and points out the direction of improvement for the improvement of management capability of the university by further scoring the key domains key practices.

3.4 Maturity evaluation of case subjects

3.4.1 Faculty self-evaluation

Based on the weights of the indicators determined by the hierarchical analysis method, we conducted a case study on University H. There are 28 second-level colleges in University H, of which a total of 21 faculties are responsible for undergraduate teaching, and we chose 11 out of the 21 faculties to be the target of this self-assessment. These 11 faculties are: College of Computer Science and Technology, College of Media and Design, College of International and Public Affairs, College of Zhiyuan, College of Life Science and Technology, College of Materials Science and Engineering, College of Shipbuilding, Oceanic and Architectural Engineering, College of Aeronautics and Astronautics, Paris Hi-Tech College of Engineering Excellence, College of Pharmacy, and College of Agriculture and Biology. These 11 faculties cover the major disciplines of arts, science, engineering, agriculture and medicine, and thus have good representation in the sample selection.

In the evaluation process, each vice dean of teaching firstly makes a factual judgment on the management ability of the faculty, and if he/she answers "yes", he/she has to give relevant statement materials to explain. The whole maturity evaluation is divided into two parts, self-assessment and other evaluation, the self-assessment can be obtained directly through the self-judgment of the faculties, while the other evaluation has to use the fuzzy synthesis evaluation method with the help of experts. Therefore, we carry out the maturity evaluation of 11 faculties according to the above evaluation requirements, and firstly, we statistically analyze the results of the judgmental part, that is, the self-assessment. Finally, we calculated the overall maturity of the self-assessment of the management ability of the 11 faculties by combining the different weighting coefficients of each dimension, and the results are shown in Figure 2. We can clearly see the level of management ability of the faculties, and there is a big difference in the overall maturity of management ability of each faculty, and the faculty with the lowest maturity score is nearly 40% lower than the faculty with the highest score.

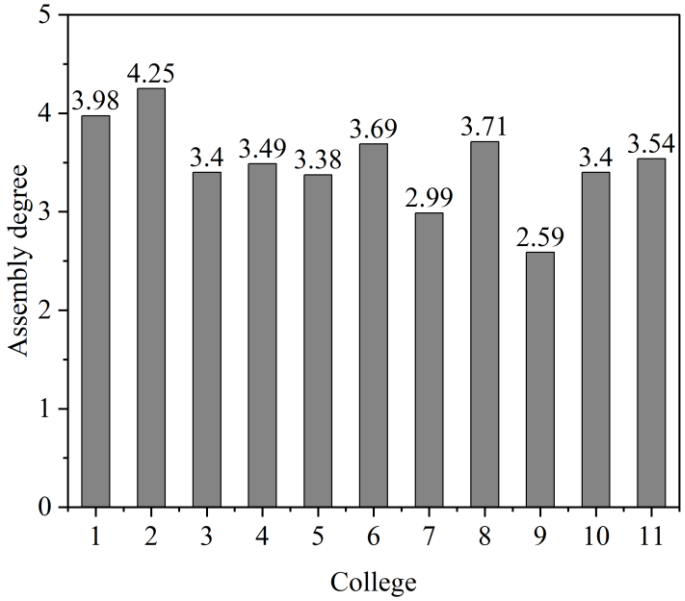

Figure 2: Cases of the different colleges of the management ability complement

It can be seen that although they are all in the same school, there is still a great deal of variability among different faculties. This diversity is not only reflected in the different

attributes of the disciplines, but also in the level of management. This tells us that even within the school should not take a “one-size-fits-all” approach to management, and must take into account the differences in the disciplines and management level of each department. At the same time, the quality management of university teaching needs to adhere to the concept of “faculty as an entity”, which is the law of talent cultivation and knowledge research, and only if the quality management level of each faculty can realize self-improvement, the overall quality of higher education can be continuously improved.

3.4.2 Model evaluation

Since the other evaluation stage requires organizing review experts to evaluate the faculty quality management maturity statement materials, which involves more human and material resources, we chose the School of Media and Design among the 11 faculties as the case object of the other evaluation stage, considering the time constraints of this study and the ability to support the funding.

Below, we take the evaluation results of the "Student Development Management" factor set M2 as an example to present the specific fuzzy evaluation process and the final comprehensive evaluation results. There are a total of 7 secondary indicators in M2. Twenty-five evaluation experts successively evaluated M21, M22, and so on based on the departmental statement materials. Make a judgment based on the maturity level of M27. Among them, the evaluation results of the "student source construction" of M21 are as follows: 1 expert determined it to be "repetitive level", 7 experts determined it to be "defining level", 12 experts determined it to be "management level", and 5 experts determined it to be "optimization level". Based on this, it can be concluded that the single-factor evaluation set R21 of M21 = (0, 1/25, 7/25, 12/25, 5/25) = (0, 0.04, 0.28, 0.48, 0.20), indicating that it belongs to the "repetition level" at the 0.04 degree and to the "definition level" at the 0.28 degree. At 0.48, it belongs to the "management level", and at 0.20, it reaches the "optimization level". Similarly, the secondary indicators M22, M23, etc. can be obtained. The evaluation sets corresponding to M27, R22, R23,... Table 11 of R27 shows the expert's judgment on the membership degree of the factor set of "Student Development Management" in the School of Media and Design.

Table 11: "Organizational leadership" factor set of each index membership

Student development management	Initial stage	Repetition level	Definition level	Management level	Optimization level
M21	0	0.04	0.28	0.48	0.20
M22	0	0.08	0.20	0.64	0.08
M23	0	0.28	0.48	0.24	0
M24	0.36	0.52	0.12	0	0
M25	0	0.04	0.52	0.40	0.04
M26	0.12	0.44	0.20	0.16	0.08
M27	0.04	0.28	0.44	0.24	0

On this basis, a fuzzy evaluation matrix R2 is constructed for the factor set M2 of “student development management”:

$$R_2 = \begin{bmatrix} R_{21} \\ R_{22} \\ R_{23} \\ R_{24} \\ R_{25} \\ R_{26} \\ R_{27} \end{bmatrix} = \begin{bmatrix} 0 & 0.04 & 0.28 & 0.48 & 0.20 \\ 2 & 0.08 & 0.20 & 0.64 & 0.08 \\ 0 & 0.28 & 0.48 & 0.24 & 0 \\ 0.36 & 0.52 & 0.12 & 0 & 0 \\ 0 & 0.04 & 0.52 & 0.40 & 0.04 \\ 0.12 & 0.44 & 0.20 & 0.16 & 0.08 \\ 0.04 & 0.28 & 0.44 & 0.24 & 0 \end{bmatrix}$$

Using the fuzzy evaluation matrix R2 and the weight vector W1 (two decimal places) obtained by the hierarchical analysis method, after matrix multiplication and normalization, we can obtain the comprehensive evaluation set B2 of the factor set M2 of the "management of student development", i.e.:

$$B_2 = W_2 \bullet R_2 = (0.1, 0.11, 0.39, 0.17, 0.1, 0.05, 0.07) \bullet \begin{bmatrix} 0 & 0.04 & 0.28 & 0.48 & 0.20 \\ 2 & 0.08 & 0.20 & 0.64 & 0.08 \\ 0 & 0.28 & 0.48 & 0.24 & 0 \\ 0.36 & 0.52 & 0.12 & 0 & 0 \\ 0 & 0.04 & 0.52 & 0.40 & 0.04 \\ 0.12 & 0.44 & 0.20 & 0.16 & 0.08 \\ 0.04 & 0.28 & 0.44 & 0.24 & 0 \end{bmatrix}.$$

$$= (0.0705, 0.2588, 0.3553, 0.2781, 0.0373)$$

Similarly, the evaluation set of each level of indicators from B1 to B10 can be obtained as a way to be able to observe the performance of the management capability of the School of Media and Design on different key process domains, and Table 12 shows the affiliation of the maturity level on each level of indicators of the School of Media and Design.

Table 12: Results of the maturity grade of each index

Primary indicator	Initial stage	Repetition level	Definition level	Management level	Optimization level
M1	0.0567	0.3957	0.4487	0.0589	0.0400
M2	0.0705	0.2588	0.3553	0.2781	0.0373
M3	0.0547	0.1443	0.4647	0.2435	0.0928
M4	0.0715	0.0085	0.3200	0.4945	0.1055
M5	0.0609	0.2407	0.3048	0.3671	0.0264
M6	0.1574	0.2693	0.2806	0.2338	0.0589
M7	0.0338	0.1104	0.3052	0.4925	0.0581
M8	0.0184	0.3924	0.2862	0.152	0.151

Therefore, the fuzzy evaluation matrix R corresponding to the factor set M of management capability maturity of the School of Media and Design is:

$$R=\begin{bmatrix} B_1 \\ B_2 \\ B_3 \\ B_4 \\ B_5 \\ B_6 \\ B_7 \\ B_8 \end{bmatrix}=\begin{bmatrix} 0.0567 & 0.3957 & 0.4487 & 0.0589 & 0.0400 \\ 0.0705 & 0.2588 & 0.3553 & 0.2781 & 0.0373 \\ 0.0547 & 0.1443 & 0.4647 & 0.2435 & 0.0928 \\ 0.0715 & 0.0085 & 0.3200 & 0.4945 & 0.1055 \\ 0.0609 & 0.2407 & 0.3048 & 0.3671 & 0.0264 \\ 0.1574 & 0.2693 & 0.2806 & 0.2338 & 0.0589 \\ 0.0338 & 0.1104 & 0.3052 & 0.4925 & 0.0581 \\ 0.0184 & 0.3924 & 0.2862 & 0.1520 & 0.1510 \end{bmatrix}$$

Combined with the set of weights W for each level of indicators, it is possible to derive the decision set B for the maturity of the management capacity of the School of Media and Design, i.e. $B=W\cdot R=(0.0624,0.2159,0.3388,0.3305,0.0524)$

Through the decision set B we can get the fuzzy comprehensive evaluation results of the School of Media and Design on each level of maturity evaluation, based on which we need to analyze the relevant data in order to draw actionable conclusions. In order to make full use of the information brought by the fuzzy decision set B, we need to do further in-depth and refined processing, assigning the maturity evaluation level to the corresponding parameters and decision set B for comprehensive consideration, so as to make the final maturity judgment results more accurate and intuitive. At this point, we introduce the parameter vector $C=\left(c_1,c_2,\cdots,c_m\right)^T$, and then take the five equal grades of 100 points as the parameter vector, then $C=(0,25,50,75,100)^T$. The final maturity score of the management capability of the School of Media and Design of the evaluated subject:

$$P=C\bullet B=\begin{bmatrix} 0 \\ 25 \\ 50 \\ 75 \\ 100 \end{bmatrix}\bullet\left(0.0624,0.2159,0.3388,0.3305,0.0524\right)=52.36$$

According to the setting of the above parameter vector, the total management capability maturity level of the College of Media and Design is 52.36 points, reflecting that the overall management capability maturity of the college is still in the defined stage, and thus there is still much work to be done in the standardization and institutionalization of management capability. By comparing the self-assessment and other assessment results of the College of Media and Design, we can find that the other assessment results are much lower than the self-assessment results. This reflects that the faculty's perception of self is higher than the experts' judgment, that is to say, the faculty thinks that what it has done in management is in place and perfect, but in the opinion of the experts, there are still many deficiencies and things that need to be improved. Therefore, the maturity evaluation should be based on the self-assessment of colleges and universities on the one hand, and assisted by the power of his assessment at the same time. Only here the other assessment is different from the traditional external assessment, but to better help universities and faculties to recognize themselves and carry out self-assessment, to reduce the cognitive bias generated by complacency, so as to stimulate the awareness of improvement and improve the quality of work.

4 Path to improve the management level of colleges and universities

Colleges and universities should make full use of and study the latest education laws and regulations and policies. Allocate special funds and set up a special department to study the policies of the education department. And through regular visits, inter-school visits, strengthen the cooperation with excellent colleges and universities, to build on their strengths and avoid their weaknesses, and reform the development of the school. At the same time, education laws and regulations are also an important outcome factor, which is influenced by national control policies and thus affects the development of colleges and universities, further emphasizing the importance of this indicator.

Characteristics of school running is a key factor to enhance the core competitiveness of colleges and universities in the same way as the innovation of enterprises. The development of school characteristics will not only promote the school's brand building, but also can promote the school's employment situation, thus driving the growth of the number of students in the school, the quality of students to improve, and form a power mechanism for the overall development of colleges and universities. At the same time, in the market economy, the importance of the characteristics of the problem is self-evident, in the increasing number of colleges and universities in the context of the characteristics of the competitiveness. The establishment of school running characteristics on the one hand, need to “school running characteristics” as a five-year round of colleges and universities in the teaching assessment of an important indicator, to guide colleges and universities to pay attention to, summarize, refine and carry forward the characteristics of their own schools. On the other hand, it is necessary to take the creation of professional characteristics and disciplinary characteristics as an important reform and construction goal in the planning of educational and teaching reform and development, so as to improve the school's taste and core competitiveness.

The development of school characteristics need to have advanced school philosophy and educational ideas as a guide. For example, Beijing University's “academic freedom, inclusive”, Harvard University's “I love my teachers, I love the truth” and so on reflect a school's philosophy and educational ideas. These advanced concepts are condensed and refined, not just for slogans for external propaganda, and need to adhere to the implementation of the formation of the school teachers and students of the common cultural consciousness, and with the development of society, the times and constantly enriched, in order to always maintain the philosophy of education and educational thinking of the advancement of the school in a certain aspect of the formation of the school's characteristics.

The development of schooling characteristics needs to be supported by specialties. The most important basis for the construction of the characteristics of colleges and universities is the construction of professional characteristics, disciplinary characteristics and curriculum characteristics, colleges and universities can only reflect the advantages of running a school with characteristics by strengthening the construction of faculties centered on the construction of specialties, disciplines and courses, and the most important thing for the enhancement of the connotation of colleges and universities is to set up high-level courses, disciplines and specialties.

In general, the development of colleges and universities should be centered on the construction of the school itself, taking into account the actual situation of local economic development, joining hands with the local government to strive for more financial subsidies, cultivating suitable talents based on the social demand, setting up a mechanism of financial aid based on the income level of the residents in the region, and fully studying and utilizing the latest education laws and regulations. It should establish brand awareness, appropriately

increase the scale of operation and teacher incentive system, strengthen the construction of faculty, teaching conditions, professional settings, teaching achievements and school characteristics, and later increase the number of students, improve student quality, improve employment and thus strengthen the school's service capacity and social contribution.

5 Conclusion

Based on the process of education quality management in colleges and universities, the article draws on the maturity model, constructs a maturity model of management ability in colleges and universities, and establishes a quantitative maturity level measurement method by using the hierarchical analysis method and fuzzy comprehensive evaluation theory. Taking University H as an example, the results of faculty self-evaluation show that there are large differences between different faculties, and the highest-scoring faculty is higher than the lowest-scoring faculty by about 40%. According to the maturity evaluation model, the maturity level of the college of media and design of the university was measured. The results show that the total maturity level of management competence of this college is 52.36 points. It also proves that the evaluation method is reasonable and effective, and can provide a reference for enhancing and improving the management of education quality in colleges and universities, as well as promoting the establishment and improvement of the internal quality assurance system in colleges and universities.

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