The Hierarchy Grey Comprehensive Evaluation Model of the Information Service Capability in Colleges and Universities

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Abstract. This paper discusses the characteristics of the information service capability in colleges and universities, and establishes the evaluation index system including information environment, information services infrastructure, information resources, information service mode, information service institutions and effects. This paper builds a comprehensive evaluation model of the information service capability based on Analytic Hierarchy Process and grey system theory, and then analysis the feasibility of the evaluation model by case.

Introduction

With the rapid development of information technology and the widespread application, the information service based on information network is growing rapidly. The new capability of the information service is put forward in colleges and universities. It is valuable to actively research the characteristics of the information service work and organize the evaluation of the information service capability [1,2].

Drawing on the experience of evaluation of information service capability in enterprise [3,4], the informatization evaluation model in colleges and universities is researched by using Delphi method, Analytic Hierarchy Process (AHP) and Fuzzy comprehensive evaluation method [5,6]. But, the index system does not fully reflect the characteristics of the information service of colleges and universities, and the evaluation content is not very integrity as well as the evaluation model is not very operational. In this paper, the evaluation index system is redesigned, and the index weight is recalculated by using Analytic Hierarchy Process (AHP) and grey system theory. Therefore this paper gives a quantitative analyzing method for the evaluation of the information service capability in colleges and universities.

The Evaluation Index System of the Information Service Capability

Characteristics of the Information Service Capability

Comparing with the social information service institutions, in colleges and universities, it is showing the different on four aspects. At first, the information service function should be suitable for talents cultivation process, a healthy information culture, and improving education effect. The second, the information service demand should be based on the need of students and faculty, and meet the requirements for teaching work and scientific research. The third, from the traditional way to personalized service, the information service modes should be developmental, which is necessary to use the new information technology such as big data and mining, cloud computing and sorting, information retrieval and push technology. The fourth, the information service resources should consist of paper resources, digital resources and network resources, which are often analyzed filtered, integrated, optimized for information services.
Evaluation Index System

According to the characteristic of the information service capability and basic elements of evaluation index system, this paper constructs the evaluation index system of information service capability in colleges and universities, which is composed of the target layer, the criterion layer and the index layer.

The target layer A means the goal of evaluation of information service capability in colleges and universities. The criterion layer means the first level index, which is composed of 6 indexes such as information environment, information services infrastructure, information resources, information service mode, information service institutions and information service effects, writing as $B_t(t=1, 2,...,6)$. The index layer means the second level index, which is composed of 28 indexes such as information culture, campus network, personalized service, service quality, evaluation of students, evaluation of teachers, evaluation of social, etc., writing as $C_{tk}$ (Shown in Table 1).

Table 1. Evaluation Index System of the Information Service Capability.

<table>
<thead>
<tr>
<th>Goal</th>
<th>First level index</th>
<th>Second level index</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$B_1$ Information environment</td>
<td>$C_{11}$ Information laws and regulations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$C_{12}$ Information ethics</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$C_{13}$ Information service system</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$C_{14}$ Information culture</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$C_{15}$ Information security</td>
</tr>
<tr>
<td></td>
<td>$B_2$ Information services infrastructure</td>
<td>$C_{21}$ Campus network</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$C_{22}$ Information device configuration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$C_{23}$ Information management system</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$C_{24}$ Investment in informatization</td>
</tr>
<tr>
<td></td>
<td>$B_3$ Information resources</td>
<td>$C_{31}$ Library resources</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$C_{32}$ Database resources</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$C_{33}$ Portal web resources</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$C_{34}$ Development of information resources</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$C_{35}$ Information resources sharing</td>
</tr>
<tr>
<td></td>
<td>$B_4$ Information service mode</td>
<td>$C_{41}$ Information consultation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$C_{42}$ Information release</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$C_{43}$ Information retrieval</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$C_{44}$ Personalized service</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$C_{45}$ Training</td>
</tr>
<tr>
<td></td>
<td>$B_5$ Information service institutions</td>
<td>$C_{51}$ Jobs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$C_{52}$ Functions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$C_{53}$ Service skills</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$C_{54}$ Service quality</td>
</tr>
<tr>
<td></td>
<td>$B_6$ Information service effects</td>
<td>$C_{61}$ Evaluation from students</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$C_{62}$ Evaluation from teachers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$C_{63}$ Evaluation from management person</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$C_{64}$ Evaluation of the education industry</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$C_{65}$ Evaluation of the social</td>
</tr>
</tbody>
</table>

By using Analytic Hierarchy Process (AHP) method, this paper calculates the relative
weight of the criterion layer compared with the target layer, and the index layer compared with the criterion layer. Also, based on the grey system theory, the gray type of the evaluation and the weight matrix are calculated. By calculating the evaluation value, the comprehensive evaluation model is built.

The Gray Multi-level Comprehensive Evaluation Model

Calculation of Index Weight

According to the hierarchical structure of the evaluation index system of the information service capability, using Analytic Hierarchy Process and adopting 9-point scale method, we calculate the relative weight of each index by square root method. As an example to calculate the relative weight of first level index compared with the goal $A$, we structure the judgment matrix $A=(b_{ij})_{6\times6}$ (Shown in Table 2), then calculate the eigenvector $W_B=(w_1, w_2, w_3, w_4, w_5, w_6)$. From the consistency validation, $CR=0.032<0.1$, we get the relative weight vector $W_B=(0.0563, 0.1288, 0.2295, 0.1737, 0.1023, 0.3094)$.
Similarly, we calculate the judgment matrix of each second level index compared with the first level index $B_i$ ($i=1,2,\ldots,6$), and calculate the vector of the relative weight $W_i$, which $W_1$, $W_2$, $W_3$ shown in Table 3 to Table 5, and $W_4=(0.0749, 0.2195, 0.3525, 0.2192, 0.1336)$, $W_5=(0.1603, 0.0953, 0.2776, 0.4668)$, $W_6=(0.1148, 0.3363, 0.1781, 0.0943, 0.2764)$.

All of the judgment matrixes are conformed to consistency validation ($CR_1=0.025$, $CR_2=0.026$, $CR_3=0.057$, $CR_4=0.013$, $CR_5=0.012$, $CR_6=0.041$).

**Determine Gray Type of the Evaluation**

According to the reality of the evaluation of the information service capability in colleges and universities and advice from experts, we determine the four grey types of the evaluation [7], and denote by $V=$(very strong, strong, general, weak), and the corresponding level is $V=$(9, 7, 5, 3). Then we define four definite weighted functions $f_e(x)$ ($0\leq x\leq 10$, $e=1,2,3,4$):

$$f_1(x)=\begin{cases} \frac{1}{9}x, & x\in[0,9] \\ 1, & x\in[9,10] \end{cases}$$

(1)

$$f_2(x)=\begin{cases} \frac{1}{7}x, & x\in[0,7] \\ 2-\frac{1}{7}x, & x\in[7,10] \end{cases}$$

(2)

$$f_3(x)=\begin{cases} \frac{1}{5}x, & x\in[0,5] \\ 2-\frac{1}{5}x, & x\in[5,10] \end{cases}$$

(3)

$$f_4(x)=\begin{cases} 1, & x\in[0,3] \\ 2-\frac{1}{5}x, & x\in[3,6] \\ 0, & x\in[6,10] \end{cases}$$

(4)

**Construct the Weight Matrix of Gray Evaluation**

Set the evaluation matrix as $D=(d_{ik}^{(t)})_{k\times k}$ of $t$th index $B_t$ ($t=1,2,\ldots,6$) in the first level index, and $d_{ik}^{(t)}$ is the evaluation value of index $C_{ik}$ evaluated by all the experts.

Set $f_e(d_{ik}^{(t)})$ as the weight of $d_{ik}^{(t)}$ belong to the $e$th grey evaluation, then calculate the grey evaluation coefficient $p_{ke}^{(t)}$ as follows, which is of index $C_{ik}$ belong to the $e$th grey evaluation.

$$p_{ke}^{(t)} = \sum_{i=1}^{K} f_e(d_{ik}^{(t)})$$

(5)

Then calculate the total grey evaluation coefficient $p_{k}^{(t)}$ as follows, which is of index $C_{ik}$ belong to every grey evaluation.

$$p_{k}^{(t)} = \sum_{e=1}^{4} p_{ke}^{(t)}$$

(6)

Then we calculate the weight value $r_{ke}^{(t)}$ ($t=1,2,\ldots,6$), as the grey evaluation of indexes $C_{ik}$.
\[ r_{ke}^{(t)} = \frac{p_{ke}^{(t)}}{p_k^{(t)}} \]  

(7)

Then corresponding the first level index \( B_i \), the \( t \)th weight matrix \( R_t (t=1,2,\cdots,6) \) of grey evaluation is as follows.

\[ R_t = \{ r_{ke}^{(t)} \}_{k\times d} \]  

(8)

**Comprehensive Evaluate**

To Calculate the \( t \)th\((t=1,2,\cdots,6) \) index in the first level index, and denote the evaluation vector by \( U_t \),

\[ U_t = W_t \cdot R_t \quad (t=1,2,\cdots,6) \]  

(9)

Then the weight matrix \( R \) of grey evaluation compared with goal \( A \) is as follows.

\[ R = (U_1, U_2, \cdots, U_6)^T \]  

(10)

So, the comprehensive evaluation vector \( U \) is as follows.

\[ U = W_p \cdot R \]  

(11)

As a result, the comprehensive evaluation value \( Z \) is as follows.

\[ Z = U \cdot V^T \]  

(12)

**Analysis of Case**

Using the proposed comprehensive evaluation model, a college organized information service capability evaluation work. The questionnaire survey was organized in advance. According to the index system, the eight experts rated the score of the information service capability with full marks of 10 and differential of 0.5. With the second level index, experts get the evaluation matrix \( D_i \ (i=1,2,\ldots,6) \). For example, \( D_3 \) is as follows.

\[
D_3 = \begin{bmatrix}
7.5 & 8.5 & 8 & 8.5 & 8 & 8.5 & 8 & 7.5 \\
9 & 9 & 9 & 8.5 & 8 & 8.5 & 8 & 9 \\
6 & 6 & 5.5 & 7.5 & 7 & 5 & 5.5 & 7 \\
5.5 & 6 & 6 & 6.5 & 5.5 & 6.5 & 6.5 & 6.5 \\
5.5 & 6.5 & 6.5 & 5.5 & 6 & 5.5 & 6.5 & 6.5 \\
\end{bmatrix}
\]

Taking the "information resources \( B_3 \)" as an example, and using Eq.1 to Eq.4 and Eq.5, we calculate the evaluation matrix as \( R_3 \).

\[
R_3 = \begin{bmatrix}
0.4203 & 0.3979 & 0.1818 & 0.0 \\
0.4652 & 0.3870 & 0.1478 & 0.0 \\
0.2865 & 0.3610 & 0.3178 & 0.0347 \\
0.2865 & 0.3689 & 0.3267 & 0.0176 \\
0.2794 & 0.3592 & 0.3352 & 0.0262 \\
\end{bmatrix}
\]
Using Eq.9, we calculated the comprehensive evaluation vector $U_3$ of first level index as $B_3$.

$$U_3 = W_3 \cdot R_3 = (0.3897, 0.3813, 0.2189, 0.0102)$$

Also, we calculated $U_1, U_2, \cdots, U_6$, and using Eq.10, we got the grey evaluation matrix as $R$.

$$R = \begin{bmatrix}
0.3902 & 0.3997 & 0.2073 & 0.0028 \\
0.2925 & 0.3413 & 0.2924 & 0.0738 \\
0.3897 & 0.3813 & 0.2189 & 0.0102 \\
0.3310 & 0.3691 & 0.2571 & 0.0428 \\
0.3706 & 0.4117 & 0.2177 & 0.0 \\
0.3887 & 0.3897 & 0.2216 & 0.0 
\end{bmatrix}$$

Using Eq.11, we calculated the comprehensive evaluation vector of the information service capability as $U$.

$$U = W_{\overline{B}} \cdot R = (0.3647, 0.3808, 0.2315, 0.0194)$$

Using Eq.12, we calculated the comprehensive evaluation value as $Z$.

$$Z = U \cdot V^T = 7.18$$

Therefore, the evaluation result of the information service capability of this college belongs to the "strong" level. This evaluation conclusion is accepted by this college.

**Conclusion**

The information service capability of colleges and universities is the basic requirement and an important symbol of higher education. With qualitative and quantitative methods to analyze the importance of the various indicators, this paper builds the information service capability evaluation index system and evaluation model for promoting the improvement of the information service capability. To organize the evaluation of the information service capability, that is conducive to improve the information technology application ability of teachers and students, and to improve the quality of cultivation of talents.

**References**


