Evaluation of Professional Training Orientation Based on Grey Theory

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Abstract

The goal setting of professional personnel training is the primary task of professional construction in colleges and universities. Based on the CDIO ability outline system, it constructs a professional training ability index system, and evaluates each ability index through the whitening weight function evaluation method of gray theory. Through empirical research on professional construction, the clustering coefficient of professional training ability indicators is obtained, and the grey categories of each ability index are determined; Through the comprehensive clustering coefficient, it can determine the level and type of professional personnel training, clarify the positioning of professional personnel training, and determine the direction for the follow-up work of professional construction.

Keywords: *CDIO, Grey System, Whitening Weight Function, Professional Training Ability.*

1 INTRODUCTION

With the development of society into a new normal, changing and transformation will gradually become the main themes of this situation. Changing and transformation will involve different kinds of transforming in all aspects of society, such as adjustment of industrial structure and transformation of economic structure. All these changings require a lot of engineering and applied talents who can adapt to these transformations. These evolutions require them not only to master the increasing professional knowledge and professional skills, but also to understand the humanities more than ever, understand many global issues, have cultural diversity and effective communication skills.

In the process of higher education transforming from external extensional development to connotative construction, it is no doubt that the orientation of professional training is an important part of the intentional construction of professional personnel training in colleges and universities. Some description of talent training goals in colleges and universities has changed from a qualitative description of training specifications to a quantitative description of an index system centered on ability training, this change requires that the orientation of professional training be consistent with the needs of the whole society. Therefore, how to reflect the needs of the society for specific majors more accurately has become a problem that must be solved in the reform of higher education. In the process of professional personnel training in colleges and universities, students, schools, and industries (enterprises), as the main stakeholders, form a community of social value in the process of self-value realization based on their own needs. However, due to the information asymmetry between enterprises, schools and students, the students trained by colleges and universities cannot meet the talent demand standards of enterprises and industries, and there is a phenomenon that colleges and universities cannot cultivate talents needed by enterprises and society. Therefore, formulating a professional training ability system for social needs has become an essential issue in the cultivating of professional talents. The professional training capability system refers to the improvement of specific professional training specifications and indicators in the process of professional construction, combining the school's own advantages and characteristics, and consulting to the requirements of the Ministry of Education on professional training catalogs and training specifications, which can show the differences between the same majors in different colleges and universities.

2 CONSTRUCTION OF PROFESSIONAL ABILITY SYSTEM BASED ON CDIO

The CDIO engineering education model is the latest achievement of the international engineering education

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reform in recent years. The meaning of CDIO is: Conceive, Design, Implement and Operate. It takes the product (system) development to the life cycle from product (system) operation as a carrier, allowing students to take the active, experiential and integrated approach to acquiring engineering knowledge, competencies and attitudes [1] [2].

The CDIO training outline divides the ability of engineering talents into four levels: basic engineering knowledge, personal ability, ability of teamworking and engineering system ability, it carries out comprehensive training for students at four levels through an integrated training method. At present, most of the talent training programs of colleges and universities use descriptions such as "talent training specifications" and "talent training requirements" to reflect the professional requirements for talent training. There is no index and quantification in most of the colleges and universities, and the operability is not strong. At the same time, Teaching Reform is not only to reform the curriculum system, but more importantly, to reflect and implement the skills and critical new thinking which are required by the society in the training of professional talents. The CDIO training syllabus is a systematic reflection of the ability of engineering talents. By referring to the CDIO training syllabus, a CDIO-based professional training ability index system can be constructed, as shown in Table 1.

Table 1: CDIO's professional training ability index system

Index code	Index	Standard CDIO outline corresponds to major categories
X_1	1.1 Basic scientific knowledge	Conceive: Engineering basic knowledge
X_2	1.2 Professional basic knowledge	
X_3	1.3 Application knowledge of professional positions	
X_4	2.1 Engineering reasoning and problem-solving skills	Design: Personal ability
X_5	2.2 Experiment and discover knowledge	
X_6	2.3 System thinking	
X_7	2.4 Personal abilities and attitudes	
X_8	2.5 Professional competencies and attitudes	
X_9	3.1 Teamwork	Implement: interpersonal team skills
X_{10}	3.2 Communication	
X_{11}	3.3 Communication in foreign languages	
X_{12}	4.1 External and social environment	Operate: ability of engineering system
X_{13}	4.2 Enterprise and business environment	
X_{14}	4.3 Conception of the system	
X_{15}	4.4 Design	
X_{16}	4.5 Implementation	
X_{17}	4.6 Running	

3 GREY EVALUATION MODEL

Grey system theory is a tool for solving uncertainty problems [3] [4] [5]. As the main content of grey system theory, grey clustering evaluation method is mainly used to solve the problem of classification of various elements and objects in the system, and has been widely used in economics, management, engineering and other fields. For instance, Chen and Ting analyze service quality and customer satisfaction by utilizing the grey system theory [3]. Huang applies the grey system theory for examination of the effects of telecare on the life quality of older individuals [4]. Pai and colleagues tap on the grey system theory to build a model for the evaluation of transportation effects on air quality trends [5]. However, few studies have applied the theory to the field of college student education.

The whitening weight function is a quantitative description of the degree to which each data point belongs to a certain gray hazy set according to known information [6] [7] [8], and it reflects the subjective judgment of the degree of "preference" for different values within the value range of the hazy set. The determination of whitening weight function is the key link of grey clustering theory from qualitative analysis to quantitative modeling. In this paper, the gray clustering analysis of the index value is carried out by constructing a mixed triangular whitening weight function (as shown in Figure 1), including function types such as the lower limit measure whitening weight, the upper limit measure whitening weight and the center point whitening weight. The application scenarios of the evaluation method of the triangular whitening weight function are:

Assume the number of evaluation objects is n, the number of evaluation metrics is m, and there are s grey classes. The sample observation value of evaluation object i about evaluation index j is x_{ij}, $i=1,2,\cdots,\mathrm{n}$; $j=1,2,\cdots,m.$ the corresponding evaluation object i is evaluated according to the value of x_{ij}. The specific process is as follows:

(1) The hybrid triangular whitening weight function [7] [8] is constructed, and the specific steps are as follows:

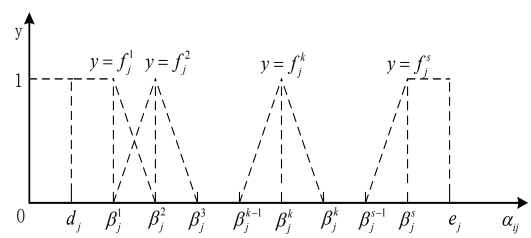

Figure 1: Schematic diagram of the mixed triangle whitening weight function

Step1: Let the value range of the evaluation index j be $\left[d_j,e_j\right]$ According to the grey class number s of the evaluation result, determine the turning point of grey class 1 as β_j^1, the turning point of grey class s as β_j^s and the center point $\beta_j^2,\beta_j^3,...,\beta_j^{s-1}$ of grey class $k\left(k\in\{2,3,...,s-1\}\right)$;

Step2: Construct the lower limit measure whitening weight function $f_j^1(-,-,\beta_j^1,\beta_j^2)$ of gray class 1 and the upper limit measure whitening weight function $f_j^s(\beta_j^{s-1},\beta_j^s,-,-)$ of gray class s;

Supposed x_{ij} as the comprehensive evaluation value of the evaluation index j of the evaluation object i, When $x_{ij}\in\left[d_j,\beta_j^2\right]$ or $x_{ij}\in\left[\beta_j^{s-1},e_j\right]$, the values $f_j^1\left(x_{ij}\right)$ or $f_j^s\left(x_{ij}\right)$ for grey class 1 and grey class s can be calculated from the formula.

$$f_j^1(x_{ij})=\begin{cases}0, & x_{ij}\notin[\mathrm{d}_j,\beta_j^2]\\ 1, & x_{ij}\in[\mathrm{d}_j,\beta_j^1]\\ \dfrac{\beta_j^2-x_{ij}}{\beta_j^2-\beta_j^1}, & x_{ij}\in[\beta_j^1,\beta_j^2]\end{cases} \quad (1)$$

or

$$f_j^s(x_{ij})=\begin{cases}0, & x_{ij}\notin[\beta_j^{s-1},\mathrm{e}_j]\\ \dfrac{x_{ij}-\beta_j^{s-1}}{\beta_j^s-\beta_j^{s-1}}, & x_{ij}\in[\beta_j^{s-1},\beta_j^s]\\ 1, & x_{ij}\in[\beta_j^s,\mathrm{e}_j]\end{cases} \quad (2)$$

Step 3: Construct the center point whitening weight function of gray class $k\left(k\in\{2,3,...,s-1\}\right)$. $(\beta_{k-1},0)$ is the center point of $k-1$ gray classes, $(\beta_{k+1},0)$ is the center point of the k+1 gray class, connect point $(\beta_k,1)$ with points $(\beta_{k-1},0)$ and $(\beta_{k+1},0)$ respectively, construct the triangular whitening weight function $f_j^k(\bullet)$, $j=1,2,\cdots,m$; $k=1,2,\cdots,s$ of the index j on the gray class k;

For a comprehensive evaluation value x_{ij} of the index j, the membership degree $f_j^k(x_{ij})$ of the gray class $k(k=1,2,\cdots,s)$ can be calculated by the formula.

$$f_j^k(x_{ij})=\begin{cases}0, & x_{ij}\notin[\beta_{k-1},\beta_{k+1}]\\ \dfrac{x_{ij}-\beta_{k-1}}{\beta_k-\beta_{k-1}}, & x_{ij}\in(\beta_{k-1},\beta_k]\\ \dfrac{\beta_{k+1}-x_{ij}}{\beta_{k+1}-\beta_k}, & x_{ij}\in(\beta_k,\beta_{k+1})\end{cases} \quad (3)$$

(2) According to formula (1), (2) or (3), calculate the membership degree $f_j^k(x_{ij})$ of gray class $k(k=1,2,\cdots,s)$;

(3) Calculate the gray clustering coefficient vector σ_i^k of the evaluation object belonging to the gray class $k(k=1,2,\cdots,s)$ level according to formula (4), where $f_j^k(x_{ij})$ is the whitening weight function of the subclass k of index j, and ρ_j is the weight of the index j. :

$$\sigma_i^k = \sum_{j=1}^{m} f_j^k(x_{ij}) \bullet \rho_j \quad (4)$$

(4) It is determined that the evaluation object i belongs to the gray class k^*, $\max\{\sigma_i^k\} = \sigma_i^{k^*}$; when there are multiple evaluation objects that belong to the k^* gray class, the order of each evaluation object belonging to the k^* gray class can be further determined according to the size of the comprehensive clustering coefficient.

4 CASE ANALYSIS

The accurate positioning of the training objectives and training specifications of professional talents is the primary task of professional construction. The application of the evaluation model of the triangular whitening weight function is expounded by combining the examples determined by our school's information management and information system professional personnel training ability system.

(1) Design of professional training ability index system

Based on Table 1, the specific indicators are refined according to the specific requirements of the major (the content of indicators is explained), such as the refinement of indicator x_2 to master the basic theory and knowledge of modern information technology, enterprise management, SAP application and development, etc. Thus, a CDIO-based professional training ability index system is formed, and it also helped make a social questionnaire.

(2) Determine stakeholder weights and evaluation index weights

Through the expert survey on the stakeholder weights, the weights of each indicator are obtained as shown in Figure 2:

Stakeholder	Experts	Related Enterprises	Graduates	Working Students	Professional Teachers	Current Students
Weights (γ_m)	0.2	0.2	0.2	0.15	0.15	0.1

Figure 2: Stakeholder weights

In order to fully consider the data during the survey, and not to be biased in the evaluation, the method of equal weighting is adopted for each indicator, and the weight of each indicator is 0.0588, as shown in Figure 3.

(3) Divide and evaluate gray categories

Bloom's taxonomy divides the complexity of human thinking into six levels: memory, understanding, application, analysis, synthesis and evaluation. These six levels are arranged in the order from the simplest to the most complex. There is no obvious boundary for the division of different levels, for the difficulty class is not so strict. Everyone can easily develop from one level to another in the process of learning [9] [10] [11]. Bloom's taxonomy is helpful to understand and describe the level of professional talent ability training indicators. By combining the professional talent training specifications with Bloom classification, the six levels can be further divided into three evaluation gray categories. The mapping relationship between professional talent training positioning and bloom classification is constructed (as shown in Figure 3). Thus, it can be concluded that the evaluation gray categories of professional talent training ability system are deep training (gray 1), key training (Gray 2), shallow training (gray 3), etc

Shallow Cultivation		Key Cultivation		Deep Cultivation	
Memory	Comprehension	Application	Analysis	Overall	Evaluation

Figure 3: Cultivation positioning and Bloom taxonomy mapping

(4) Determination of the value range of the evaluation index

Through the expert evaluation method (Delphi method), the value boundary and extension value $d, \beta_1, \beta_2, \beta_3, e_j$ of each evaluation index are determined to be 2, 3, 3.5, 4.5 and 5, as shown in Figure 3.

(5) Determination of the actual value of the evaluation index

The survey data was obtained by conducting surveys on 6 types of stakeholders. According to the survey results, the average value $\bar{x}_{im}$ of the x_i index of the stakeholder in m is calculated, and the actual value $x_i = \sum_{m=1}^{6} \bar{x}_{im} \bullet \gamma_m (m = 1, 2, \cdots 6)$ of the x_i index is determined according to the determined weight γ_m of each type of stakeholder, as shown in Figure 3.

(6) Construction of hybrid triangular whitening weight function

According to the evaluation model of the mixed triangular whitening weight function, the $f_j^1(x)$, $f_j^2(x)$, and $f_j^3(x)$ functions are respectively constructed.

(7) Calculation of the whitening weight function of each evaluation index

According to the actual value of each indicator, the clustering coefficient of each indicator can be calculated by using the constructed triangular whitening weight function of each gray class, as shown in Figure 4.

Index Code	Weights	Actual Value	Whitening weight clustering coefficient		
			Deep Training	Key Training	Shallow Training
x_1	0.0588	3.8389	0.3389	0.6611	0.0000
x_2	0.0588	3.6457	0.1457	0.8543	0.0000
x_3	0.0588	4.0820	0.5820	0.4180	0.0000
x_4	0.0588	3.5371	0.0371	0.9629	0.0000
x_5	0.0588	3.3197	0.0000	0.6394	0.3606
x_6	0.0588	3.5674	0.0674	0.9326	0.0000
x_7	0.0588	3.9091	0.4091	0.5909	0.0000
x_8	0.0588	3.8357	0.3357	0.6643	0.0000
x_9	0.0588	3.6009	0.1009	0.8991	0.0000
x_{10}	0.0588	3.7786	0.2786	0.7214	0.0000
x_{11}	0.0588	3.5480	0.0480	0.9520	0.0000
x_{12}	0.0588	3.1400	0.0000	0.2800	0.7200
x_{13}	0.0588	3.3114	0.0000	0.6229	0.3771
x_{14}	0.0588	3.4663	0.0000	0.9326	0.0674
x_{15}	0.0588	3.1923	0.0000	0.3846	0.6154
x_{16}	0.0588	3.4220	0.0000	0.8440	0.1560
x_{17}	0.0592	3.4977	0.0000	0.9954	0.0046

Figure 4: Clustering Information of Evaluation Index

(8) Comprehensive clustering calculation of evaluation objects

According to the comprehensive clustering calculation formula and the weight data of each indicator, the comprehensive clustering coefficient of each grey category is calculated as follows: $\sigma^1 = 0.1353, \sigma^2 = 0.7269, \sigma^3 = 0.1378$.

Through the calculation of the whitening weight clustering coefficient of each indicator, it is possible to clarify the expectations of each stakeholder for the specific indicators of the professional training ability system, such as $x_1, x_2, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}, x_{11}, x_{13}, x_{14}, x_{16}, x_{17}$ are the key training gray classes; x_3 is the deep training gray class; x_{12}, x_{15} are the shallow training gray classes. The calculation results truly reflect the society's demand for this major. Through the comprehensive clustering calculation of the evaluation objects, it can be concluded that the positioning of the professional talent training target σ_2 is the key training gray category, and the corresponding Bloom classification levels are application and analysis, which is consistent with the orientation of the training target of applied talents in this major. It is also consistent with the society's demand for applied talents, which is more consistent with the trend of our country's education reform. After determining the gray categories of the professional training ability system indicators according to the evaluation model, expert evaluation and discussion are carried out, and the gray categories of each indicator are finally determined. Then, with the professional training ability system as the core, carry out the theoretical course system, design the practical course system and quality project of the professional talent training plan, implement the training requirements of indicators into specific courses and specific projects, to realize the integrated design of professional training ability system, theoretical curriculum system, practical teaching system, and quality education projects.

5 CONCLUSIONS

The professional construction system engineering involves the determination of professional personnel training objectives, the accurate positioning of personnel training specifications, the deepening of the theoretical curriculum system, the strengthening of the practical teaching system, the establishment of the industry-university-research personnel training model, the construction of teaching resources, the reform of teaching methods and so on. The construction and evaluation of the professional training ability indicator system (that is, the accurate positioning of talent training specifications) is an important part of the professional construction system engineering. It has directional and guiding significance, and lays a solid foundation for the follow-up work of professional construction. This paper evaluates the ability indicators through the cluster evaluation model and determines the professional training ability system, which has certain practical significance and is conducive to the cultivation of professional talents in colleges to meet the needs of the society.

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