Evaluation of Core Quality of Vocational and Technical Education under CDIO Engineering Education Concept Based on AHP Comprehensive Evaluation

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Abstract—This paper analyzes the current teaching situation of vocational education, puts forward the necessity of strengthening the cultivation of students' professional core quality, and discusses the consistency between CDIO education concept and the cultivation of vocational education core quality. In order to reflect the comprehensiveness and complexity of core literacy and highlight the diversity of ability structure, this paper comprehensively uses Delphi expert survey method and analytic hierarchy process to study the core literacy evaluation, so as to increase the objectivity and scientific of the evaluation results. According to the established core literacy evaluation index system, the weight coefficients of indicators at all levels are calculated using AHP method. On this basis, the weighted summation evaluation method is used to comprehensively evaluate the core literacy, providing useful reference for students to improve their core literacy.

Keywords- CDIO education concept； core literacy; evaluation; Delphi expert survey method; AHP; index system; weight

1 INTRODUCTION

Vocational and technical education is the main position for cultivating high-tech applied talents in the front line of production, construction, management and service. Its main feature is practical teaching, that is, every link of teaching must be combined with production practice. The teaching content of each course must be driven by completing a practical task, action oriented and designed for the purpose of application, so that the whole teaching process can be combined with work and learning, carry out in the integration of learning and doing, and highlight the cultivation of students' practical ability [1]. For a long time, vocational education tends to focus on "tools" rather than "Tao", pay attention to professionalism and ignore human nature, pay attention to employment rate and ignore the cultivation of professional development ability. With the wave of the fourth industrial revolution, the professional environment is quietly changing. Intelligent and sophisticated machines will gradually replace the traditional operation skill work. The personalized operation based on mass customization and the skill

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operation based on art and skill inheritance are popular. Enterprises tend to workers with technical skills, professionalism, innovation ability and sustainable development ability.

2 CONNOTATION OF CORE QUALITY OF VOCATIONAL AND TECHNICAL EDUCATION

As a type of higher education system, vocational and technical education has both the educational commonness of higher education and the particularity of Vocational and technical education. This dual attribute determines that the core quality of students must include the professional quality required by a specific occupation and the ability to adapt to occupation, that is, the transferable quality that can adapt to the development and changes of modern society, mainly including communication, teamwork, problem-solving, rational thinking, initiative Innovation and learning ability. Some scholars also discussed the composition of the core literacy of Vocational and technical education. For example, some scholars divide core literacy into innovation ability, self-competitiveness, relearning ability, etc. Some scholars divide the core literacy into the ability to use tools, social interaction ability, autonomous action ability and so on.

In December 2016, General Secretary Xi delivered an important speech at the national ideological and political conference of colleges and universities. The speech defined the goal, pointed out the direction and provided guidance for adhering to the fundamental task of Building Morality and cultivating talents, cultivating talents with both political integrity and ability and developing talents in an all-round way. "Core literacy" emphasized personal cultivation, social care, family and country feelings, and pays more attention to independent development, cooperative participation and innovative practice [1-5].

Finally, after analysis and statistics, revision, addition and deletion, the six core qualities and 18 connotation points of Vocational and technical education industry are finally clarified， as shown in Table 1

Table 1 Framework of students' core literacy in Vocational and technical education

Core literacy	Key Points of Literacy	Key Connotation
practical exploration	process understanding	Engineering thinking, process perspective
	practice and truth seeking	dare to practice and be good at solving problems
	keen observation	ceal with changes and pay attention to accumulation.
craftsman spirit	refine on	concentrate and pursue the ultimate professional quality
	love and dedication	the professional spirit of awe and love and due diligence.
	innovation focus	Innovative consciousness; the spirit of patience, persistence and persistence.
value penetration	humanistic quality	discover perceived, appreciate

		and evaluate beauty
	physical and mental health	good health, strong will and healthy psychology
	patriotic cultivation	Cultivate patriotism, patriotism and socialist core values.
responsibility bearing	professional ethics	Based on facts and following industry valuation norms, "everything" has evidence to rely on
	quality consciousness	Focus on quality, high quality and efficiency
	meticulous and rigorous	be strict in one 's demands
	engineering ethics	people oriented safe and reliable
communication and cooperation	communication skills	communication and cooperation between all parties; Professional communication.
	get information	inquiry and accumulation of engineering materials.
	tracking capability	follow up audit of the project.
legal integrity	legal consciousness	advocating, observing and obeying various laws
	honesty and trust worthiness	keep your promise, match your words with your deeds, and be what you say
	critical questioning	dialectical analysis and problem solving

3 CORE COMPETENCY ASSESSMENT MODEL BASED ON CDIO ENGINEERING EDUCATION CONCEPT

CDIO Engineering education mode is the latest achievement of international engineering education reform in recent years. It takes the life cycle from product R & D to product operation as the carrier, allowing students to learn engineering in an active, practical and organic way between courses. In recent years, many domestic universities and vocational colleges have learned from the CDIO teaching model and applied it to educational reform, which has achieved remarkable results, especially the students' engineering consciousness, practical ability, teamwork ability, innovation ability and expression ability have been improved [6-7].

In order to reflect the comprehensiveness and complexity of core literacy and highlight the diversity of ability structure, this paper comprehensively uses Delphi expert survey method and analytic hierarchy process to study the core literacy evaluation, so as to increase the objectivity and scientificity of the evaluation results [8-9].

3.1 Determination of index weight

According to the established core literacy evaluation index system, the weight coefficients of indicators at all levels are calculated using AHP method.

3.1.1 Determination of primary index weight

The next level indicators of student core competence evaluation (general objective A) mainly include six aspects: practical exploration (B1), craftsman spirit (B2), value penetration (B3), responsibility bearing (B4), communication and cooperation (B5), legal integrity (B6). Next, according to the importance of the first level indicators, combined with expert opinions, a pairwise judgment matrix is constructed.

3.1.1.1 Tectonic judgement

To compare the influence of the nth factor $S_i (1 \le i \le n)$ on the factor S, the method of comparison in pairs is usually adopted to establish a pair comparison matrix. Let a_{ij} represent the ratio of the influence of factors S_i and S_j on factor S, and the values of a_{ij} are shown in Table 2

Table 2 Quantitative scale value table

Importance of S_i over S_j	**Equally important**	**Slightly important**	**Obviously important**	**Very important**	**Absolutely important**
a_{ij}	1	3	5	7	9

When the relative importance is between the intermediate states of two adjacent judgment results, a_{ij} is taken as 2, 4, 6 and 8 respectively. Order $A = (a_{ij})$, A is called judgment matrix. According to the definition, judgment matrix A has the following properties:

$$a_{ij} > 0$$

$$a_{ij} \cdot a_{ji} = 1$$

$$a_{ii} = 1$$

Matrices satisfying these three properties are called positive reciprocal matrices. See Table 3 for the judgment matrix of primary indicators.

Table 3 Quantitative scale value table

A	B1	B2	B3	B4	B5	B6
B1	1	2	9	5	3	7
B2	1/2	1	7	3	2	5
B3	1/9	1/7	1	1/5	1/9	1/5
B4	1/5	1/3	5	1	1/3	3

B5	1/3	1/2	9	3	1	7
B6	1/7	1/5	5	1/3	1/7	1

3.1.1.2 Normalization of judgment matrix

Normalize each column of the judgment matrix, and the judgment matrix is

$$\begin{bmatrix} 0.4372 & 0.4789 & 0.2500 & 0.3989 & 0.4554 & 0.3017 \\ 0.2186 & 0.2395 & 0.1944 & 0.2394 & 0.3036 & 0.2155 \\ 0.0486 & 0.0342 & 0.0278 & 0.0160 & 0.0169 & 0.0086 \\ 0.0874 & 0.0798 & 0.1389 & 0.0798 & 0.0506 & 0.1293 \\ 0.1457 & 0.1197 & 0.2500 & 0.2394 & 0.1518 & 0.3017 \\ 0.0625 & 0.0479 & 0.1389 & 0.0266 & 0.0217 & 0.0431 \end{bmatrix}$$

Add matrices by rows

$$\overline{w_1} = 0.4372 + 0.4789 + 0.2500 + 0.3989 + 0.4554 + 0.3017 = 2.3221$$
$$\overline{w_2} = 0.2186 + 0.2395 + 0.1944 + 0.2394 + 0.3036 + 0.2155 = 1.4110$$
$$\overline{w_3} = 0.0486 + 0.0342 + 0.0278 + 0.0160 + 0.0169 + 0.0086 = 0.152$$
$$\overline{w_4} = 0.0874 + 0.0798 + 0.1389 + 0.0798 + 0.0506 + 0.1293 = 0.5658$$
$$\overline{w_5} = 0.1457 + 0.1197 + 0.2500 + 0.2394 + 0.1518 + 0.3017 = 1.2083$$
$$\overline{w_6} = 0.0625 + 0.0479 + 0.1389 + 0.0266 + 0.0217 + 0.0431 = 0.3407$$

Normalize vector $\overline{w} = [2.3221, 1.4110, 0.1521, 0.5658, 1.2083, 0.3407]$

$$\sum_{i=1}^{6} \overline{w_i} = 2.3221 + 1.4110 + 0.1521 + 0.5658 + 1.2083 + 0.3407 = 6$$

$$w_1 = \frac{\overline{w_1}}{\sum_{i=1}^{6} \overline{w_i}} = \frac{2.3221}{6} = 0.3870$$

The same can be obtained

$w_2 = 0.2352 \quad w_3 = 0.0254 \quad w_4 = 0.0943 \quad w_5 = 0.2014 \quad w_6 = 0.0568$

The eigenvector

$w = [0.3870, 0.2352, 0.0254, 0.0943, 0.2014, 0.0568]$ obtained is the weight coefficient of each first level evaluation index.

3.1.1.3 Consistency inspection

First, calculate the maximum eigenvalue $\lambda_{\max}$ of the judgment matrix. The process is as follows

$$Aw = \begin{bmatrix} 1 & 2 & 9 & 5 & 3 & 7 \\ 1/2 & 1 & 7 & 3 & 2 & 5 \\ 1/9 & 1/7 & 1 & 1/5 & 1/9 & 1/5 \\ 1/5 & 1/3 & 5 & 1 & 1/3 & 3 \\ 1/3 & 1/2 & 9 & 3 & 1 & 7 \\ 1/7 & 1/5 & 5 & 1/3 & 1/7 & 1 \end{bmatrix} \begin{bmatrix} 0.3870 \\ 0.2352 \\ 0.0254 \\ 0.0943 \\ 0.2014 \\ 0.0568 \end{bmatrix}$$

$$\begin{aligned}(Aw)_1 &= 1\times 0.3870 + 2\times 0.2352 + 9\times 0.0254 + 5\times 0.0943 \\ &\quad + 3\times 0.2014 + 7\times 0.0568 = 2.5593\end{aligned}$$

$$\begin{aligned}(Aw)_2 &= 1/2\times 0.3870 + 1\times 0.2352 + 7\times 0.0254 + 3\times 0.0943 \\ &\quad + 2\times 0.2014 + 5\times 0.0568 = 1.5762\end{aligned}$$

$$\begin{aligned}(Aw)_3 &= 1/9\times 0.3870 + 1/7\times 0.2352 + 1\times 0.0254 + 1/5\times 0.0943 \\ &\quad + 1/9\times 0.2014 + 1/5\times 0.0568 = 0.1546\end{aligned}$$

$$\begin{aligned}(Aw)_4 &= 1/5\times 0.3870 + 1/3\times 0.2352 + 5\times 0.0254 + 1\times 0.0943 \\ &\quad + 1/3\times 0.2014 + 3\times 0.0568 = 0.6146\end{aligned}$$

$$\begin{aligned}(Aw)_5 &= 1/3\times 0.3870 + 1/2\times 0.2352 + 9\times 0.0254 + 3\times 0.0943 \\ &\quad + 1\times 0.2014 + 7\times 0.0568 = 1.3571\end{aligned}$$

$$\begin{aligned}(Aw)_6 &= 1/7\times 0.3870 + 1/5\times 0.2352 + 5\times 0.0254 + 1/3\times 0.0943 \\ &\quad + 1/7\times 0.2014 + 1\times 0.0568 = 0.3464\end{aligned}$$

$$\begin{aligned}\lambda_{\max} &= \frac{1}{n}\sum_{i=1}^{n}\frac{(Aw)_i}{w_i} = \frac{1}{6}\left[\frac{2.5593}{0.3870} + \frac{1.5762}{0.2352} + \frac{0.1546}{0.0254} + \frac{0.6146}{0.0943}\right. \\ &\quad \left. + \frac{1.3571}{0.2014} + \frac{0.3464}{0.0568}\right] = 6.4593\end{aligned}$$

$$CI = \frac{\lambda_{\max} - n}{n-1} = \frac{6.4593 - 6}{6-1} = 0.0919, RI = 1.2600$$

$$CR = \frac{CI}{RI} = \frac{0.0919}{1.2600} = 0.0729 < 0.1$$

Therefore, it can be seen that the consistency test result of the judgment matrix is relatively satisfactory. It can be determined that the weight coefficients of each index of the first level evaluation index practical exploration (B1), craftsman spirit (B2), value penetration (B3), responsibility bearing (B4), communication and cooperation (B5), legal integrity (B6) are 0.3870, 0.2352, 0.0254, 0.0943, 0.2014, and 0.0568 respectively.

If the consistency of the judgment matrix is not satisfied, the value of the judgment matrix needs to be readjusted until the judgment matrix has satisfactory consistency. Similarly, the weights of the secondary and tertiary evaluation indicators can be determined to determine the overall ranking of indicators at all levels.

3.1.2 Overall ranking of core literacy evaluation indicators

The overall ranking of levels is the weight of each sub index of the lowest level relative to the overall target level. In this way, the core quality can be improved by finding the weaknesses of the core quality in a quantitative and intuitive way.

Through the previous calculation, we can get the total ranking of indicators at all levels, as shown in Table 4.

Table 4 Total ranking results of indicators at all levels

core literacy (weight)	Secondary indicators (weight)	total weight w_{ci}
practical exploration (0.3870)	process understanding (0.3242)	0.1255
	practice and truth seeking (0.4157)	0.1609
	keen observation (0.2601)	0.1006
craftsman spirit (0.2352)	refine on (0.4485)	0.1055
	love and dedication (0.2548)	0.0599
	innovation focus (0.2967)	0.0698
value penetration (0.0254)	humanistic quality (0.3406)	0.0087
	physical and mental health (0.1156)	0.0029
	patriotic cultivation (0.5438)	0.0138
responsibility bearing (0.0943)	professional ethics (0.4469)	0.0421
	quality consciousness (0.3247)	0.0306
	meticulous and rigorous (0.1494)	0.0141
	engineering ethics (0.0790)	0.0074
communication and cooperation (0.2014)	communication skills (0.4173)	0.0840
	get information (0.3542)	0.0713
	tracking capability (0.2285)	0.0460
legal integrity (0.0568)	legal consciousness (0.2724)	0.0155
	honesty and trust worthiness (0.3429)	0.0195
	critical questioning (0.3847)	0.0218

Through the above calculation, the weight of indicators at all levels can be obtained, and the evaluation of core literacy can be calculated quantitatively. The calculation method is to multiply the score of each secondary indicator (hundred point system) by the total weight of the corresponding secondary indicators, and then calculate the sum, which is the final score.

If the score of each item of the secondary index is F_i and the weight is w_{ci}, the final score of the core quality is

$$F = \sum_{i=1}^{19} F_i w_{ci}$$

The school can strengthen the cultivation of students' core literacy according to the evaluation results.

4 CONCLUSION

The cultivation of core literacy in Vocational and technical education is a systematic project, which is based on the curriculum reform infiltrating the concept of core literacy. Starting from the two fundamental issues of "what kind of student to cultivate" and "how to cultivate student", CDIO teaching mode aims to cultivate skilled talents with practical innovation. Cultivate students' engineering literacy and teamwork spirit. On the basis of consulting a large number of documents, this paper designs the evaluation index system of students' core literacy, establishes the weight of each index, and gives the evaluation method of core literacy. It is of great significance to improve the educational and teaching skills of teachers in vocational colleges, promote their self-development, achieve their professional growth, and cultivate the core quality of vocational and technical education.

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