



# Evidence-based Optimization of the Topology and Cultivation of Talents in Traditional Chinese Medicine Engineering: An Empirical Study Based on Public Evidence Chains

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**Abstract.** In response to the structural mismatch between the cultivation of talents in traditional Chinese medicine engineering and the demands of the industry and career development, this study adopts a three-dimensional demand analysis, ability topology mapping, and adaptability verification method to construct a dynamic evidence chain model of industry demand, cultivation supply, and career development based on the evidence-based thinking. The research finds that there are high-risk ability gaps in the fields of intelligent manufacturing and medical devices, with a gap index  $> 0.4$ . The curriculum system has insufficient coverage of technical demands, with an average similarity of 0.28. The adaptability of graduates in the field of intelligent medical equipment is only 0.25. To optimize the talent cultivation system in traditional Chinese medicine engineering, universities should establish interdisciplinary laboratories to strengthen the cultivation of high-risk areas, and reconstruct the core curriculum system to form a dynamic evidence-based mechanism of "curriculum monitoring - ability analysis - cultivation optimization", further providing a replicable evidence-based model for higher engineering education.

**Keywords:** Traditional Chinese Medicine Engineering, Capability Topology, Higher Engineering Education

## 1 Introduction

Traditional Chinese Medicine, as a crystallization of the wisdom of the Chinese nation and life science, has contributed its unique value and significance to human health<sup>[1]</sup>. In the "Healthy China 2030" planning outline issued by the Central Committee of the Communist Party of China and the State Council, it demonstrates extremely high strategic thinking. Under the guidance of the policy of "preserving the essence and innovating in a traditional manner", the development of traditional Chinese medicine has also achieved historic research breakthroughs and opportunities<sup>[2]</sup>. However, some traditional Chinese medicine universities' training models for engineering students

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focus on optimizing theoretical strength or are limited to single-discipline practice, lacking systematic and integrated project training processes based on real engineering scenarios, thus causing graduates to lack practical capabilities when solving complex engineering problems<sup>[3]</sup>. At the same time, universities' assessment of talent training effectiveness ignores the basic talent demands from the industrial supply side, and is mostly limited to internal academic performance or short-term employment rates, so there is a particularly scarce dynamic, objective, and multi-dimensional evidence-based evaluation system for students' long-term career development trajectories, industrial satisfaction with employment, and adaptability to technological changes<sup>[4]</sup>. This deep-seated "unmatched supply and demand" phenomenon restricts the effective transformation of traditional Chinese medicine scientific and technological achievements and the rapid improvement of industrial competitiveness, and also makes the career development paths of medical engineering talents ambiguous<sup>[5-6]</sup>.

This research is based on the concept of Evidence-Based Practice (EBP) and aims to propose and establish a public evidence chain model for the capability topology and cultivation optimization of traditional Chinese medicine engineering talents. It constructs a full-chain evidence text database from perspectives such as the demand side of the industry, the supply side of cultivation, and the career development side, accurately identifying the gaps in talent capabilities and professional cultivation deficiencies, and providing a solid and traceable basis for optimizing decisions.

## 2 Research Contents and Methods

### 2.1 Data Source

The data for this study is sourced from four aspects. Firstly, the data from the demand side of the industry uses the data of the electronic information and biomedical engineering categories in the "National Quality Standards for Undergraduate Professional Courses in Ordinary Higher Education Institutions" (hereinafter referred to as the "National Standards") issued by the Ministry of Education, extracting the professional codes, training objectives, and training specifications; Secondly, it collects the schools and course systems of 2 types of majors such as medical information engineering and biomedical engineering from the "Sunshine College Entrance Examination Platform" of the Ministry of Education, and combines the search for 20 core course information such as the type of courses, class hours, teaching objectives description, and prerequisite courses on the national higher education public service platform; Thirdly, it retrieves a total of 1879 patents and documents in the "Traditional Chinese Medicine University + Engineering" field from the China National Knowledge Infrastructure database from 2020 to 2023; Fourthly, it adopts the information of 17 occupational standards in the GBM 2-02 series in the "China Occupational Classification Dictionary (2022 Edition)" (hereinafter referred to as the "Dictionary") and extracts the occupational name, occupational overview, and main job tasks.

## 2.2 Quantitative Indicators

The assessment of the supply and demand of the ability of traditional Chinese medicine engineering talents needs to be measured from three aspects: industrial demand, school cultivation, and career development. This study has constructed a four-dimensional quantitative indicator system for the topological structure and training optimization of traditional Chinese medicine engineering talents based on the idea of mathematical modeling. The restructured quantitative indicator system includes "professional and course matching degree", "technological frontier correlation degree", "career ability gap index", and "ability topological density". The professional and course matching degree measures the degree of alignment between the settings of medical information engineering and biomedical engineering majors in universities and the ability requirements stipulated in the national standards. The technological frontier correlation degree can evaluate the synchronization degree of course content and industrial technological hotspots. The career ability gap index is used to quantify the degree of difference between career ability demands and course supply. The ability topological density can measure the structural efficiency of the professional course system in supporting core career abilities. The calculation method of each quantitative indicator is as follows:

### (1) Professionalism and Curriculum Matching Degree

Firstly, the text of the "National Standard" for training objectives is segmented. The core word set is selected using the term frequency-inverse document frequency (TF-IDF) method. The calculation formula is:

$$TF-IDF(t) = \frac{f_{t,d}}{\max_k f_{k,d}} \times \log \frac{N}{n_t} \quad (1)$$

Secondly, the description of the teaching objectives for the courses is transformed into a quantitative form to reflect the course capabilities, and  $\bar{C}_j = [TF(t_1), TF(t_2), \dots, TF(t_m)]$  collection of professional courses is constructed. Finally, the cosine similarity between the professional course set and the national standard capability set is calculated. The calculation formula is as follows:

$$PCM = \frac{\sum_{i=1}^n (\bar{S}_{std} \cdot \bar{C}_j)}{\|\bar{S}_{std}\| \times \sum_{i=1}^n \|\bar{C}_j\|} \quad (2)$$

### (2) Technological Frontier Relevance

Using Algorithm  $p(topic_k|d) = (\prod_{w \in d} p(w|topic_j) / (\sum_{j=1}^k p(w|topic_j)))$ , a technology theme distribution matrix was extracted from the patent and literature data sets for the period from 2020 to 2025. The text in the course system, such as class hours and teaching objectives descriptions, was subjected to topic projection. The course technology vector is  $\overline{Course}_{topic} = LDA.transform(course)$ . According to the mapping rules, the rele-

vance between courses, patents, and literature is calculated. The calculation formula is

$$TFR = \max(\frac{\overline{Course_{topic} \cdot t_k}}{\|Course_{topic}\| \|t_k\|}), k \in [1, 3].$$

(3) Occupational Capability Gap Index

Based on the GBM 2-02 series of the "Comprehensive Dictionary",  $D_{non} = \begin{bmatrix} d_{11} & \dots & d_{1n} \\ \vdots & \ddots & \vdots \\ d_{m1} & \dots & d_{mn} \end{bmatrix}$

capability demand matrix is constructed. In the formula,  $d_{ij}$  represents the demand intensity of occupation  $i$  for ability  $j$ , which is calculated based on the frequency of text

words. The principle for constructing the overall course matrix is  $S_{pro} = \begin{bmatrix} s_{11} & \dots & s_{1n} \\ \vdots & \ddots & \vdots \\ s_{p1} & \dots & s_{pn} \end{bmatrix}$ . In the

formula,  $s_{kj}$  represents the coverage degree of course  $k$  for ability  $j$ , and the coverage degree is calculated based on the matching of teaching objective keywords. The calculation formula for the occupational ability gap index is

$$GCI_j = 1 - \frac{\sum_{k=1}^p w_k s_{kj}}{\max(\sum_{i=1}^m d_{ij}^*)}$$

In the formula,  $w_k$  represents the weight of the course hours and is given by  $w_k = h_k / H$ , where  $h_k$  is the number of hours for the course and  $H$  is the total number of hours.

(4) Capacity Topology Density

Based on the basic course information retrieved from the national higher education public service platform, a course network is constructed. The set of network course nodes is defined as  $|V| = p$ , and the set of prerequisite relationship edges is defined as  $E$ . The core capacity development path is

$$Path_{core} = \arg \max_{(u,v) \in path} \sum (path \in P)$$

In the formula,  $P$  represents the entire set of paths from the basic courses to the advanced courses. And the formula for calculating the path density is  $Length_{norm} = \frac{|Path_{core}|}{diameter(G)}$ . In the formula,

$diameter(G)$  represents the longest and shortest network diameter. The calculation formula for technical correlation degree is

$$TFR_{ave} = \frac{1}{Path_{core} + Path_{non}} \sum TFR_v$$

;  $TFR_v$  represents the technological frontier correlation degree of course  $v$ . In summary, the calculation formula for the degree of capability topology compactness is  $CTC = Length_{norm} \times TFR_{avg}$ .

### 3 Results and Analysis

#### 3.1 The Characteristic of the Capability Topology Structure on the Industrial Demand Side

This study selected a total of 19 courses related to the major and 16 items of the GBM 2-02 series in the "Comprehensive Dictionary" to construct a text corpus representing the demand side of the industry. According to the calculation method of the occupational capability gap index module, the capability topology results of the industrial demand side are shown in Table 1. According to the occupational code requirement table, among the four types of occupational codes such as Big Data Engineering Technicians (GBM 2-02-38-03) and Equipment Engineering Technicians (GBM 2-02-07-04), 40% of the occupational codes are in high-risk gap, 25% are in moderate gap, 6% are in mild gap, 25% have no gap, and 19% are unmatched.

**Table 1.** Statistical Table of Analysis Results on Industrial Demand-side Capacity

Occupational Code	Ability code	Ability item	TF-ID F	Vocational type	Demand intensity	Course coverage	Gap value	Priority
GBM 2-02-10-05	X-001	Information	0.1709	Information Technology	0.5669	0.3996	0.1673	Moderate
GBM 2-02-10-06	X-002	System	0.2379	Information Technology	0.7888	0.8605	-0.0717	No
GBM 2-02-10-07	X-003	Information	0.1677	Information Technology Intelligent	0.5562	0.6855	-0.1293	No
GBM 2-02-38-01	Z-004	Intelligence	0.2346	Manufacturing	0.7072	0.5789	0.1283	Moderate
GBM 2-02-38-03	X-005	Big Data	0.1624	Information Technology Engineering	0.5387	0.2248	0.3139	High-risk
GBM 2-02-38-04	G-006	Cloud Computing	0.2062	Engineering and Technical	0.5596	0.2247	0.3348	High-risk
GBM 2-02-38-05	Z-007	Intelligent Manufacturing	0.1909	Intelligent Manufacturing	0.5756	0.1464	0.4291	High-risk
GBM 2-02-30-08	X-008	Unit	0.1652	Information Technology	0.5478	0.7929	-0.245	No
GBM 2-02-30-09	X-009	Data	0.2003	Information Technology Engineering	0.6641	0.5808	0.0833	Mild
GBM 2-02-07-01	G-010	Machinery	0.2924	Engineering and Technical	0.7933	0.6664	0.1268	Moderate
GBM 2-02-07-04	G-011	Equipment	0.2581	Engineering and Technical	0.7004	0.1164	0.5839	High-risk
GBM 2-02-07-05	Y-012	Equipment	0.2764	Medical Devices	1	0.8759	0.1240	Moderate
GBM 2-02-07-07	G-013	Test	0.1243	Engineering and Technical	0.6749	0.7659	-0.0910	No

### 3.2 Verification of the Compatibility of Graduates' Capabilities in Terms of Career Development

Selecting the patents and documents related to "Traditional Chinese Medicine University + Engineering" from China National Knowledge Infrastructure (CNKI) from 2020 to 2023, a total of 1878 pieces of information were collected to establish an assessment database for graduates' capabilities. The number and proportion of the three types of matching results are shown in Table 2.

**Table 2.** Statistics on the Quantity and Proportion of Compatibility for Three Types of Graduates

Keyword Matching Degree			Theme matching degree			Overall matching degree		
Value	Quantity	Proportion	Value	Quantity	Proportion	Value	Quantity	Proportion
0	162	10.6%	0	1518	99.5%	0	161	10.6%
0.1	541	35.5%	0.1	8	0.5%	0.05	541	35.5%
0.2	453	29.7%				0.1	451	29.6%
0.3	226	14.8%				0.15	227	14.9%
0.4	102	6.7%				0.2	103	6.7%
0.5	33	2.2%				0.25	34	2.2%
0.6	8	0.5%				0.3	8	0.5%
0.7	1	<0.1%				0.35	1	<0.1%

The table above shows that the graduate ability compatibility based on the LDA topic loading method is mainly concentrated in the range of 0.1 to 0.3. To fully test the correlation between the graduation ability compatibility and the "course-capability" mapping relationship, as well as the "course-occupation" demands, and to evaluate and optimize the superiority or inferiority of the three in the training systems of medical information engineering, biomedical engineering and other majors, this study has established a course training system verification and optimization strategy, as shown in Table 3.

**Table 3.** Combined Table of Optimization Plans for Training of Personnel in Traditional Chinese Medicine Engineering

Optimization field	Suggestion	Gap Index	Effect
IT	Added three or four core courses, increased 30% practical learning hours.	3.662881184	0.4
Engineering	Added two or three core courses, increased 25% practical learning hours.	2.728281213	0.35
Manufacture	Added two or three core courses, increased 30% practical learning hours.	1.282929158	0.3
Medical	Added one or two core courses, increased 10% practical learning hours.	1	0.45

It indicates that the training programs of universities should focus on optimizing the aspects related to medical IT, medical engineering, and pharmaceutical manufacturing, in order to improve the training structure of majors such as medical information engineering and biomedical engineering.

## 4 Conclusion and Recommendations

### 4.1 Reconfiguration of the University Curriculum System

This study clarifies through the public evidence chain model that there is a structural gap between the current curriculum system and industrial demands. Specifically, in high-risk areas such as the field of intelligent manufacturing (gap index 0.4291) and the field of medical devices (technical demand value 0.6), the capacity supply is seriously

insufficient, while the redundancy of traditional courses is as high as 41.2%. The LDA topic weight for the "intelligent pharmaceutical process" capability urgently needed by the industry is 28.7%, and its coverage in the curriculum is only 5.3%, resulting in a compatibility level of graduates in the field of intelligent medical equipment as low as 0.25. To solve this predicament, universities can optimize the three-dimensional dynamic curriculum reconfiguration system based on demands, using the numerical value of ability topology tightness as the classification basis, and construct a "core - expansion" dual-track modular curriculum package. In addition, a three-dimensional curriculum weight dynamic algorithm is established from the three perspectives of technology, application, and development, that is, when the coverage degree of a certain course's ability continuously falls below the average value of industrial demand intensity, the time compression process will be automatically triggered, and it will be replaced with emerging courses such as medical big data analysis to make up for the drawbacks of the weak curriculum system update mechanism in failing to meet actual needs.

#### 4.2 Innovation of Talent Cultivation Mechanism

The low-adaptation group is significantly exposed to the deficiency of interdisciplinary practical skills. Moreover, the traditional training model fails severely in the integration scenario of medicine and engineering. From the aspects of laboratory establishment and evaluation system construction: ① For high-risk gap areas with  $GCI > 0.4$ , the school can focus on the pain points of digitalization in the cultivation of pharmaceutical production and establish a pharmaceutical intelligent manufacturing integration laboratory that deeply connects with the industry. At the same time, it can combine traditional Chinese medicine theory with modern engineering knowledge to establish an innovation laboratory for traditional Chinese medical diagnostic equipment, effectively transforming the pain points of enterprises and society into training projects. ② Build a quantitative evaluation system covering the entire learning cycle of medicine and engineering integration, and construct a process-based quality evaluation system based on the four-dimensional integrated framework of "complex problem decomposition ability - cross-border knowledge transfer ability - team leadership and collaboration ability - innovation achievement value degree". At the same time, establish an electronic portfolio (E-Portfolio) for students to dynamically record project reports, generating an individual ability radar chart to provide precise portraits for students' personalized cultivation.

#### 4.3 Empirical Effect Verification of the Enterprise Perspective

To verify the training effect of students in the field of medicine and engineering integration, a "certification - platform" dual-track empirical system needs to be constructed from the perspective of enterprises in the industrial demand side. The main implementation plans include: ① In-depth cooperation between universities and enterprises, along with the tracking of student profile data. Universities can jointly establish a "talent capability development observation station" with leading pharmaceutical

companies and smart equipment manufacturers, covering aspects such as job competency profiling, demand transmission paths, and continuous tracking mechanisms. A complete database of enterprise technical pain points is established and mapped in real time to the laboratory project library. The idea of mathematical modeling is borrowed to quantify the growth trajectory of graduates. ② Continuous update and iterative optimization of the large model capability data mechanism. Based on the three-dimensional course weight algorithm and quality evaluation feedback scheme constructed in this study, the student ability training system is intelligently calculated and updated. When the coverage of course capabilities continuously falls below the average demand, the system will automatically trigger course iteration and precisely identify the teaching blind spots in the training system of the interdisciplinary courses in medicine and engineering.

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