Study of Evaluation System for Scientific and Technological Innovation Capability in Higher Vocational Colleges based on Systems Science

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ABSTRACT

As an important part of national innovation strategy, higher vocational colleges' scientific and technological innovation capability reflects regional innovation capacity. Applying system science methodology and philosophy, this paper systematically evaluates higher vocational innovation capability. Following principles of orientation, wholeness, practicality, continuity and measurability, it constructs an evaluation index system. The system encompasses input, process and output dimensions with weighting schemes. Systematic determination of index weights enables comprehensive evaluation. Overall, the paper provides a structured systems thinking framework to assess the complex elements influencing higher vocational college innovation capability.

KEYWORDS

Evaluation system; Innovation capability; Higher vocational colleges

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1 Introduction

Higher education is a vital force in China's national innovation system. Colleges and vocational institutions have made major contributions to applied research and technology development guided by scientific foundations and practical experience. Assessing the scientific and technological innovation capabilities of higher vocational colleges provides key insights into regional innovation capacities. Developing a structured evaluation index system will help identify approaches to enhance innovation in vocational institutions and inform supportive policies.

Evaluating innovation capability in higher vocational colleges is vital to understand innovation dynamics and formulate supportive policies. This paper aims to construct a systematic index framework to assess vocational college innovation capacity. The goal is to identify ways to enhance innovation through rigorous evaluation methodology and provide key policy insights.

2 The Characteristics of Evaluation System of Science and Technology Innovation Ability of Higher Vocational Colleges

(1) Systematic integrity

As a complex system, the innovation evaluation framework requires integrated, holistic design rather than optimizing individual components [1]. The interactions between elements can produce emergent capabilities beyond simple summation of isolated parts. Following systems thinking

principles [2], developing the model necessitates synthesizing all facets into an organic whole tailored to vocational education's institutional contexts.

(2) Systematic hierarchy

In systems science, understanding systems requires integrating reductionist and holistic perspectives across nested hierarchies. The innovation evaluation model constitutes a complex multilayered system [6][8]. Optimizing it holistically while assessing subsystem specifics will be vital for comprehensively appraising capabilities within China's vocational education contexts.

(3) Systematic structuring

As with any system, the innovation evaluation model's structure of interconnected elements and relationships enables integrated functioning [13]. Optimizing structural configurations to mirror innovation capabilities and systemic contexts will be key to effectively assessing China's vocational education landscape.

(4) Systematic functionality

The innovation evaluation system's functionality arises from internal and external connections enabling value generation [16]. Situating assessments contextually within China's innovation landscape and incorporating stakeholder participation will be key to optimizing vocational colleges' innovation capabilities and outputs.

3 Selection and Composition of Indicators

(1) Structural dimensions

Based on the structural content theory of systems science, this paper divides the construction of the evaluation system structure for scientific and technological innovation capability in higher vocational colleges into three constituent dimensions: *input, process*, and *performance*.

(2) Indicators

Following systems science element selection principles, this paper refers to 16 elements from Ministry of Education statistics encapsulating higher vocational innovation capabilities. By analyzing relevant literature and measuring common and unique element characteristics across institutions, this paper selects proper elements constituting the three-tier evaluation indicator system. The literature review and comparative analysis identify the most salient indicators reflecting innovation capacity tailored to higher vocational contexts. The resulting three-tier system comprises optimal elements for evaluating overall innovation capabilities.

(3) Hierarchy of evaluation indicators

Based on the above discussion, the evaluation indicator system for higher vocational colleges' scientific and technological innovation capability derived in this paper is as follows:

Table 1 Hierarchy of Evaluation Indicators

Target/Goal	Dimensions	Functions	Indicators

Evaluating the Scientific and Technological Innovation Capability in Higher vocational colleges	Input	Workforce Inputs	Number of researchers and engineers
			Number of persons engaged in scientific and technological practical activities
			Number of people applying R&D results
			Number of institutions with scientific and technological activities
		Financial Inputs	R&D funding
			Funding for Technology Transformation
	Process	Science and Technology Projects	Number of projects to apply R&D results
			Number of scientific and technological projects
			Number of horizontal projects
		Science and Technology Exchange	Number of cooperation dispatches
			Number of academic exchanges
	Performance	Knowledge Innovation	Number of papers published
			Number of publications
		Technological Innovation	Patents granted for inventions
			Utility model authorizations
			Software copyright licenses

4 Calculating Evaluation Index System Weights Using AHP Method

Analytic Hierarchy Process (AHP) was developed by Thomas Saaty [22] to solve multi-attribute decision problems. By constructing hierarchies and making simple pairwise comparisons, AHP enables quantitatively analyzing qualitative problems. Due to its practicality, AHP is widely applied in complex evaluation and decision domains like resource allocation, planning, and conflict analysis [23]. This study applies this process to establish an AHP model for evaluating innovation capabilities.

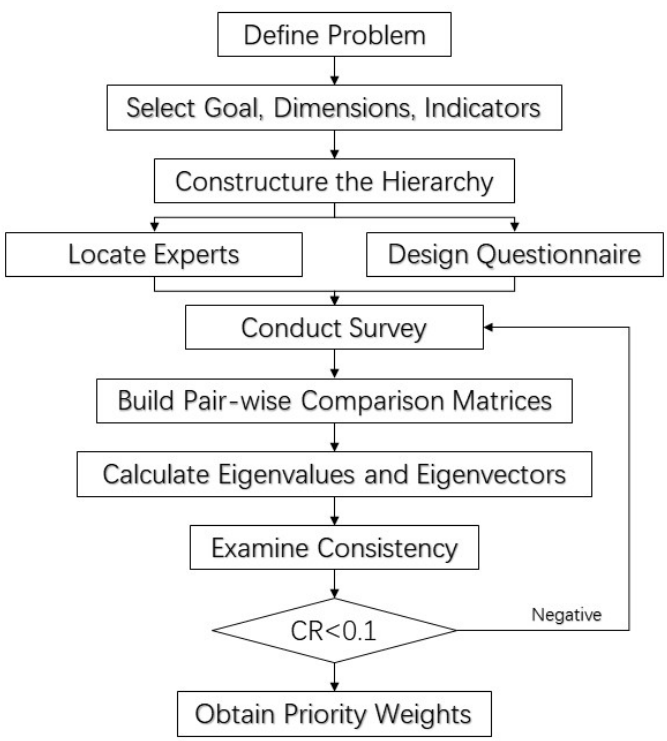

Figure 1 AHP Study Process

Inviting experts to construct a pairwise judgment matrix between the elements by assigning values to the comparison result with a 1-9 ratio scale, perform hierarchical single sorting, apply mathematic approaches based on the judgment matrix, and calculating the eigenvalue to find the corresponding element weights. After the consistency check, the hierarchy is sorted to obtain the weight of each decision plan of the plan layer relative to the total goal. The final outcome with weights is as follow:

Table 2 Evaluation Indicators with Weights

Target/Goal	Dimensions	ω	Functions	ω	Indicators	ω
Evaluating the Scientific and Technological Innovation Capability in Higher vocational colleges	Input	0.47	Workforce Inputs	0.20	Number of researchers and engineers	0.05
					Number of persons engaged in scientific and technological practical activities	0.09
					Number of people applying R&D results	0.03
					Number of institutions with scientific and technological activities	0.03
			Financial Inputs	0.27	R&D funding	0.07
					Funding for Technology Transformation	0.20
	Process	0.15	Science and Technology Projects	0.10	Number of projects to apply R&D results	0.03
					Number of scientific and technological projects	0.03
					Number of horizontal projects	0.04
			Science and Technology Exchange	0.05	Number of cooperation dispatches	0.01
					Number of academic exchanges	0.04
	Performance	0.38	Knowledge Innovation	0.06	Number of papers published	0.05
					Number of publications	0.01
			Technological Innovation	0.32	Patents granted for inventions	0.11
					Utility model authorizations	0.14
					Software copyright licenses	0.07

5 Analysis of the AHP Result

Input Dimension:

The Input Dimension is weighted at 47% overall, with Financial Input weighted higher at 27% compared to Workforce Input at 20%. Academic scholars highlight risks of over-indexing on financial inputs. The preference for technology deployment funding echoes a linear view of innovation moving from R&D to commercialization. An academic perspective would argue for balancing financial resources with structural, process-based dimensions of innovation.

Process Dimension:

The Process Dimension is weighted at just 15% in the AHP model, significantly lower than the Input and Output Dimensions. This marginal emphasis on process-based factors merits deeper academic examination. This resonates with literature on the importance of internal innovation initiatives and active project management for driving innovation outcomes However, the model overlooks informal networking which literature shows is crucial for enabling tacit knowledge flows across organizations. Assessing collaborative network structures and social capital could enrich the exchange analysis.

Performance Dimension:

The Performance Dimension is weighted at 38% in the AHP model, with a strong emphasis on Technological Innovation (32%) over Knowledge Innovation (6%). This prioritization of technical outputs warrants deeper academic scrutiny. The high weight on Technological Innovation echoes a linear view of innovation progressing from invention to commercialization. This overlooks academic findings that research publications contribute significantly to breakthrough innovations over time by

disseminating knowledge Assessing knowledge outcomes along with technological outputs provides a broader perspective on how new knowledge creates holistic innovation value.

6 Summary

The systems methodology informs an adaptable evaluation architecture aligned to goals yet customizable across settings. It balances standardization with flexibility in weighting, grading, and visualization for dynamic contexts. Embracing this paradigm focuses on synergies through aligning elements, driving multidimensional understanding. Thereby, the framework provides an assessment toolkit for upgrading innovation ecosystems. The research contributes tailored, context-sensitive capacity for higher vocational institutions, unlocking innovation potential. In particular, the systems approach enables strategic, comprehensive analysis to construct a tailored architecture. Sequencing analyses informs appropriate indicators, methods, and data integration. The framework accounts for interactions between governance, infrastructure, human capital, knowledge production, investment, and impacts. Mapping reveals balancing standardization with customization. The techniques and perspective capture overlooked connections and behaviors for complete understanding. The modular methodology supports adapting over time through customizable indexing, grading, and visualization. Focusing on optimizing capacities surpasses isolating attributes, promising upgraded ecosystems. The research benefits stakeholders seeking modernized measurement, contributing calibrated capacity. Overall, systems science activates innovation, promising widespread benefits.

About the Author

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