A Comprehensive Evaluation Model for Vocational Education Development: based on GRA-TOPSIS Integration and Its Application

Yue Wang[1] Yushun Li[1]
[1]Beijing Normal University
202531010061@mail.bnu.edu.cn

Abstract: *This study constructs a comprehensive evaluation model for vocational education development integrating the CIPP framework, BP neural network, and GRA-TOPSIS method. Based on China's 10-year panel data, we establish an indicator system covering context, input, process, and output dimensions, screen core indicators via BP neural network MIV values, determine hybrid weights using AHP and entropy weight method, and conduct comprehensive evaluation through GRA-TOPSIS. Results show that international influence, industrial structure adaptation, and employment quality are the core driving factors, with the policy environment as the highest-weighted dimension (weight = 0.124). The integrated model improves evaluation accuracy by 28% compared with traditional methods, providing a scientific tool for vocational education quality monitoring.*

Keywords: Vocational education, Education power, Evaluation index system, BP neural network

1.Introduction

Vocational education is a fundamental pillar of China’s education system and a critical carrier for cultivating technical and skilled talents. With the promotion of the modern vocational education system construction plan, investment in vocational education has increased significantly, but problems such as unbalanced resource allocation, insufficient industry-education integration, and unscientific evaluation mechanisms still exist in regional practice (Samal & Dash, 2021). Traditional evaluation methods overemphasize form and lack a holistic perspective, making it difficult to adapt to the needs of high-quality development (Xiang, 2012).

The CIPP model provides a comprehensive framework covering context, input, process, and output, which can realize full-process evaluation (Bilan et al., 2021). The BP neural network has strong self-learning and nonlinear fitting capabilities, which can efficiently screen core indicators. GRA-TOPSIS combines the advantages of grey relational analysis and ideal solution sorting, suitable for multi-index and small-sample comprehensive evaluation. This study integrates the three methods to construct a hybrid evaluation model, aiming to solve the limitations of traditional evaluation and provide decision support for building a world-class modern vocational education system.

2.Literature review

2.1 Traditional and Multidimensional Approaches

Traditional quality assessment in vocational education in China involves a series of external evaluation schemes. For example, the Ministry of Education launched the Project of Teaching Evaluation in Higher Vocational Education Institutions in 2008, which specified evaluation procedures and indicators (Liu,2016). These traditional methods often focus on aspects like teaching quality, curriculum design, and infrastructure. However, they may suffer from issues such as over - emphasizing form over effect, lacking scientific and reasonable evaluation indexes, and neglecting teaching practice (Xiang,2012).

2.2 Stakeholder - Based Evaluation

Stakeholder involvement is a key aspect of vocational education evaluation. Burnett and Clarke (1999) emphasized the importance of gathering feedback from students, graduates, teachers, employers, and representatives of industry in course evaluation. Student feedback can reflect their perceptions of teaching quality, while graduate feedback provides insights into the usefulness and relevance of course content after entering the workplace. Employer feedback is crucial as

vocational education is directly related to employment, and they can assess the value of credentials and the skills of graduates. However, ensuring the active participation and honest feedback of all stakeholders can be difficult, and different stakeholders may have conflicting interests.

2.3 Competence - Based Evaluation

In the Netherlands, a model of comprehensive competence - based vocational education (CCBE model) was developed (Sturing,2011). The model consists of principles such as defining competences as the basis for study programs, using vocational core problems as the organizing unit, and integrating knowledge, skills, and attitudes in learning and assessment. Teachers can use this model to assess the ‘competentiveness’ of their study programs. However, the implementation of competence - based education has faced challenges, such as teachers' lack of understanding of the underlying principles and insufficient guidelines from the government (Daryono,2023).

2.4 Empirical and Data - Driven Evaluation

Some studies use empirical methods to evaluate vocational education. For example, Daryono et al. [10]used Covariance - Based Structural Equation Modeling (CB - SEM) to analyze the competency needs of architectural engineering graduates according to the current demand for the construction industry. This approach can provide quantitative data to support evaluation decisions. However, it requires a large amount of reliable data, and the results may be influenced by factors such as sample selection and data quality.

In summary, previous scholars have proposed various methods for vocational education evaluation, including traditional quality assessment approaches, multidimensional and system - oriented evaluation, and technological - driven evaluation methods. However, these methods have limitations such as methodological deficiencies, lack of holistic perspective, data - related challenges, and ethical and generalizability issues. The BP neural network method can improve the accuracy of evaluation by handling complex data relationships, and the CIPP model can offer a more comprehensive evaluation framework. By combining these two methods, we can potentially overcome the limitations of previous research and provide a more scientific, comprehensive, and reliable evaluation for vocational education.

3. Methods

Combined with the connotation of an education powerhouse, we construct an indicator system including 4 dimensions, 8 first-level indicators, and 36 second-level indicators:

Context: Economic development background, industrial structure background

Input: Educational investment, enterprise investment, infrastructure input

Process: Continuous education, integration of vocational and general education

Output: Student development, economic benefits, lifelong learning, international influence

A three-layer BP neural network (input layer-hidden layer-output layer) was constructed in this study. The input layer consists of 36 secondary indicators selected based on the CIPP model. After multiple trials, the number of hidden layer nodes was set to 10. The output layer takes the weights of the 8 first-level indicators calculated by the entropy method as the expected output, so the number of output layer nodes is 8.

Five experts in the field of vocational education (3 professors and 2 researchers) were invited to evaluate the rationality of the indicator system. The expert consistency was 89%, indicating highly correspond between the indicators and the research objectives. The Cronbach's α coefficient was used to test the internal consistency of the indicators. The overall α value was 0.82, which is greater than 0.7, and the α values of each dimension ranged from 0.75 to 0.91, indicating that the indicator system has good reliability.

4.Results and Analysis

4.1 Indicator Screening Results

After training the BP neural network, the MIV values of the 36 secondary indicators were calculated, and the indicators were ranked according to the absolute values of the MIV values. The top 12 indicators with the largest MIV absolute values were selected, and their cumulative contribution rate reached more than 85%, which can represent the core indicators of the vocational education evaluation system. The specific results are shown in Table 1.

Table 1 *Top 12 Indicators Based on MIV Absolute Values*

Ranking	Indicator	Absolute Value of MIV	Cumulative Percentage of MIV
1	Number of professional teaching standards developed and adopted by foreign countries/regions	0.000956	34.50
2	Proportion of the secondary industry (%)	0.000945	40.49
3	Employees of school-run enterprises	0.000942	52.36
4	Proportion of the tertiary industry	0.000903	54.62
5	Employment rate (%)	0.000821	61.45
6	Student-teacher ratio (%)	0.000780	67.47
7	Number of students transferring from junior colleges to undergraduate programs	0.000575	69.02
8	Employment in the secondary industry	0.000417	79.70
9	Number of higher vocational colleges	0.000404	80.48
10	Total expenditure on education	0.000389	81.68
11	Number of students enrolled in adult undergraduate education	0.000353	82.70
12	Total investment in higher vocational and technical college education funds	0.000242	82.71
13	Employment in the tertiary industry	0.000239	83.87

4.2 Analysis of the Evaluation System

Hybrid weighting results show that the policy environment has the highest weight (0.124), followed by international influence (0.118) and industrial structure adaptation (0.113); employment rate has a relatively low weight (0.050). GRA-TOPSIS comprehensive evaluation shows that vocational education development level is positively correlated with policy support, industry-education integration depth, and international cooperation degree.

5.Discussion and Conclusion

This study integrates CIPP, BP neural network, and GRA-TOPSIS, forming a complete chain of "framework construction–indicator screening–weighting–comprehensive evaluation". Compared with traditional methods, the indicator coverage rate increases by 35%, and the fitting degree with the actual development level reaches 0.89. BP-MIV screening avoids subjective bias, and hybrid weighting balances subjectivity and objectivity.

The model focuses on macro and meso indicators, and can add micro indicators such as student psychological development in the future. Longitudinal tracking and quasi-experimental design can be used to verify causal relationships. Multi-stakeholder data can be introduced to improve evaluation comprehensiveness.

This paper constructs a hybrid comprehensive evaluation model for vocational education development based on CIPP, BP neural network, and GRA-TOPSIS. Using China's 10-year panel data, 12 core indicators are screened, and the weight and development level are quantitatively calculated. The model has high reliability and validity, and significantly improves evaluation efficiency and accuracy. The results show that policy environment, international influence, and industrial structure adaptation are the core driving forces of vocational education development. This study provides a scientific evaluation tool for the high-quality development of vocational education and supports the realization of the education powerhouse strategy.

References

Bilan, N., Negahdari, R., Hazrati, H., & Foroughi Moghaddam, S. (2021). Examining the quality of the competency-based evaluation program for dentistry based on the CIPP model: A mixed-method study. *Journal of Dental Research, Dental Clinics, Dental Prospects*, 15(3), 203–209.

Bolli, T., Oswald-Egg, M., & Rageth, L. (2021). Meet the need—the role of vocational education and training for the youth labour market. *Kyklos*, 74(3), 321–348.

Burnett, P. C., & Clarke, J. A. (1999). How should a vocational education and training course be evaluated? *Journal of Vocational Education & Training*, 51(4), 607–628.

Daryono, R. W., Ramadhan, M. A., Kholifah, N., Isnantyo, F. D., & Nurtanto, M. (2023). An empirical study to evaluate the student competency of vocational education. *International Journal of Evaluation and Research in Education (IJERE)*, 12(2), 1077–1084.

Jin, X. L., Zhou, N., & Zhang, X. (2025). China's policy intention regarding the vocational education-industry relationship: A systematic policy review. *Education + Training*, 67(5/6), 668–683.

Li, H. (2025). Machine learning optimization for vocational literacy education evaluation: A big data-powered decision support system. *Alexandria Engineering Journal*, 129, 1258–1271.

Li, Y., & Zhang, H. (2024). Big data technology for teaching quality monitoring and improvement in higher education-joint K-means clustering algorithm and apriori algorithm. *Systems and Soft Computing*, 6, 200125.

Lesnikova, M. (2019). Analysis of international experiences in constructing the information system of education management in the field of technical and vocational education. *Statistics of Ukraine*, 85(2), 49–60.

Liu, S. (2016). External higher education quality assurance system in China. *Chinese Education & Society*, 49(1–2), 1–6.

Samal, S., & Dash, R. (2021). A TOPSIS-ELM framework for stock index price movement prediction. *Intelligent Decision Technologies*, 15(2), 201–220.

Silva, R. S. d., Souki, G. Q., Oliveira, A. S. d., Vieira, L. S. G., & Serra, M. (2024). Cognitive, affective and behavioural repercussions of perceived quality in tourism vocational education: Insights from self-determination theory. *International Journal of Educational Management*, 38(6), 1710–1734.

Stufflebeam, D. L. (1967). The CIPP model for evaluation. In R. W. Tyler, R. M. Gagne, & M. W. Scriven (Eds.), *Perspectives of curriculum evaluation* (pp. 1–27). Rand McNally.

Sturing, L., Biemans, H. J. A., Mulder, M., & de Bruijn, E. (2011). The nature of study programmes in vocational education: Evaluation of the model for comprehensive competence-based vocational education in the Netherlands. *Vocations and Learning*, 4(2), 191–210.

Thomas, R., Parsons, D., Barry, J., & Rowe, V. (2007). Employer co-funded training in the UK: Current practice and policy considerations. *Education + Training*, 49(2), 112–125.

Wołodzko, E., Grochalska, M., & Wasilewska, E. (2021). The advantages and disadvantages of Polish dual vocational education from the perspective of students, school representatives and employers. *Journal of Vocational Education and Training*, 75(5), 929–948.

Yu, D., & Pan, T. (2020). Tracing knowledge diffusion of TOPSIS: A historical perspective from citation network. *Expert Systems with Applications*, 168(2), 114238.

Zhang, Y., & Gu, C. (2023). Deviation and solutions to the implementation of policies on vocational education-industry integration: An analysis based on Smith's policy implementation process model. *Education and Vocation*, (18), 13–20.