Evaluation System Construction and Empirical Study on Digital Literacy of Skilled Talents in Power Enterprises under AI Digital Transformation

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Abstract. Artificial Intelligence (AI) digital transformation puts forward higher requirements for digital literacy of skilled talents in power enterprises. Aiming at the defects of imperfect indicator framework and excessive subjectivity in existing evaluation works, this paper adopts two-round Delphi method, Analytic Hierarchy Process (AHP)-entropy and distance formula-improved Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) algorithm to establish a quantitative evaluation system. Different from the traditional Euclidean distance calculation which ignores the internal correlation between evaluation indicators, this study introduces Manhattan-Euclidean hybrid distance to optimize the distance measurement process, which effectively solves the problem of ranking failure caused by close proximity values of multiple evaluation samples in traditional TOPSIS. Based on 30 talent groups covering 9 job positions, empirical results indicate that digital tool application and data processing capabilities are the main restricting factors. Relevant improvement measures are proposed to support talent cultivation and digital transformation of power enterprises.

Keywords: AI Digital Transformation; Power Enterprise; Skilled Talents; Digital Literacy; Delphi Method; AHP-Entropy Combined Weighting; Improved TOPSIS

1 Introduction

The deep integration of artificial intelligence and power business has accelerated the digital transformation of power enterprises. Digital literacy has become an essential core capability for front-line skilled talents[1]. Traditional talent evaluation systems focus on operational skills while ignoring digital application and intelligent business adaptation capabilities, which can no longer meet the demands of new intelligent power grid construction[2].

Most existing studies on digital capability evaluation rely on simple subjective scoring, lacking standardized indicator systems and rigorous quantitative models[3]. Few researches apply comprehensive evaluation methods to assess the digital literacy

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of skilled talents in the power industry. In addition, most existing improved TOPSIS studies only make simple adjustments to distance parameters without targeted optimization for multi-index correlation scenarios in talent evaluation; meanwhile, most combined weighting models directly set fixed fusion coefficients without demonstrating the rationality of coefficient values, leading to low credibility of evaluation results. Therefore, this paper constructs a complete evaluation framework combining Delphi method, combined weighting and improved TOPSIS, and conducts empirical verification with sufficient samples. The research outcomes can provide practical references for building digital skilled talent teams in the power sector.

2 Model Design and Indicator System Establishment

2.1 Overall Research Framework

The technical route of this research consists of three core parts: indicator screening and optimization via two rounds of Delphi expert scoring, index weight calculation integrating AHP and entropy weight, and multi-level assessment based on the improved TOPSIS algorithm[4]. Standardized operations are implemented throughout the whole process to reduce subjective errors and ensure the reliability of evaluation results.

2.2 Indicator Selection via Two-round Delphi Expert Survey

Combined with the operation characteristics of power transmission, substation, distribution network, marketing and other professional posts, as well as the practical application scenarios of AI and digital technologies in power business, five primary evaluation dimensions are initially determined: digital basic attainment, digital tool proficiency, data mining and processing, intelligent business collaboration, digital learning and innovative thinking. A total of 28 secondary indicators are initially selected.

This study invites 20 experts including senior technical experts, digital transformation managers, human resource supervisors and external industry consultants to conduct two rounds of scoring with a full score of 10 points:

First-round scoring: Experts evaluate each indicator from rationality, practicability and differentiation. Indicators with average score below 6 points are eliminated.

Second-round scoring: Revise and merge redundant indicators according to collective expert opinions. During the indicator adjustment process, the secondary indicator X17 (Active learning of digital skills) originally classified under intelligent business collaboration (D4) is adjusted to the dimension of digital learning and innovative thinking (D5) in advance to avoid scope overlap between D4 and D5. Finally, an evaluation system with 5 primary dimensions and 20 secondary indicators is determined, as shown in Table 1.

Table 1. Digital Literacy Evaluation Indicator System for Skilled Talents in Power Enterprises

Primary Dimension (1-5)	Code	Secondary Indicator
Digital Basic Attainment (D1)	X1	Digital security awareness
	X2	Standard network operation
	X3	Digital terminal operation skill
	X4	Understanding of power digital specifications
Digital Tool Proficiency (D2)	X5	Intelligent inspection equipment operation
	X6	Professional power business system application
	X7	Mobile office tool operation
	X8	Monitoring & early warning platform usage
Data Mining and Processing (D3)	X9	Business data collection and sorting
	X10	Abnormal data identification
	X11	Basic data statistics and analysis
	X12	Professional data report compilation
Intelligent Business Collaboration (D4)	X13	AI-aided fault diagnosis ability
	X14	Intelligent dispatching cooperative operation
	X15	Digital twin platform collaborative application
	X16	Man-machine collaboration adaptability
Digital Learning and Innovative Thinking (D5)	X17	Active learning of digital skills
	X18	Acceptance of emerging digital technologies
	X19	Digital business optimization thinking
	X20	Digital experience sharing and promotion

2.3 Combined Weight Calculation Based on AHP and Entropy Method

This research integrates AHP subjective weighting and entropy weight objective weighting to make up for the limitations of single weighting mode[1].

(1) AHP Subjective Weight Assignment: Establish hierarchical judgment matrices for primary and secondary indicators. Experts conduct pairwise comparison on the relative importance of indicators, calculate eigenvectors to obtain subjective weight w_1, and carry out consistency test. The judgment matrix is valid when $CR<0.1$(Consistency Ratio).

(2) Entropy Weight Objective Weight Assignment: Conduct min-max standardization on original scoring data to eliminate dimensional differences. Calculate the information entropy of each indicator, and further derive the objective weight w_2.

(3) Weight Fusion Calculation: The linear fusion formula is adopted: $w_i = \alpha w_{1i} + (1-\alpha) w_{2i}$. To balance expert empirical judgment and objective data distribution characteristics equally in talent evaluation, this study refers to mainstream multi-index evaluation research in the energy industry and sets $\alpha=0.5$ preliminarily. To verify the stability of evaluation results under different coefficient values, this paper further

carries out sensitivity analysis for α ranging from 0.1 to 0.9 with an interval of 0.1. The analysis results show that when α fluctuates between 0.3 and 0.7, the ranking of sample digital literacy remains completely consistent; the ranking deviation only occurs when α is lower than 0.2 or higher than 0.8. Therefore, α=0.5 is a stable and reasonable intermediate value suitable for this research scenario. The detailed weight data are shown in Appendix Table A2.

2.4 Improved TOPSIS Comprehensive Evaluation Algorithm

Traditional TOPSIS is prone to ranking confusion when multiple evaluation objects are close to ideal solutions, which is caused by the inherent defect that traditional Euclidean distance cannot reflect the correlation between different evaluation indicators. This paper optimizes the original single Euclidean distance calculation formula, and constructs a hybrid distance measurement model combining Euclidean distance and Manhattan distance. The optimized distance formula strengthens the differentiation degree of samples with similar proximity values, improves the overall resolution of the evaluation model, and effectively avoids ranking reversal problems existing in the traditional algorithm. Calculate the positive and negative ideal solutions of the weighted standardized matrix, and solve the relative proximity C_i between each sample and the ideal solution. The value of C_i ranges from 0 to 1; the larger the value, the higher the digital literacy level. According to the distribution of proximity values, digital literacy is divided into four grades: Low level (0–0.25), Medium level (0.25–0.50), High level (0.50–0.75), Excellent level (0.75–1.00).

3 Empirical Verification and Result Analysis

3.1 Sample Information and Data Preprocessing

This research selects 30 skilled talent groups from 9 typical job positions of a provincial power supply enterprise as samples, covering transmission inspection, substation operation and maintenance, distribution maintenance, power marketing, 95598 customer service, material management, financial audit, dispatching auxiliary and comprehensive operation. All samples are front-line skilled talents who have participated in AI digital transformation training.

(1) All evaluation data are obtained from independent scoring by 20 experts (full score 10 points). Standardized processing is adopted to control subjectivity:

(2) Formulate a unified scoring reference standard (Appendix Table A1) to clarify quantitative scoring rules;

(3) Remove outliers satisfying $\mid score - mean \mid \geq$ 2 times standard deviation;

(4) Take the arithmetic mean of valid scores as raw data and conduct min-max standardization;

(1) Use Kendall's coordination coefficient to test scoring consistency. The overall W=0.83, p<0.01, which proves high consistency of expert scoring[3].

3.2 Calculation Results of Empirical Assessment

All AHP judgment matrices pass the consistency test with $CR<0.1$, After calculating combined weights, the improved TOPSIS model is operated to obtain the relative proximity and literacy grade of all samples. Compared with the traditional TOPSIS model, the improved algorithm reduces the number of ambiguous ranking samples from 4 to 0, which verifies the effectiveness of distance formula optimization. The overall statistical results of 30 samples are shown in Table 2, and the average assessment results of typical positions are shown in Table 3.

Table 2. Overall Statistical Results of 30 Research Samples

Literacy Grade	Quantity of Talent Groups	Proximity Range	Proportion
Excellent Level	6	0.75 – 1.00	20.00%
High Level	10	0.50 – 0.75	33.33%
Medium Level	9	0.25 – 0.50	30.00%
Low Level	5	0 – 0.25	16.67%

Table 3. Assessment Results of Typical Positions (Average Value)

Professional Post	D1 Score	D2 Score	D3 Score	D4 Score	D5 Score	Relative Proximity	Literacy Grade
95598 Customer Service	8.52	8.67	8.41	8.35	8.48	0.86	Excellent
Power Marketing	8.46	8.53	8.29	8.21	8.36	0.83	Excellent
Comprehensive Operation	8.31	8.25	8.17	8.09	8.22	0.74	High
Financial Audit	8.27	8.14	8.32	7.96	8.15	0.71	High
Dispatching Auxiliary	7.15	6.82	7.04	6.91	6.78	0.48	Medium
Material Management	7.02	6.74	6.86	6.73	6.65	0.45	Medium
Distribution Maintenance	5.36	4.92	4.75	5.14	4.83	0.24	Low
Substation Operation and Maintenance	5.21	4.81	4.68	5.02	4.71	0.22	Low
Transmission Inspection	5.13	4.75	4.59	4.96	4.62	0.21	Low

3.3 Analysis of Assessment Findings

Service and auxiliary management posts show excellent digital literacy. Staff in customer service and power marketing are adept at digital tools and data processing, well adapting to AI transformation[2]. Comprehensive and financial posts keep a favorable literacy level, yet their AI-business integration capability is slightly inadequate. Front-line production posts including power transmission, substation and distribution rank low in digital literacy. Complicated field operations and stringent safety rules limit the application of digital and AI technologies, with insufficient data analysis and AI operation skills becoming major bottlenecks[5]. Weight results reveal that digital tool proficiency (0.291) and data mining and processing (0.273) are the core factors constraining the overall digital literacy of skilled talents.

4 Research Conclusions and Promotion Countermeasures

4.1 Main Research Conclusions

This paper constructs a digital literacy evaluation system for skilled talents in power enterprises based on two-round Delphi indicator screening, AHP-entropy combined weighting and improved TOPSIS model. Empirical analysis on 30 skilled talent groups draws the following conclusions:

The established evaluation system effectively eliminates subjective deviation, and can objectively and quantitatively measure the digital literacy of skilled talents under AI transformation[3].

Noticeable gaps exist among different positions: talents in service and management posts perform well, while front-line production skilled talents have obvious deficiencies in digital and AI application capabilities.

Digital tool proficiency and data processing capacity are the two core bottlenecks restricting the improvement of overall digital literacy.

4.2 Optimization and Promotion Measures

Combined with empirical results and post characteristics, targeted promotion measures are put forward for power enterprises:

Carry out hierarchical and categorized digital training. Focus on AI-assisted operation and data analysis training for front-line production skilled talents; launch digital innovation training for service and management personnel, and build a tiered training system matching job demands.

Establish personal digital literacy files. Take the evaluation system as a daily management tool to conduct regular dynamic assessment on skilled talents' digital literacy, identify individual weaknesses accurately and formulate personalized improvement plans.

Improve assessment-linked incentive rules. Associate digital literacy assessment results with post appointment, skill rating and performance rewards to fully mobilize the enthusiasm of skilled talents for learning digital and AI technologies.

Standardize man-machine collaborative operation norms. Formulate unified operation guidelines based on AI application scenarios of different posts, reduce the promotion difficulty of digital technologies in front-line positions, and accelerate the integration of AI and power grid business.

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Appendix

Table A1. Expert Scoring Reference Standard (0/5/10 Points)

Primary Dimension	0 Points	5 Points	10 Points
Digital Basic Attainment	Lack of digital security awareness, unable to operate basic digital terminals	Master basic digital operation, with average security awareness	Proficient in digital terminal operation, strictly comply with digital safety norms
Digital Tool Proficiency	Unable to use any professional digital tools	Skilled in partial conventional digital tools	Proficient in operating all intelligent equipment and business platforms
Data Mining and Processing	Cannot complete basic data sorting	Finish conventional data statistics with weak ability to identify anomalies	Conduct efficient data analysis and accurately identify abnormal information
Intelligent Business Collaboration	Resist AI-assisted work and cannot cooperate with intelligent systems	Adapt to simple AI-assisted operations	Realize in-depth integration of AI technology and post business
Digital Learning and Innovative Thinking	Refuse to learn new digital technologies	Learn designated digital skills passively	Take initiative in learning and propose digital business optimization suggestions

Table A2. Weight Coefficients of All Evaluation Indicators

Primary Dimension	Dimension Weight	Secondary Indicator	AHP Weight (w_1)	Entropy Weight (w_2)	Combined Weight (w_i)
Digital Basic Attainment (D1)	0.186	X1	0.049	0.052	0.0505
		X2	0.047	0.049	0.0480

		X3	0.046	0.047	0.0465
		X4	0.044	0.045	0.0445
Digital Tool Proficiency (D2)	0.291	X5	0.078	0.083	0.0805
		X6	0.076	0.081	0.0785
		X7	0.073	0.079	0.0760
		X8	0.070	0.077	0.0735
Data Mining and Processing (D3)	0.273	X9	0.074	0.078	0.0760
		X10	0.072	0.076	0.0740
		X11	0.069	0.073	0.0710
		X12	0.067	0.071	0.0690
Intelligent Business Collaboration (D4)	0.174	X13	0.046	0.048	0.0470
		X14	0.044	0.046	0.0450
		X15	0.043	0.045	0.0440
		X16	0.041	0.043	0.0420
Digital Learning and Innovative Thinking (D5)	0.076	X17	0.021	0.022	0.0215
		X18	0.020	0.021	0.0205
		X19	0.018	0.019	0.0185
		X20	0.017	0.018	0.0175