

ESSENTIAL NETWORK TECHNOLOGY COMPETENCIES OF VOCATIONAL STUDENTS IN PUTIAN, CHINA UNDER THE SMART INDUSTRY CONTEXT: A COMPETENCY GAP ANALYSIS

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Abstract

Against the backdrop of China's "Made in China 2025" national strategy and the accelerating intelligent transformation of manufacturing industries, vocational education faces a critical challenge of aligning talent training with rapidly evolving industry demands. In Putian, China's renowned "Shoe Capital", the rapid development of intelligent footwear, electronics and equipment manufacturing industries has created an urgent need for skilled network technology professionals, yet a significant competency gap persists between vocational graduates and enterprise requirements. This study aims to 1) construct a three-dimensional competency framework for network technology students integrating national teaching standards and Putian's local industrial context 2) analyze the competency gaps between students' current abilities and both national teaching standards and enterprise demands 3) propose targeted curriculum optimization strategies to enhance competency-job alignment. A cross-sectional quantitative research design was employed. Data were collected from 400 valid respondents including vocational students and graduates through structured questionnaires. Descriptive statistics, one-sample t-tests, independent samples t-tests, and Pearson correlation analysis were used to test four research hypotheses. The results indicate that students' technical skills ($M=3.09$) and professional qualities ($M=3.35$) slightly exceed the national teaching standard (3 points), while advanced industrial scenario skills ($M=3.01$) do not reach the required benchmark. Furthermore, participation in school-enterprise cooperative training significantly improves students' advanced industrial scenario skills ($p<0.001$). The acquisition of "1+X" vocational certificates significantly increases graduates' job-major matching degree ($p<0.001$). Curriculum-industry alignment shows a strong negative correlation with job adaptation period ($r=-0.786$, $p<0.001$). The findings provide empirical evidence for regional vocational education curriculum reform and deeper industry-education collaboration under the global smart industry transformation.

Keywords: Smart Industry, Network Technology, Vocational Education, Competency Framework, School-Enterprise Collaboratin.

Introduction

Made in China 2025 (MIC 2025), China's national strategy to build a global manufacturing powerhouse, focuses on integrating new-generation information technology with manufacturing [1]. As the foundation of intelligent industries, network technology is critical for industrial digitalization and upgrading. However, compared with Germany's mature "dual system" vocational education, China's vocational colleges face prominent talent training mismatches: students' practical skills fail to meet the Teaching Standards for Computer Network Technology Major in Higher Vocational Education (hereinafter "Teaching Standards") or enterprise needs, leading to a structural talent supply-demand contradiction [2]. Germany achieves skill-industry alignment via vocational education investment, 70% enterprise-participated curriculum development [3], and standardized certification, while China's vocational education lacks adaptive regional scenario training and synchronous course updates.

Putian, the "Shoe Capital of China", is accelerating the intelligent transformation of its three pillar industries (footwear and apparel, electronic information, high-end equipment) under MIC 2025. Preliminary 2025 research reveals local bottlenecks: insufficient intelligent equipment networking, a major network technology talent gap, and poor professional relevance of vocational graduates. Against the Teaching Standards, Putian vocational schools have three core shortcomings: insufficient curriculum coverage of core content; limited industrial-level training cases; and inadequate school-enterprise collaboration, resulting in students' weak adaptability to real industrial scenarios.

Research Scope

Geographic scope: Putian City, focusing on its three intelligent industrial clusters, with Fujian Meizhou Bay Vocational and Technical School as the core. Target group: 2023-2025 network technology students from 5 Putian public vocational schools, and personnel from 5 local intelligent enterprises, focusing on Meizhou Bay Vocational and Technical College's Information Engineering Department. Competency scope: Technical skills (aligned with the Teaching Standards), advanced industrial scenario skills, and professional qualities. Timeframe: 2023-2025, combined with local industrial internet construction and industry-education consortium operation.

Defintion of Core Concepts

Intelligent industry: A new system centered on AI, industrial internet, IoT, automation and edge computing, applied in footwear and apparel, electronics, intelligent logistics, etc.

Essential Network Technology Competencies: Based on the Teaching Standards, a "knowledge-skills-qualities" system for typical work tasks, divided into technical skills, advanced industrial scenario skills, and professional qualities.

Municipal industry-education consortium: A government-led, college-enterprise collaborative talent training mechanism based on local industry needs and the Teaching Standards [4].

"1+X" certificates: The full designation is "Academic Credential + Multiple Vocational Skill Level Certificates," wherein "1" represents the academic credential and "X" represents the multiple vocational skill level certificates. Aimed at enhancing students' vocational skills and employability, this initiative constitutes a key reform measure and major innovation within China's *Implementation Plan for National Vocational Education Reform*.

Skill mismatch theory: Germany's "dual system" achieves high skill coverage via deep enterprise curriculum involvement, while Chinese vocational schools have skill mismatches due to insufficient school-enterprise training [5].

Dynamic Capability Framework: Intelligent industry requires a three-dimensional competency model ("technical skills - advanced industrial scenario skills - professional qualities"), consistent with Industry 4.0's "interdisciplinary technical + soft skills" requirements.

Relevant Literature

National policies: MIC 2025 and "Opinions on Deepening the Reform of the Modern Vocational Education System" emphasize vocational education-industry alignment. The Teaching Standards define computer network technology training objectives and core skills, providing a policy basis. Regional research shows Putian vocational schools lack industrial-level skills training, with practical cases disconnected from enterprises and the Teaching Standards. International-domestic experience: Germany's "dual system" relies on enterprise curriculum involvement; domestic research shows 72-hour short micro-courses improve vocational students' technical skill mastery [6]. Existing studies confirm that "1+X" certificate alignment with industry needs and the Teaching Standards enhances graduates' employment competitiveness, forming a "literature-standards-framework-path" theoretical connection.

Conceptual Framework

Based on the literature review and research hypotheses, this study develops a conceptual framework explaining the relationships between instructional factors, student competencies, and employment outcomes. Independent variables include school-enterprise cooperative training, "1+X" certificate acquisition, and curriculum-industry alignment. These influence the mediating variable (student competencies: technical skills, advanced industrial scenario skills, professional qualities), which further affects employment outcomes (job-major matching degree, job adaptation period). The conceptual framework of this study is illustrated in Figure 1.

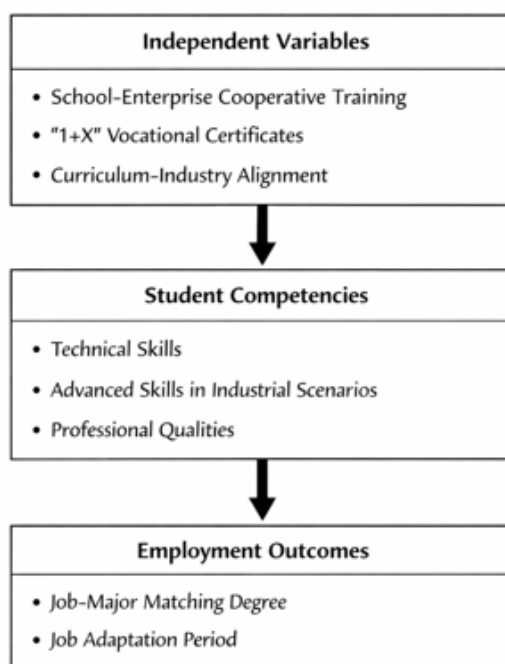


Figure 1 Conceptual Framework

Research objectives

Based on the national teaching standards for computer network technology majors and the talent competency demands of Putian's intelligent manufacturing industry, this study focuses on full-time students and graduates majoring in computer network technology from local secondary vocational schools in Putian. Three logically ordered and empirically supported research objectives are proposed as follows:

Table 1 Prioritized Research Objectives

Priority	Specific Research Objective
1	Construct a three-dimensional competency framework covering technical skills, advanced industrial scenario skills and professional qualities by combining national teaching standards and Putian local industrial demands, forming dual evaluation criteria for competency assessment.
2	Quantitatively analyze students' competency gaps with reference to the 3-point national teaching benchmark and 4-point enterprise employment benchmark across three competency dimensions.
3	Propose three curriculum optimization schemes including modular curriculum design, school-enterprise training and "1+X" certificate integration, and verify their effects on improving post matching and shortening job adaptation cycle.

Table 1 lists three research objectives sorted by research priority in the order of framework construction, gap analysis and curriculum optimization. The objectives are designed based on national vocational teaching specifications and Putian local intelligent manufacturing industry talent requirements.

Research Questions

1. Competency Compliance Status Assessment

Does the current competence of computer network technology students in Putian vocational colleges meet the requirements of teaching standards and the actual needs of enterprises, within the three-dimensional framework of "technical skills (core competencies aligned with teaching standards - advanced skills in industrial scenarios (adapting to Putian industries - professional qualities))"?

2. School-Enterprise Training and Advanced Skill Development

Can participating in the joint construction of training bases by schools and enterprises (which meet the requirements of teaching standards and internship sites) significantly improve students' mastery of advanced skills (such as industrial protocol parsing and edge computing deployment)?

3. "1+X" Certificates and Employment Matching

Does obtaining the "1+X" certificate recommended by the teaching standards (such as network system construction and operation and maintenance, cloud computing platform operation and maintenance and development) improve the match between graduates and their job positions?

4. Curriculum Fit and Job Adaptation Cycle

a negative correlation between the alignment of course content with industry needs and teaching standards and the students' job adaptation period (i.e., the higher the alignment, the shorter the adaptation period)?

Research Hypotheses

Based on preliminary research, the following hypotheses are proposed:

H1: Putian vocational computer network technology students' average three-dimensional competency score meets the Teaching Standards (3 points) but is lower than enterprise core position requirements (4 points).

H2: Students participating in school-enterprise joint training bases (meeting the Teaching Standards' internship requirements) have a higher mastery rate of advanced industrial scenario skills than non-participants.

H3: Graduates with "1+X" certificates have a higher job-major matching degree than those without.

H4: Course alignment with Putian's intelligent industry needs and the Teaching Standards is negatively correlated with graduates' job adaptation period.

Research Methodology

This study adopted a cross-sectional quantitative design with stratified random sampling. Descriptive and inferential statistics were applied to verify the four research hypotheses.

1. Population and Sampling Methods

Population: The population included approximately 1,200 computer network technology-related students from 5 public vocational colleges in Putian (2023–2025), and 10 personnel from 5 local intelligent enterprises (e.g., Three Trees, Huafeng Industry and Trade).

Sample and Sampling Methods: **Student Sample:** Stratified random sampling was adopted, with 200 students selected (100 from Meizhou Bay Vocational College and 25 from each of the other 4 colleges). Meizhou Bay Vocational and Technical College is the largest vocational college in Putian with the largest number of computer network technology students (accounting for approximately 50% of the total number of students in the city), so 100 students were selected from it. **Enterprise Sample:** Purposive sampling was used to select 5 representative enterprises covering footwear, electronics, and equipment manufacturing. **Graduate Sample:** 200 graduates were randomly selected for a career development tracking survey.

2. Research Tools

Student Skills Assessment Scale: Designed based on teaching standards and enterprise needs, covering three dimensions (Technical Skills, Advanced Skills in Industrial Scenarios, Professional Qualities) with a 5-point Likert scale (1 = no knowledge, 5 = highly proficient).

Enterprise Needs Survey Questionnaire: Based on teaching standards, focusing on enterprise industry, job skill requirements, and new employee competency evaluation, using a 5-point Likert scale.

Graduate Career Development Tracking Survey Questionnaire: Covering on-campus status, current employment status, and competency feedback.

3. Tool Inspection

Reliability: A pre-test ($n=50$) was conducted; Cronbach's $\alpha \geq 0.7$ (reliable) for scales/questionnaires, and cross-coder reliability ≥ 0.8 for interview outlines. **Validity:** Three vocational education experts reviewed content validity; factor analysis (eigenvalues > 1) confirmed the construct validity of the skills assessment scale.

4. Data Collection

Table 2 Data Collection Process

Stage	Time Period	Data Collected	Method
T1	Sep–Nov 2025	Student competency assessment and enterprise needs survey	Paper and online questionnaires
T2	Dec 2025–Jan 2026	Graduate career development tracking and follow-up competency evaluation	Online survey and HR data

Table 2 illustrates the two-stage data collection process of this study, including the time periods, types of data collected, and corresponding data collection methods. Data were collected in two stages: the first focused on student competencies and enterprise needs, and the second tracked graduates' career development and job adaptation.

5. Variable Types

Table 3 Variables and Measurement Scales

Variable Type	Variable	Operational Definition	Measurement Scale
Independent Variable	School–Enterprise Cooperative Training	Participation in enterprise training programs during study	Yes / No
Independent Variable	“1+X” Vocational Certificate	Whether the student obtained a national vocational certificate	Yes / No
Independent Variable	Curriculum–Industry Alignment	Degree to which courses match industry needs	Likert scale (1–5)
Dependent Variable	Technical Skills	Ability in network configuration, security, and Linux systems	Likert scale (1–5)
Dependent Variable	Advanced Industrial Skills	Industrial protocol analysis and intelligent manufacturing networking	Likert scale (1–5)
Dependent Variable	Professional Qualities	Teamwork, problem solving, and learning ability	Likert scale (1–5)
Outcome Variable	Job–Major Matching	Alignment between graduate job and major	Ordinal scale
Outcome Variable	Job Adaptation Period	Time required for independent job performance	Months

Table 3 presents the variables and measurement scales used in this study, covering independent variables, dependent variables, and outcome variables with their operational definitions and measurement standards.

6. Statistical Methods

Descriptive statistics: Calculated mean, standard deviation, and percentage to describe data distribution.

Inferential statistics: One-sample t-test (verify H1, comparing competency scores with teaching/enterprise standards); independent samples t-test (verify H2, school-enterprise training effect; H3, “1+X” certificate effect); Pearson correlation analysis (verify H4, relationship between curriculum alignment and job adaptation period).

Research Results

This section presents data quality, descriptive statistics, hypothesis verification results, and their theoretical implications based on the research framework.

1. Sample, Data Quality and Descriptive Statistics

A total of 453 questionnaires were collected, with 400 valid ones (200 current students, 89.7% valid rate; 200 graduates, 87.0% valid rate). Among current students, 96 participated in school-enterprise training and 104 did not; 103 held "1+X" certificates and 97 did not. The sample was well-represented, with graduates mainly employed in Putian's intelligent industries. Missing values ($\leq 3.2\%$) were handled by sequence mean replacement; 2 data entry errors were corrected, and no extreme outliers were found.

2. Reliability and Validity Analysis

Table 4 Reliability Analysis of Competency Scale

Dimension	Cronbach's Alpha	Project-total score correlation range	Range of α coefficients after item deletion	evaluate
Technical Skills	0.893	0.714-0.767	0.863-0.875	excellent
Advanced Industrial Skills	0.895	0.735-0.785	0.858-0.876	excellent
Professional Qualities	0.753	0.560-0.609	0.641-0.686	Acceptable

Table 4 presents the internal consistency reliability results of the three-dimensional competency scale. All Cronbach's α coefficients exceed the acceptable threshold of 0.70, with technical skills and advanced industrial skills dimensions reaching excellent reliability levels ($\alpha > 0.89$). All item-total correlations are above 0.5, and deleting any item would reduce the overall α coefficient, indicating no items need to be removed and the scale has good internal consistency.

Table 5 Results of Exploratory Factor Analysis

Dimension	KMO value	Bartlett's test (χ^2)	df	p - value	Number of extracted factors	Cumulative variance explained (%)	Factor loading coefficient range	Commonality range
Technical skills	0.878	539.549	10	0.000	1	70.148	0.819-0.859	0.670-0.738
Advanced skills in industrial scenarios	0.843	459.225	6	0.000	1	76.040	0.850-0.883	0.723-0.780
Professionalism	0.691	141.053	3	0.000	1	67.054	0.810-0.836	0.656-0.700

Table 5 shows the exploratory factor analysis results for structural validity testing. All KMO values are greater than 0.6, and Bartlett's test of sphericity is significant at the $p < 0.001$ level, confirming the data is suitable for factor analysis. Each dimension extracts exactly one factor, consistent with the theoretical framework. The cumulative variance explained exceeds 67% for all dimensions, and all factor loadings are above 0.81, demonstrating excellent structural validity of the scale.

3. Descriptive Statistical Analysis

Table 6 Descriptive Statistics of Student Competencies

Variable	N	Mean	S.D.
Technical Skills	200	3.089	0.682
Advanced Skills in Industrial Scenarios	200	3.014	0.751
Professional Qualities	200	3.347	0.611
Curriculum-Industry Alignment	200	3.210	0.645
Job-Major Matching Degree	200	2.014	0.938
Job Adaptation Period (months)	200	4.86	1.73

Table 6 reports the descriptive statistics of students' competencies and employment-related indicators, including the number of samples, mean values, and standard deviations. Professional qualities had the highest mean, while advanced industrial skills had the lowest mean and highest variability. Graduates' average job adaptation period was 4.86 months, with curriculum-industry alignment and job-major matching degree at medium levels.

4. Hypothesis Testing and Result Analysis

4.1 H1 Test: Analysis of the Compliance Status of Three-Dimensional Capabilities

Table 7 One-Sample t-Test (H1)

Variable	Mean	Test Value	t	p-value
Technical Skills	3.089	3	2.470	0.014
Advanced Industrial Skills	3.014	3	0.259	0.796
Professional Qualities	3.347	3	8.458	<0.001
Technical Skills	3.089	4	-14.03	<0.001
Advanced Industrial Skills	3.014	4	-18.65	<0.001
Professional Qualities	3.347	4	-11.82	<0.001

Table 7 presents the one-sample t-test results used to verify Hypothesis 1, comparing students' competency levels with the national teaching standard and enterprise requirement. H1 is partially verified: Technical skills ($p < 0.05$) and professional qualities ($p < 0.001$) exceeded the 3-point teaching standard, while advanced industrial skills did not ($p = 0.796$). All dimensions were significantly lower than the 4-point enterprise standard ($p < 0.001$), consistent with situated learning theory (advanced skills require real enterprise practice).

4.2 H2 & H3 Test: Effects of School-Enterprise Training and "1+X" Certificate

Table 8 Independent Samples t-Test (H2 & H3)

Effect of School-Enterprise Training on Industrial Skills

Group	N	Mean	SD
Participated	96	3.326	0.601
Not participated	104	2.726	0.698

Effect of "1+X" Certificate on Job Matching

Group	N	Mean	SD
Certificate holders	103	2.60	0.91
Non-holders	97	1.28	0.87

Table 8 shows the independent samples t-test results for verifying Hypothesis 2 and Hypothesis 3, examining the effects of school-enterprise training and "1+X" certificates. H2 is fully verified: Students in school-enterprise training had significantly higher advanced industrial skills ($M = 3.326$ vs. 2.726 , $t = 6.141$, $p < 0.001$), confirming situated learning theory. H3 is fully verified: Graduates with "1+X" certificates had higher job-major matching ($M = 2.60$ vs. 1.28 , $t = 19.012$, $p < 0.001$), supporting signaling theory.

4.3 H4 Test: Relationship between Course Fit and Job Adaptation Cycle

Table 9 Pearson Correlation Matrix (H4)

Variables	1	2	3
Curriculum–Industry Alignment	1		
Job Adaptation Period	-0.786***	1	
Job–Major Matching	0.462***	-0.531***	1

***p < 0.001

Table 9 displays the Pearson correlation matrix for testing Hypothesis 4, revealing the relationships among curriculum-industry alignment, job adaptation period, and job-major matching degree. H4 is fully verified: Curriculum-industry alignment had a strong negative correlation with job adaptation period ($r=-0.786$, $p<0.001$), robust via Spearman test ($r=-0.810$, $p<0.001$), consistent with skill mismatch theory.

Table 10 Corresponding Empirical Research Findings

Item	Specific Research Finding
Finding 1 (Match Priority 1)	The dual-standard three-dimensional competency framework is applicable to local student evaluation, overcoming the limitations of relying solely on national standards for competency assessment.
Finding 2 (Match Priority 2)	H1 receives partial empirical support. Students' technical skills and professional qualities exceed national benchmarks; however, advanced industrial scenario skills remain below both national and enterprise expectations.
Finding 3 (Match Priority 3)	H2, H3, and H4 receive strong empirical support. School–enterprise training, “1+X” certification integration, and curriculum–industry alignment significantly improve job-major matching and reduce graduates' workplace adaptation period.

***p < 0.001

Table 10 presents empirical findings corresponding one-to-one with the three prioritized research objectives in Table 1. All findings are concluded from questionnaire data and statistical hypothesis testing results.

Conclusion and Discussion

Against the context of MIC 2025 regional intelligent industrial transformation, this study explores the matching relationship between Putian vocational network technology students' competencies, national teaching standards, and regional industry needs. Using 400 valid samples and a three-dimensional competency framework, it provides empirical support for regional vocational education reform.

1. Elaboration of Core Research Findings

The core finding is the "partial compliance paradox": students' basic technical skills and professional qualities meet national teaching standards, but their advanced industrial scenario skills (critical to industrial needs) do not meet either standards or enterprise requirements. This stems from disconnected training models and real industrial scenarios, consistent with situated learning theory [7]. School-enterprise training improves advanced skills; "1+X" certificates enhance job-major matching [8]; curriculum-industry alignment shortens job adaptation periods, aligning with Cappelli's skill mismatch theory [9].

2. Dialogue with Previous Studies

This study supplements Cappelli's (2015) skill mismatch theory [9] with micro-empirical evidence from Chinese regional manufacturing. It identifies a "sufficient basic competencies but insufficient scenario application" imbalance, differing from the traditional view that skill mismatches stem from delayed educational supply. Instead, this mismatch arises primarily from the disconnection between classroom instruction and real industrial environments. This finding supports existing studies showing that rapid technological transformation outpaces vocational education updates, which in turn creates persistent competency gaps between graduates and industries [10-14].

The findings also verify situated learning theory's applicability in manufacturing vocational education. Workplace participation helps students acquire tacit knowledge and practical competencies unobtainable via classroom instruction alone, aligning with prior research [5], [10], [15]. Unlike Mingwei and Yao's (2025) vocational employment competency model [10], this study focuses on network technology and industrial scenario alignment, filling the empirical gap in intelligent manufacturing technical competency research.

This study also enriches Spence's (1973) signaling theory [8] in the technical labor market. Unlike Weiss (1995) [11], who focused on human capital's wage role, it highlights vocational certifications' signaling function for employment outcomes. "1+X" certificates serve as credible signals to reduce employer-graduate information asymmetry. Unlike Bishop and Abraham's (1993) job matching research [12], it quantifies curriculum-industry alignment's impact on job adaptation, extending labor market matching theory. Furthermore, the findings contribute to Industry 4.0 workforce skill literature. Digital technologies and intelligent manufacturing have increased demand for interdisciplinary technical competencies [16], [17]. Existing studies note vocational education's difficulty adapting curricula, causing advanced skill shortages [18]. This study provides empirical evidence for deeper vocational education-industry integration.

Recommendation

1. Vocational Colleges: Build a "Standard + Scenario" dual-driven curriculum aligned with national Teaching Standards, integrate "1+X" certificate skills into core course assessments, and co-build enterprise-level training bases via the industry-education consortium to improve students' advanced industrial scenario skills.

2. Enterprises: Form hybrid teaching teams with colleges to develop scenario-based teaching cases, provide Teaching Standards-compliant on-the-job internships with one-on-one mentorship, and share training resources to ease SMEs' independent investment pressure.

3. Government & Industry Associations: Establish incentive policies for industry-education integration, formulate localized skill standards for Putian's intelligent industries, and build a talent supply-demand big data platform to align vocational education with industrial iteration.

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