Adapting to Technological Tides: A Study on the Evolution and Enhancement of Vocational Education Teachers' Competence in China

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Abstract. This study quantitatively investigates the teaching competence of Chinese vocational education teachers in the information age. Based on self-assessment data from 1,024 in-service teachers who participated in the Digital Teaching Skills Enhancement Training (2021–2023), six competency dimensions are evaluated: Curriculum Development, Curriculum Teaching, Professional Knowledge, Industry Knowledge, Information Literacy, and Research and Development. Descriptive statistics and ANOVA reveal that teacher age and experience significantly influence competence levels, with seasoned teachers demonstrating stronger performance in specific skills. The analysis also highlights regional disparities and professional development needs. The study proposes targeted strategies—including tailored training and inter-regional collaboration—to enhance teaching adaptability and effectiveness. These findings provide an empirical basis for improving teacher quality and supporting technology-driven educational reform.

Keywords: teaching competence, teacher experience, professional growth, educational strategies, vocational education

1 Introduction

In the AI-driven information age, vocational education faces pressing challenges in teacher competency development. Existing research recognizes the need for "dual-professional" teachers who combine academic and industry expertise, yet lacks systematic empirical evidence about their actual competencies. Previous studies have identified general gaps but fail to provide detailed analysis of how specific factors affect teaching quality.

This study makes three distinct contributions to address these limitations. First, it develops and validates a comprehensive six-dimensional framework to assess teaching competencies. Second,

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it provides robust empirical evidence from 1,024 Chinese vocational teachers, revealing how age, experience, and regional factors influence competency development. Third, it proposes targeted strategies based on empirical findings, moving beyond generic recommendations to offer precise interventions.

These contributions advance our understanding of vocational teacher competencies and provide evidence-based solutions for teacher development in the digital era, ultimately supporting the success of educational reform.

2 Literature Review

Scholarly discourse has extensively examined the pedagogical competencies required for vocational education instructors in the digital era. Berglund et al. emphasize critical reflection as essential for praxis-oriented teaching [1], while Brennan et al. highlight integrating industry-specific knowledge into pedagogy as fundamental to professional efficacy [2]. Sevilla further theorizes that corporate immersion enhances instructional proficiency, noting that vocational teachers often transition from industry, with teaching competence being key to their reorientation [3].

Digital competence is widely recognized as critical. Suárez Guerrero et al. find that although vocational instructors can operationalize specific technologies, they struggle to systematically incorporate them into assessment regimes [4]. Tapani and Salonen identify three essential competency areas: teaching and learning, authentic development, and assessment [5]. Al-Momani adds that VET teachers must synchronize implementation competencies (e.g., technology integration) with methodological competencies (e.g., student-centered strategies), advocating digital tools like VR to bridge gaps in interdisciplinary and values education [6]. Nurhadi and Lyau propose a four-dimensional framework—administrative, teaching and learning, quality assurance, and networking—that significantly affects both teaching effectiveness and student outcomes [7].

Domestic research reflects distinct localization characteristics. Zhang Ni et al. outline five ICT teaching competency dimensions: awareness, knowledge, design, implementation, and innovation [8]. Wu Maqun proposes a six-dimensional model covering pedagogical conceptions, curriculum design, technology use, and professional development [9]. Xue Dong et al. identify three evolutionary trajectories in digital teaching competence: resource design, technology integration, and collaborative instruction [10]. Similarly, Xu Hongye [11] and Wang Caixia et al. [12] emphasize context-driven competencies, while Wang Yang and Ke Xiaohua [13] and Xie Yueguang et al. [14] offer structured frameworks for informatization teaching ability spanning preparation, implementation, training, and evaluation.

3 Methods

The purpose of this study is to analyze the current situation and challenges of vocational education teachers' teaching competence in the information age and to explore enhancement strategies. To this end, a quantitative research design was employed, utilizing a self-assessment questionnaire based on the multi-dimensional framework developed by Diao and Hu (2022). This framework comprehensively measures teaching competence across six key dimensions.

3.1 Instrument: Reliability and Validity

The research instrument was a self-assessment questionnaire adapted from the scale developed by Diao and Hu (2022), which measures teaching competence across six dimensions: Curriculum Development Ability (18 items), Curriculum Teaching Ability (19 items), Professional Knowledge (6 items), Industry Knowledge (14 items), Information Literacy (17 items), and Research and Development Ability (10 items). A total of 84 items were measured on a five-point Likert scale.

To ensure the reliability and validity of the instrument in the context of this study, we conducted the following tests on the pooled sample ($N = 1,024$). The reliability analysis yielded a Cronbach's alpha of .964 for the overall scale, indicating excellent internal consistency. The validity of the questionnaire was assessed through factor analysis. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was .959, well above the recommended threshold of .60, and Bartlett's test of sphericity was significant ($\chi^2 = 6050.490$, $df = 153$, $p < .001$), confirming that the data were highly suitable for factor analysis. These results robustly support the high reliability and structural validity of the questionnaire for measuring teaching competence in this sample.

3.2 Participants and Sampling Procedure

This study employed a purposive sampling method to target a specific and relevant population: in-service vocational education teachers who were actively engaged in professional development. The participants were recruited from the Digital Teaching Skills Enhancement Training (DTSET) program conducted between 2021 and 2023. This sampling frame was chosen because these teachers are at the forefront of confronting the challenges and requirements of the information age, making them a highly pertinent group for investigating the study's research questions.

Participation in the survey was mandatory as part of the training program, which resulted in a 100% response rate ($N = 1,024$ from 1,024 distributed). While this approach ensures a complete dataset from a defined group of upskilling teachers, it is acknowledged that it may introduce potential biases, such as social desirability bias in self-assessments. Strategies to mitigate this, such as guaranteeing respondent anonymity, were implemented.

4 Research Results

4.1 Personal Characteristics of Teachers

Vocational education teachers' current instructional capabilities show significant regional disparities, gender imbalances, and uneven distribution of educational backgrounds. Overall, the teaching cohort is characterized by high educational qualifications, professional diversity, and a pronounced emphasis on knowledge transmission.

In terms of regional distribution, East China and Northwest China have the highest number of teachers. In higher education, Northwest China leads with 276 teachers, followed by Central China (213), North China (99), Northeast China (97), and East China (65). In secondary vocational education, Northwest China reports 158 teachers, Central China 91, and East China 25, while no data

is available for North and Northeast China. These imbalances are influenced by factors such as economic development, policy interventions, geographical location, and the allocation of educational resources.

The teaching workforce in Chinese vocational education demonstrates distinct demographic characteristics. Female educators substantially outnumber their male counterparts across both higher education (476 vs. 274) and secondary education (180 vs. 94). The Northwest region maintains the highest concentration of teachers in both institutional types, reflecting its strategic emphasis on vocational education development. The larger teacher population in higher education institutions suggests preferential resource allocation and policy attention to this sector.

Age distribution analysis reveals a predominantly mid-career faculty, with the largest cohort aged 31–40 (396 teachers), followed by those 41–50 (308), 51–60 (175), and under 30 (144). Only one teacher exceeds 61 years. Teaching experience patterns show a mature workforce, with the majority possessing 11–20 years of experience (440), while substantial groups have 0–5 years (221) or over 21 years (213) of experience. Notably, 531 teachers reported no prior professional experience before entering education.

Professional title distribution follows expected patterns, with intermediate titles being most common (414), followed by associate senior (300), junior (272), and senior titles (38). Academic qualification data indicate a highly educated faculty, dominated by master's degree holders (516), with bachelor's degrees (382), other qualifications (107), and doctoral degrees (19) following. Discipline distribution shows education and sports as the largest specialization (233), ahead of culture and arts (152), electronics and information (136), equipment manufacturing (129), and finance and business (100). Course assignment patterns highlight the central role of foundational professional courses (558 teachers) and core professional courses (516), exceeding basic public courses (402) and advanced professional courses (152).

These demographic patterns collectively depict a vocational education system characterized by gender imbalance toward female educators, mid-career dominance, high academic qualifications, and strong emphasis on foundational professional training. The concentration of teachers in education and sports disciplines alongside the focus on core professional courses underscores the system's alignment with workforce development priorities.

Statistical analysis identified several significant correlations within the teacher population. A positive association emerged between teacher age and work experience, reflecting expected career progression patterns. Academic qualifications demonstrated systematic relationships with course assignments, revealing that instructors with graduate degrees predominantly teach core and advanced professional courses. Discipline-specific patterns in professional titles were evident, with natural science faculty achieving higher-ranking positions. The influence of academic background manifested in teaching assignments, as humanities and arts specialists showed reduced involvement in advanced courses.

Additionally, substantial teaching experience correlated strongly with assignment to core and advanced curricula, indicating institutional recognition of expertise. These patterns collectively demonstrate how demographic and professional characteristics—specifically age, qualifications, and professional rank—systematically shape instructional roles. The observed relationships reflect complex interactions among institutional structures, career development pathways, and individual spe-

cialization within China's vocational education framework.

4.2 Teachers' Teaching Competence

This study conducted a comprehensive analysis of teaching competencies through descriptive statistics, incorporating measures of central tendency and dispersion to assess educators' self-evaluations. The examination of mean, median, and standard deviation values reveals fundamental patterns in the assessment data, providing valuable insights into performance variations across competency domains. The subsequent table summarizes the statistical profile of teaching capabilities across six critical dimensions.

Table 1: Descriptive Statistical Results of Teachers' Teaching Competence

Dimension	Mean	Median	Std. Dev.	Min	Max
Curriculum Development Ability	3.68	3.79	0.89	1.00	5.00
Curriculum Teaching Ability	4.01	4.00	0.79	1.00	5.00
Professional Knowledge	4.01	4.00	0.80	1.00	5.00
Industry Knowledge	3.68	3.78	0.89	1.00	5.00
Information Literacy	3.85	3.92	0.82	1.00	5.00
Research and Development Ability	3.76	3.94	0.86	1.00	5.00

The assessment reveals a generally strong performance across teaching competencies, with notable variation among specific domains. Curriculum Teaching Ability and Professional Knowledge emerge as particular strengths, both achieving mean scores of 4.01 that indicate consistently high proficiency levels. Information Literacy and Research and Development Ability demonstrate moderate performance, with scores ranging from 3.76 to 3.85 reflecting adequate but less uniform competence. Conversely, Curriculum Development Ability and Industry Knowledge present the most significant development opportunities, with identical mean scores of 3.68 and substantial score dispersion highlighting these as priority areas for targeted intervention.

Regional assessment identifies clear geographic disparities in teaching competency. Northeast (23.84) and North China (23.76) lead in performance, likely reflecting advantages in educational resources, policy support, and training systems. Central China trails significantly (22.21), indicating substantial development needs. East China, Northwest, and South China occupy the middle range, demonstrating adequate competency with measurable improvement potential.

Regional analysis reveals Northeast China excels in curriculum development, teaching ability, and professional knowledge, while Central China trails in these domains. North China leads in industry knowledge and information literacy, with Southwest and Central China underperforming. Northeast and North regions also show stronger research capability versus Central China's lower performance. This regional advantage likely reflects superior teacher development investments.

One-way ANOVA results ($p < 0.05$) confirm significant teaching competence variations across demographic and professional factors. Higher academic qualifications consistently predict better

Table 2: Average Total Scores by Region

Region	Average Total Score
Central	22.21
Northeast	22.47
North China	23.76
East China	23.84
Northwest	22.90
South	23.01

performance across all competency dimensions, establishing educational background as a decisive factor in teaching effectiveness.

Table 3: Analysis of Variance Results for Teaching Ability by Education Level

Teaching Ability Dimensions	p-value
Curriculum Development Ability	0.000
Curriculum Teaching Ability	0.000
Professional Knowledge	0.000
Industry Knowledge	0.000
Information Literacy	0.000
Research and Development Ability	0.000
Total Score	0.000

Box plots demonstrate pronounced score variations by educational level. PhD holders and similarly high-qualified teachers consistently achieve superior scores across all competencies, with higher medians and interquartile ranges confirming stronger performance. Limited outliers do not affect core patterns. These visual results validate the ANOVA findings, establishing educational level as a significant determinant of teaching competence across dimensions.

Significant gender differences were found in curriculum development ability, professional knowledge, industry knowledge, and total scores ($p < 0.05$), suggesting that gender may influence performance in these areas, possibly due to differences in teaching styles or experiences. However, no significant differences were observed in curriculum teaching ability, information literacy, and research and development ability ($p > 0.05$), indicating that these competencies are less influenced by gender.

Significant differences in teaching competence scores were also found across age groups ($p < 0.05$), reflecting variations in experience, knowledge, and skills. More experienced teachers tend to score higher in certain areas, while younger teachers may excel in areas like information literacy, due to their familiarity with modern teaching technologies and methods.

The subsequent figure reveals significant variations in score distributions across various dimensions among different age groups, which is consistent with the results of the analysis of variance.

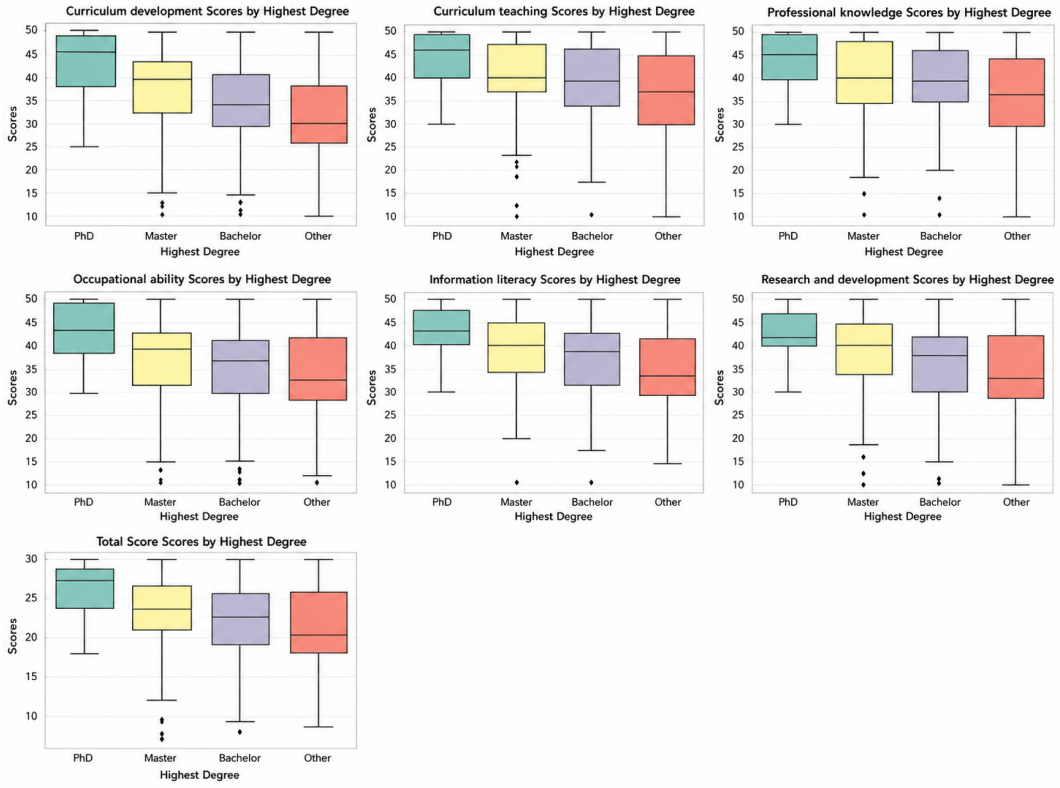

Fig. 1. Differences in Teaching Ability Scores Among Teachers with Different Education Levels.

Table 4: Statistical Comparison of Teaching Ability Scores by Gender

Teaching Ability Dimensions	**p-value**
Curriculum Development Ability	0.002
Curriculum Teaching Ability	0.826
Professional Knowledge	0.036
Industry Knowledge	0.000
Information Literacy	0.286
Research and Development Ability	0.061
Total Score	0.025

In specific dimensions, certain age groups display higher median and interquartile range scores, indicating their strengths in particular abilities. These analytical findings suggest a strong correla-

Table 5: Differences in Teaching Ability Scores Across Age Groups

Teaching Ability Dimensions	**p-value**
Curriculum Development Ability	0.000
Curriculum Teaching Ability	0.000
Professional Knowledge	0.000
Industry Knowledge	0.005
Information Literacy	0.000
Research and Development Ability	0.000
Total Score	0.000

tion between teachers' age and their performance across different teaching competence dimensions. As teachers age, they may exhibit enhanced performance in certain abilities, likely attributable to accumulated experience and deepened knowledge.

Moreover, significant differences in scores were observed between teaching experience and teaching competence ($p < 0.05$), indicating that teachers with varying levels of teaching experience exhibit statistically significant variations in their teaching competence scores. These significant differences may suggest that as teachers accumulate more teaching experience, their performance tends to improve across multiple dimensions of teaching ability. Experienced teachers often demonstrate advantages in curriculum development, teaching ability, and professional knowledge. However, it is also possible that a "ceiling effect" occurs, where the rate of improvement in certain abilities may decelerate after a certain number of years of experience.

Table 6: Differences in Teaching Ability Scores by Teaching Experience Level

Teaching Ability Dimensions	**p-value**
Curriculum Development Ability	0.000
Curriculum Teaching Ability	0.000
Professional Knowledge	0.000
Industry Knowledge	0.001
Information Literacy	0.000
Research and Development Ability	0.000
Total Score	0.000

The box plots corroborate the results of the analysis of variance. In specific dimensions, teachers with more extensive teaching experience exhibit higher median and interquartile range scores, indicative of their proficiency in these abilities. These analytical findings reveal a strong correlation between teachers' teaching experience and their performance across various dimensions of teaching ability. As teaching experience accumulates, teachers may achieve enhanced performance in multiple dimensions.

Significant differences in teaching competence scores were observed across all dimensions and

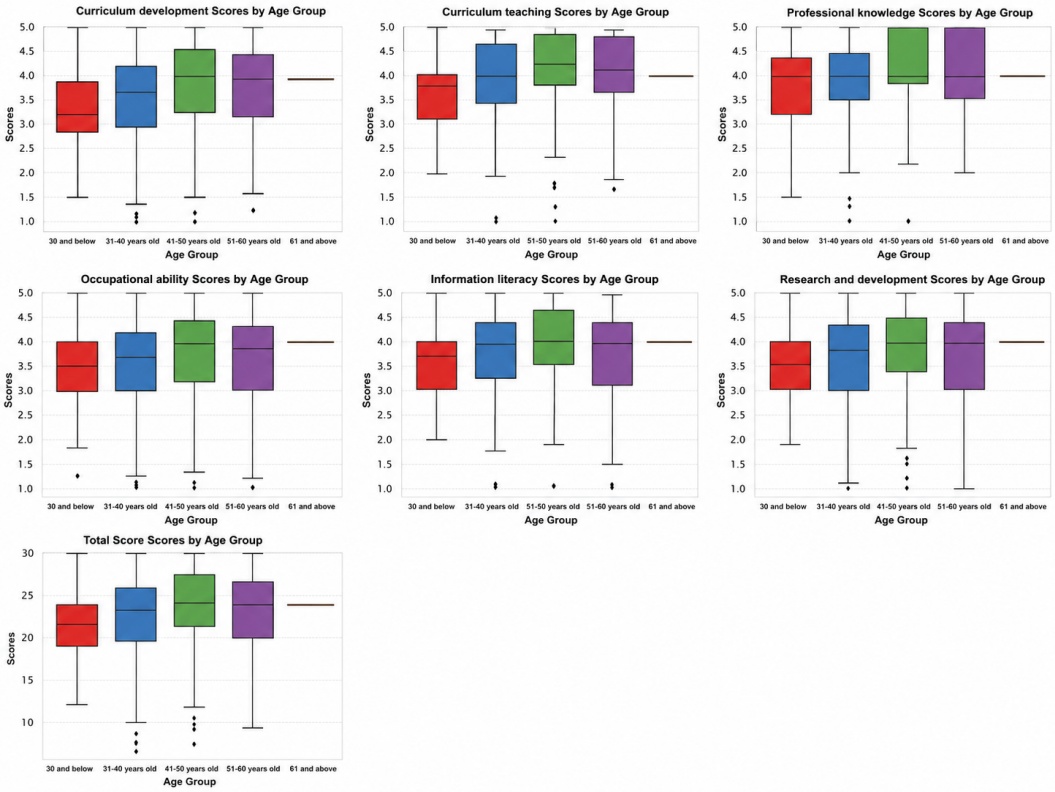

Fig. 2. Differences in Teaching Ability Scores Between Age Groups.

total scores among professional title groups ($p < 0.05$). These results indicate statistically meaningful variations in teaching performance corresponding to professional rank. The progression to higher titles appears associated with enhanced performance across multiple teaching competencies, potentially attributable to accumulated teaching experience, specialized knowledge, and privileged access to professional development resources within the educational system.

Box plots visualize score distributions across teaching ability dimensions for different professional title groups. Significant distributional variations align with ANOVA results, confirming title-based disparities. Educators with senior titles consistently demonstrate elevated median and interquartile range scores, reflecting their enhanced proficiency in specific competencies.

Heatmap analysis reveals distinct performance patterns across subject disciplines. Disciplines such as Public Safety and Justice show robust multi-dimensional performance, whereas Education and Sports display relative weaknesses in specific areas. These findings indicate strong discipline-teaching ability associations, likely attributable to divergent curricular demands and pedagogical requirements across academic fields.

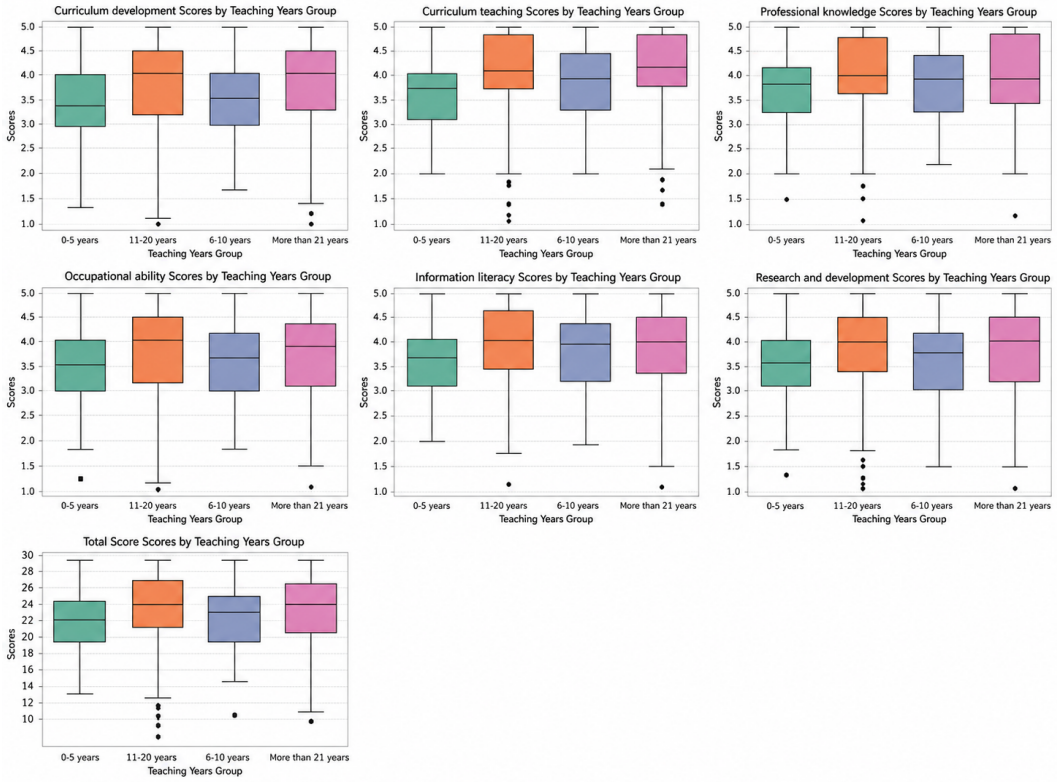

Fig. 3. Differences in Teaching Ability Scores Between Teaching Experience Levels.

Table 7: Differences in Teaching Ability Scores by Professional Title Group

Teaching Ability Dimensions	**p-value**
Curriculum Development Ability	0.000
Curriculum Teaching Ability	0.000
Professional Knowledge	0.000
Industry Knowledge	0.000
Information Literacy	0.000
Research and Development Ability	0.000
Total Score	0.000

All major subject categories show strong correlations between teaching ability dimensions and total scores. This pattern is particularly pronounced in natural sciences, where several dimensions

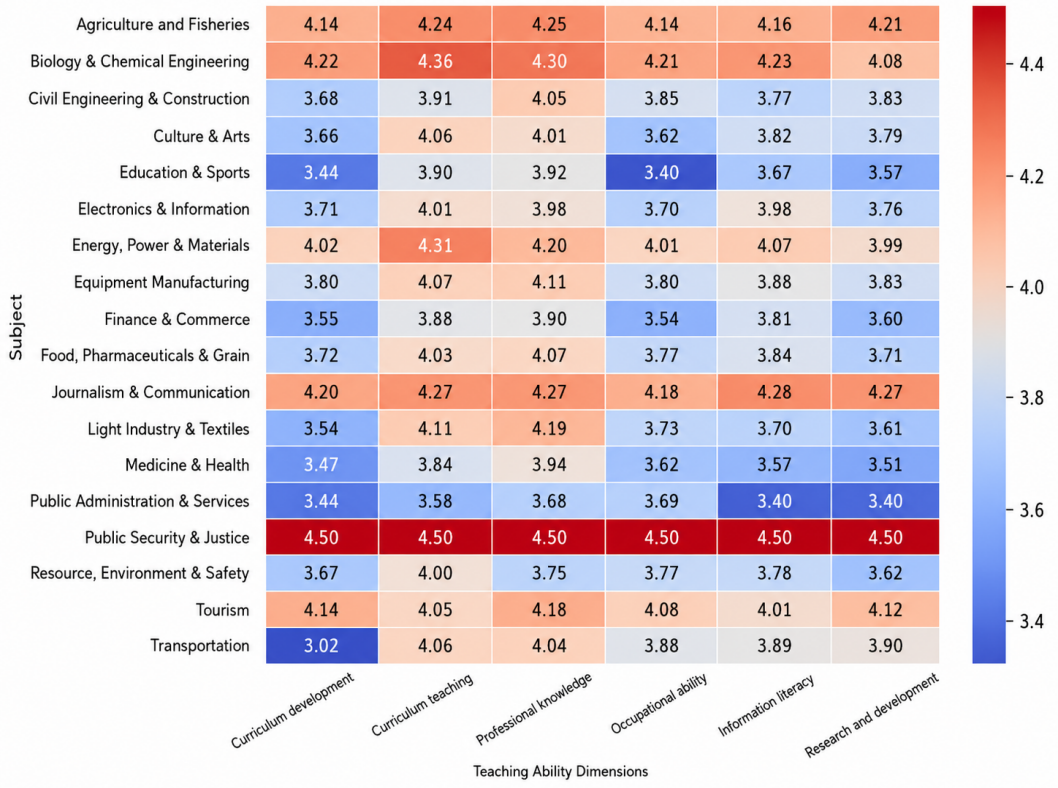

Fig. 4. Differences in Teaching Ability Scores Between Subject Discipline Groups.

approach correlation coefficients of 1.0. These findings indicate a consistent relationship between disciplinary domains and teaching performance profiles. Natural science educators demonstrate especially strong multidimensional performance, likely reflecting the field's rigorous pedagogical requirements.

5 Development Strategies for Teaching Ability of Vocational Education Teachers in the Information Age

5.1 Enhancing the Precision and Effectiveness of Teacher Training

To systematically improve the teaching competence of vocational education teachers, a targeted training intervention system should be established based on empirical research findings, addressing the specific shortcomings identified among different teacher groups.

For early-career teachers (aged ≤ 30 or with 0–5 years of teaching experience), their perfor-

mance in "Curriculum Development Ability" and "Industry Knowledge" (mean score of 3.68 for both dimensions) indicates a clear deficiency in these areas. It is recommended that university-level Teacher Development Centers establish a three-week summer intensive program titled "Introduction to Vocational Education" for newly recruited teachers. The program should integrate project-based learning curriculum design, practical training in digital teaching resource development, and rotational internships in partner enterprises to systematically strengthen their teaching foundation and industry awareness.

For mid-career key teachers (with 11–20 years of teaching experience), who represent the core faculty, updating their knowledge structure and enhancing teaching innovation capabilities are crucial. Provincial-level teacher training bases should regularly organize advanced seminars on "Industrial Technology and Teaching Innovation". These seminars should include in-depth investigations at leading enterprises and workshops focused on redesigning teaching plans based on real industrial cases, with the submission of an implementable interdisciplinary teaching plan serving as a core assessment requirement.

Regarding training formats, implementing a modular micro-credential system is recommended. High-demand skills such as "AI Teaching Assistant Applications" and "Teaching Data Analysis" should be developed into online certification courses of no more than 20 credit hours. Credits earned through successful course completion should be recognized as continuing education hours and considered in professional title evaluations, thereby supporting flexible and sustainable professional development.

5.2 Implementing Support Measures Focused on Key Deficiencies

Support policies for teachers' professional development should address common deficiencies and regional imbalances identified through empirical research.

Establish a specialized support center for "Curriculum Development and Industry Knowledge". Given that these two competencies represent common weaknesses among all teachers (mean score of 3.68), municipal education authorities or vocational education groups should take the lead in establishing physical support centers in regions with strong teaching performance, such as North China and East China. These centers' core functions would include regularly organizing open demonstration classes led by enterprise experts and master teachers, and systematically developing and maintaining a localized repository of enterprise case teaching resources to provide readily applicable teaching materials for regional educators.

Implement a Paired Assistance Program. To effectively address regional competency gaps (e.g., the central region's average total score of 22.21), provincial education administrative departments should coordinate the establishment of a structured assistance mechanism between high-performing and underperforming institutions. Collaboration should be concretized through regular online joint teaching research activities, co-applications for teaching reform projects, and two-way faculty exchange programs. Program effectiveness should be evaluated using key performance indicators such as the number of co-developed courses and jointly published teaching research outcomes.

Launch targeted competency enhancement initiatives. To address competency disparities among different groups, such as the significant advantage male teachers demonstrate in "Industry Knowledge" ($p < 0.05$), institutions should design summer "Industry Practice" special programs

for female teachers. These programs should extend beyond observational visits to include hands-on internships mentored by enterprise technicians, requiring participants to submit analytical reports on new technologies and standards in their respective positions to ensure their industry knowledge remains current with sector developments.

6 Conclusion

This study investigated the teaching competence of Chinese vocational education teachers in the information age based on self-assessment data from 1,024 in-service teachers who participated in the Digital Teaching Skills Enhancement Training program. Using a six-dimensional framework, the results indicate that teachers showed relatively strong performance in curriculum teaching and professional knowledge, whereas curriculum development competence and industry-related knowledge remained comparatively weak and therefore require greater attention in future professional development.

The analysis further revealed significant differences associated with age, teaching experience, academic qualification, gender, and region. In general, teachers with more experience and higher qualifications demonstrated stronger competence, while teachers in less advantaged regions, particularly Central China, encountered greater pressure in responding to digital and industrial transformation.

Overall, the findings suggest that strengthening vocational teachers' competence in the digital era requires both individual improvement and sustained institutional support. Practice-oriented training, deeper school-enterprise cooperation, and more balanced interregional resource sharing are especially important. This study provides empirical evidence for the design of differentiated teacher development policies and offers a useful reference for promoting the reform and high-quality development of vocational education in China under continuing technological and industrial change. It also underscores aligning teacher preparation with evolving industry needs.

7 Limitations and Future Research

This study has several limitations. The reliance on self-reported data from a mandatory training program may introduce social desirability bias and limit the generalizability of findings. The cross-sectional design cannot establish causal relationships or track competency development over time. Furthermore, the absence of classroom observations or student evaluations prevents verification of actual teaching effectiveness.

Future research should employ longitudinal designs to examine competency trajectories, integrate mixed methods including classroom observations, and correlate self-assessments with external indicators such as student learning outcomes to validate measurement approaches.

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Declaration on Generative AI. During the preparation of this study, the author used ChatGPT-5 and Grammarly for grammar and spelling checks. After using these tools, the author reviewed and

edited the content as needed and assumes full responsibility for the content of the publication.

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