Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 8, No. 6, 3796-3807
2024
Publisher: Learning Gate
DOI: 10.55214/25768484.v8i6.2823

Teacher competency development model of higher vocational schools in Shandong province, China

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Abstract: Teacher competency is fundamental to successful vocational education reforms and quality enhancement. The rapid economic transformation and industrial upgrading in Shandong Province require highly skilled talents, prompting the implementation of modern vocational education (MVE) reform. However, the current competency of vocational teachers (VTs) often falls short of MVE standards, and there is an urgent need for a development model suitable for regional characteristics as a guide. In this study, we aim to assess the current state of VT competency development in Shandong Province and propose an integrated competency development model tailored to its specific needs. Our research employed a mixed-methods design, incorporating a cross-sectional survey of 280 VTs and 140 administrators and semi-structured interviews with management personnel. We conducted the exploratory factor analysis (EFA) on a comprehensive survey questionnaire and identified six key determinants of VT competency development. Based on these findings and expert interviews, we developed an integrated competency development model, comprising the teacher's personal qualities and educational philosophy, educational technology competence, digital teaching competence, social policy, professional identity, and school culture and support. This model offers practical implications for designing effective teacher training programs and establishing supportive institutional environments, ultimately aiming to enhance the quality of vocational education through improved teacher competency.

Keywords: *Competency development model, Competency development, Exploratory factor analysis, Modern vocational education reform, Vocational teachers (VTs).*

1. Introduction

The quality of vocational education heavily relies on teacher competency development. As China continues its modern vocational education (MVE) reform, this issue has become increasingly critical (Fan et al., 2024). The reform's primary goal is to build a skilled workforce capable of supporting the country's economic transformation. Particularly in Shandong Province, where manufacturing drives regional development, industries urgently need talents in advanced manufacturing, IT, and biotechnology (Guo et al. 2020). While China's MVE reform emphasizes quality improvement through competency-based education (Ye, 2023), the gap between vocational teachers' (VTs) current capabilities and reform requirements remains significant.

Shandong Province launched the 'Dual-qualified' teacher capacity building program in 2019 as part of its MVE reform initiatives (Zhao et al., 2022). The program incorporates industry technologies into teaching practices and promotes teacher development through various training projects and competitions (Xu, 2023). Though the province has reached its 2025 target for 'Dual-qualified' teachers ahead of schedule, questions remain about the depth of these qualifications. Recent studies by Zhou et al. (2024) suggest that effective teaching requires competencies far beyond basic knowledge and skills. Scholars have examined different aspects of VT development, from motivation and digital competence to professional development frameworks (Mardi et al., 2021) (You et al. 2022) (Zhang et al. 2022). Additional research by Cattaneo et al. (2022), Romanova et al.(2022), and Thwe et al.(2023) has further

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enriched our understanding of teacher competency development. Yet existing models often fall short in addressing Shandong's specific challenges, particularly in light of emerging technologies like generative AI (Zhou et al., 2024). This gap underscores the need for a regionally focused study of VT competency development in Shandong Province.

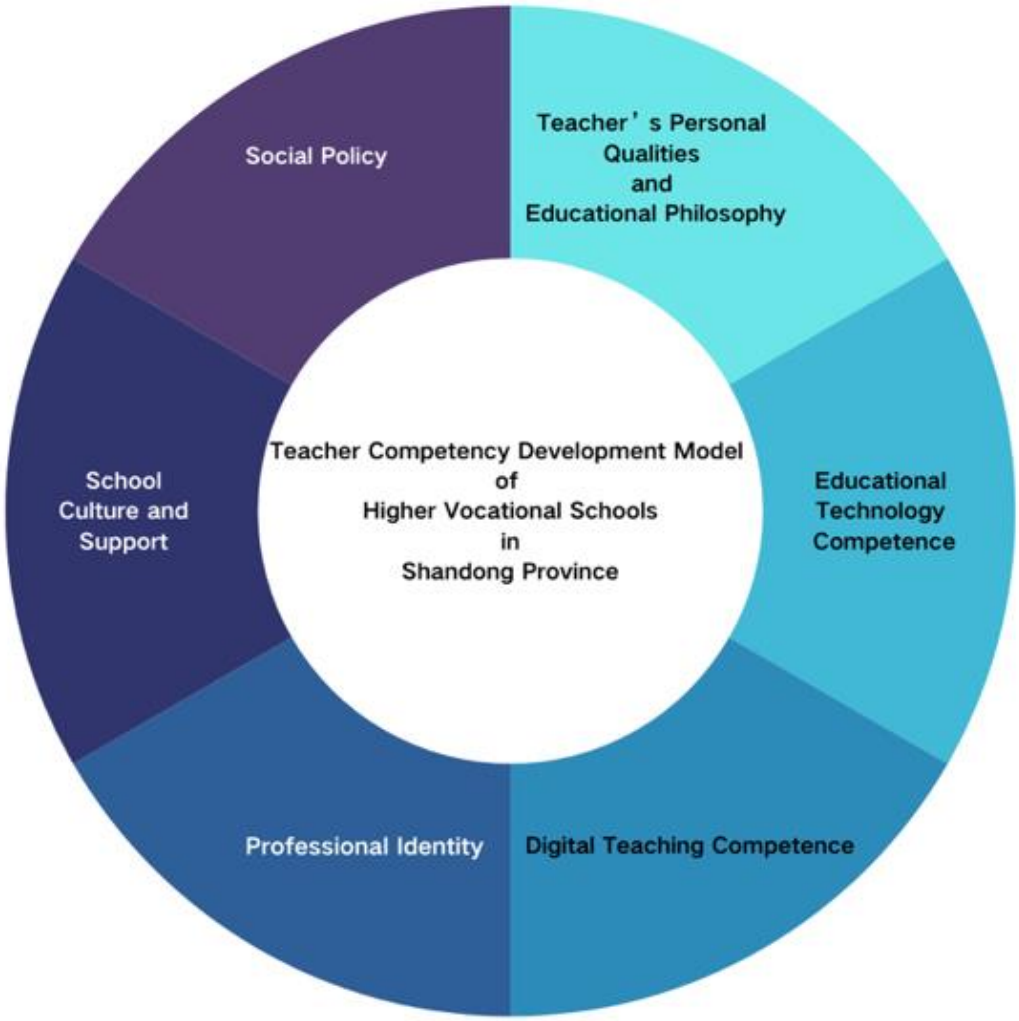

Figure 1.
Teacher competency development model of higher vocational schools in Shandong province, China.

In this work, we address crucial gaps in the existing literature by developing a comprehensive competency development model for VTs in Shandong Province, China. The study employs EFA to identify essential factors influencing VT competencies. We gathered data through a voluntary online survey completed by 280 teachers, alongside semi-structured interviews conducted with 140 administrators from 70 higher vocational institutions in Shandong Province. The survey data underwent EFA, which revealed six critical components of VT competency, as shown in Figure 1. These quantitative findings gained additional support through our administrator interviews, offering rich contextual insights into the challenges faced by VTs. Particularly noteworthy was the persistent gap between current teacher capabilities and the evolving demands of vocational education reform. Drawing on these insights, we developed a region-specific competency model that addresses the unique needs of

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Shandong's VTs, ultimately supporting both educational quality enhancement and regional economic development.

2. Literature

2.1. Teacher Competency

The term of 'competence' emerged in academic discourse through Lundberg's (1970) article, gaining prominence with McClelland's (1973) influential 1973 work. More than a single attribute, competency weaves together various elements - from cognitive abilities and motivational factors to skills and behavioral patterns. Building on early definitions, Nessipbayeva (2012) framed competency as an integrated set of capabilities crucial for role effectiveness. Today's digital era has reshaped our understanding of teacher competency; scholars increasingly recognize digital literacy as fundamental to teacher development (Redecker et al., 2017) (Ghomi & Redecker, 2019)Recent studies by Zhao and Xue (2022) and Diao and Qu (2024) further emphasize this digital dimension in the Chinese educational context.

The Chinese vocational education system faces unique challenges. Students entering vocational schools often show different academic profiles than their counterparts in general higher education, creating distinct demands for teaching approaches. Recognizing these challenges, China introduced the 'Double Qualified Teacher' initiative, emphasizing both theoretical knowledge and practical industry experience (State Council, 2022). While this policy sets broad guidelines for teacher development, questions remain about its implementation across different regional contexts and institutional settings.

2.2. Vocation Teacher's Competence Development

Teaching competency in vocational education isn't static - it evolves through ongoing engagement with new knowledge, skills, and professional growth. Recent work by Diao and Qu (2024) emphasizes how this evolution becomes particularly critical during educational reforms. Reflecting on earlier research, Anjum et al. (2007) mapped out key areas where teachers need continuous development: from curriculum design to communication skills. Their findings remain relevant today, as vocational educators face mounting pressure to bridge classroom theory with rapidly changing industry practices.

Professional growth takes many forms in vocational teaching. Sum et al., (2022) observed how resource-sharing and collaborative projects strengthen teachers' professional capabilities. This aligns with broader research on continuous professional development (CPD), where Stigler and Miller (2018) found that sustained learning significantly improves teaching quality. Later work by Lortie-Forgues and Inglis (2019) added nuance to our understanding of CPD, highlighting how contextual factors shape professional growth.

The digital transformation of education has redefined teacher competency requirements. Recent research by Smestad et al. (2023) reveals how technology reshapes teaching practices, demanding new skills in information management and digital pedagogy. The emergence of AI tools like ChatGPT has further complicated this landscape. UNESCO's (2023) framework suggests that today's teachers need more than basic digital literacy - they must understand AI fundamentals and data analytics to create meaningful learning experiences. These skills enable more personalized teaching approaches while fostering cross-disciplinary learning opportunities.

3. Methods

3.1. Population and Sample

The population used in this research was administrators and teachers at higher vocational schools in Shandong province. There are a total of 83 higher vocational institutions in Shandong Province. The sample group used 70 higher vocational institutions in Shandong Province, which are included in the Chinese Characteristics High-Level Vocational Schools and Programs Development Plan. The researcher determined the sample size using the schedule of the sample size by Krejcie and Morgan (1970, pp. 607-610). The researcher assigned 6 respondents to each higher vocational institution using simple random sampling, consisting of 2 school administrators (140 respondents) and 4 vocational teachers (280 respondents), totaling 420 respondents.

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3.2. Research Instruments

First, the questionnaire on the demographic data of the respondents. It was in the form of a checklist to ask for basic information of the respondents, namely, gender, age, the highest education, and Work experience. Second, the questionnaire of the teacher competency development of higher vocational schools in Shandong province was created by the researcher in the amount of 100 items. Finally, a semi-structured interview for 9 key informants for interview for the teacher competency development model of higher vocational schools in Shandong province.

3.3. Data Analyses

The Demographic data of the Respondents: analysis of frequency and percentage personal status of respondents.

The level of the teacher competency development of higher vocational schools in Shandong province: analysis of the mean and standard deviation.

The exploratory factors analysis (EFA) of the teacher competency development of higher vocational schools in Shandong province: analysis of the exploratory factors analysis of the teacher competency development of higher vocational schools in Shandong province.

The content analysis by in-depth- interview: Semi-structured interviews were conducted with nine educational experts to gain in-depth insights into their perspectives on teacher competency development in Shandong Province. The interview protocol included open-ended questions focused on the composition, current status, and influencing factors of teacher competency.

4. Result

4.1. The Results Demographic Data of the Respondents

The descriptive statistics are shown in Table . It illustrates the demographic breakdown of the survey respondents. The inner circle categorizes respondents by their highest educational attainment, while the outer circle provides further demographic details such as age, gender, and professional role. In the process of data cleaning, we excluded 25 administrators and teacher responses from the sample because these participants completed less than 75% of the questionnaire.

Table 1.
Demographic information of respondents.

Demographic information of respondents		**Demographic data of respondents(N=395)**	
		Frequency	**Percentage**
Gender of respondents	Male	129	32.66%
	Female	266	67.34%
Role of respondents	Administrator	131	33.16%
	Vocation teachers	264	66.84%
Age of respondents	25~29 years old	72	18.23%
	30~39 years old	136	34.43%
	40~49 years old	126	31.90%
	above 50 years old	61	15.44%
The highest education background of respondents	Bachelor's degree	85	21.52%
	Master's degree	284	71.90%
	Doctoral degree	26	6.58%
Working experience of respondents	Under 5 years	88	22.28%
	6~10 years	107	27.09%
	11~15 years	84	21.27%
	16~20 years	52	13.16%
	Above 20 years	64	16.20%

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4.2. The Results of the Level of the Teacher Competency Development of Higher Vocational Schools in Shandong Province: Analysis of the Mean and Standard Deviation

The mean values and standard deviations for 100 questionnaire items. It assesses teachers' self-perceived competencies in higher vocational education. Based on descriptive statistics, the average level of competence among vocational teachers in Shandong Province is relatively high, with minimal variation(mean=4.2, S.D=0.78). However, it is important to note that there were significant variations in responses related to the themes of generative artificial intelligence(mean=4.5, S.D=0.89) and dual-qualified teachers(mean=3.37, S.D=0.93). Younger teachers generally showed a higher acceptance of generative artificial intelligence, while older teachers scored lower on this aspect. Additionally, teachers scored generally lower on the 'dual-qualified teacher' theme, with considerable variation in their responses. This indicates a need for targeted support and training in these areas to ensure all teachers can meet the evolving demands of vocational education.

4.3. The Results of the EFA of the Teacher Competency Development of Higher Vocational Schools in Shandong Province: Analysis of the EFA

In this research, the Varimax rotation method with Kaiser normalization was used, which aims to maximize the variance of squared loadings of a factor across variables, making the output more interpretable. The scree polt as shown in Figure 2. and the rotated component matrix and communality as shown in Table 2.

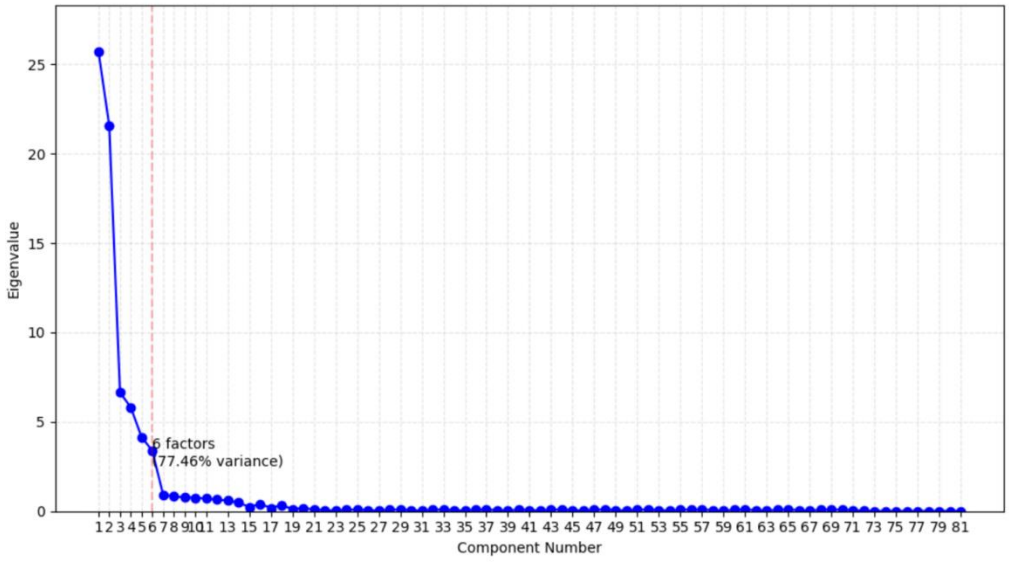

Figure 2.
Scree Polt.

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Table 2.
Rotated component matrix and communality.

Six factors(Total explained variance: 77.46%)		
	Items	**Factor loading**
	Factor 1: Teacher's Personal Qualities and Educational Philosophy	
Q27	Teachers abide by the code of professional ethics	0.884
Q22	Teachers have the ability to express themselves clearly and accurately	0.877
Q29	The Administrator provides support for the professional ethics and development of teachers	0.876
Q23	Teachers are able to communicate effectively with students, colleagues	0.874
Q7	The Administrator provides support for teachers to improve their digital capabilities	0.853
Q28	Teacher Professional Ethics Influences Teaching Practice/Teacher Teaching Practice is influenced by Professional Ethics	0.84
Q4	Teachers are able to integrate knowledge from different disciplines	0.833
Q18	Teachers are able to guide students to actively participate in school activities	0.832
Q5	Teachers are able to develop students' ability to innovate in practice	0.831
Q17	Teachers have the ability to organize and coordinate teaching	0.828
Q12	Teachers believe that they can continuously improve their professional standards	0.827
Q16	The Administrator supports teachers in learning new theories and techniques	0.82
Q2	Teachers are able to create a good classroom atmosphere	0.816
Q26	Teachers have a high sense of responsibility	0.813
Q14	Teachers take the initiative to pay attention to new knowledge and technologies in their field of expertise	0.81
Q24	Teachers are able to listen to the opinions and suggestions of colleagues, students	0.801
Q3	The Administrator provides support for the professional ethics and development of teachers	0.789
Q1	Teachers have positive and enthusiastic personalities	0.788
Q8	Teachers see the teaching profession as a rewarding career	0.769
Q19	Teachers are able to create a good classroom atmosphere	0.768
Q25	The administrator creates an environment and supports teachers to improve their communication skills	0.764
Q15	Teachers apply the new knowledge they have learned to their teaching practice	0.761
Q10	Teachers believe they can help students achieve good learning outcomes	0.751
Q20	Teachers are able to play an active role in the teaching team	0.75
Q13	Teachers often participate in various training and refresher activities	0.749
Q21	The Administrator provides support for teachers to develop leadership skills	0.697
	Factor 2: Educational Technology Competence	
Q58	Teachers are able to translate research results into teaching resources	0.789
Q43	Teachers are equipped with professional knowledge and skills to meet the current needs of higher vocational education	0.777
Q60	The administrator policy can motivate faculty to do research	0.776

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Q45	Teachers are competent in research in their field of specialization	0.771
Q59	The Administrator provides support and a platform for faculty research	0.752
Q55	The administrator provides support for teachers in the integration of industry and education	0.749
Q31	Teachers are well-versed in the practical techniques of their profession	0.741
Q57	Teachers have the ability to conduct scientific research	0.74
Q46	The Administrator provides support for teachers to develop professional knowledge and skills	0.736
Q50	The Administrator provides support for the development of teachers' practical skills	0.713
Q37	The Administrator supports teachers in learning about the latest vocational education policies and reforms	0.711
Q30	Teachers are well-versed in the theoretical knowledge of the specialty	0.698
Q34	Teachers have a solid foundation in educational theory	0.69
Q48	Teachers are able to guide students through hands-on activities	0.687
Q32	Teachers are able to effectively combine theory and practice	0.682
Q33	The administrator provides support for teachers to improve their ability to combine theory and practice	0.679
Q47	Teachers have practical skills	0.676
Q39	Teachers are able to integrate knowledge from different disciplines	0.675
Q54	Teachers regularly go to enterprises every year to participate in work practice	0.673
Q52	Teachers are able to work with companies to develop students	0.667
Q41	The Administrator supports teachers in developing interdisciplinary competence	0.666
Q42	The administrator provides incentives for the application of interdisciplinary knowledge in teaching practice	0.666
Q53	Teachers are able to guide students through school-enterprise projects	0.664
Q49	Teachers are able to develop students' ability to innovate in practice	0.643
Q36	Teachers are able to use educational theories to guide teaching practice	0.629
	Factor 3 Digital Teaching Competence	
Q66	Teachers are proficient in the use of digital teaching tools for teaching	0.933
Q63	Teachers are able to guide students in the proper use of generative AI	0.919
Q68	The Administrator provided support for the digital transformation of the classroom	0.909
Q65	The administrator policy can prevent ethical issues in the use of generative AI in teaching	0.905
Q64	The Administrator provides guidance and support for the use of generative AI in teaching	0.883
Q67	Teachers are able to use digital teaching tools according to the learning situation	0.878
Q62	Teachers are able to use generative AI to assist in teaching	0.835
Q61	Teachers believe that generative AI has a positive effect on teaching reform	0.806
	Factor 4 Social Policy	
Q91	Teachers are able to develop students' ability to adapt to the digital economy	0.914
Q92	The Administrator supports teachers in understanding the digital economy	0.898
Q93	Teachers are aware of educational policies related to vocational education	0.898

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Q99	The Administrator provides support for the growth path of 'Dual-qualified' standard teachers	0.893
Q98	The Administrator provides support for the training of 'Dual-qualified' standard teachers	0.885
Q97	The administrator provides incentives for teachers to change their teaching in line with educational policy reforms	0.883
Q95	Teachers are able to improve their personal development in accordance with educational policies	0.82
Q96	The administrator provides support to teachers in learning education policies	0.728
	Factor 5 Professional Identity	
Q70	Teachers have a deep understanding of the nature of education	0.893
Q72	Teachers can develop career plans	0.883
Q76	The Administrator supports teachers in gaining teaching experience	0.878
Q78	Teachers are proud of who they are teachers	0.877
Q77	Teachers are able to draw patterns from their teaching experience	0.862
Q81	School culture has a promoting effect on teachers' professional identity	0.774
Q75	Teachers are able to continuously improve their teaching methods based on their teaching experience	0.601
	Factor 6 School Culture and Support	
Q84	School culture fosters collaboration among teachers	0.915
Q82	School culture has a positive impact on teacher competency development	0.892
Q83	The school culture motivates teachers	0.869
Q89	Administrator facilitates the professional growth of teachers	0.854
Q86	The Administrator provides support for the development of teachers	0.811
Q88	Administrator inspires teachers to be innovative	0.796
Q87	Administrator provides a good working environment for teachers	0.625

Based on the EFA results, six distinct components were identified, explaining a cumulative variance of 77.46%. Additionally, we removed unrelated items to ensure a more accurate representation of vocational teachers' competencies in Shandong Province. Our analysis revealed six distinct dimensions shaping vocational teachers' competency development:

The first factor centers on Personal Qualities and Educational Philosophy Beyond mere teaching skills, this factor encompasses deeper elements: a teacher's ethical stance, sense of professional responsibility, and notably, their ability to bridge theoretical knowledge with practical applications across disciplines.

Educational Technology Competence emerged as our second key factor. Here we found that teachers' ability to embrace and effectively utilize educational technologies stems from their engagement with training programs and their capacity for innovation in digital tool application.

The third factor focuses specifically on Digital Teaching Competency. While related to general technology competence, this factor uniquely captures how teachers integrate digital tools into their daily teaching methods and align these practices with current educational policies.

School Policy, our fourth factor, reveals how broader social and institutional policies influence teacher competency development. This factor particularly emphasizes how school culture and administrative support systems interact to shape the teaching environment.

The fifth factor highlights the crucial role of Professional Identity reflects the internal aspects of teacher development. This includes how teachers view their role in education, approach career development, and learn from classroom experiences to refine their teaching methods.

Finally, School Culture and Support. Our findings suggest that the school environment significantly shapes teacher growth, particularly through administrative backing and fostering innovative practices.

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In this work, we comprehensively investigate the competence development of VTs in Shandong Province. First, we assess the overall competence level of VTs. Second, we explore the underlying factor structure of VTs' competence through exploratory factor analysis (EFA). Third, we develop a competence development model for VTs in Shandong Province.

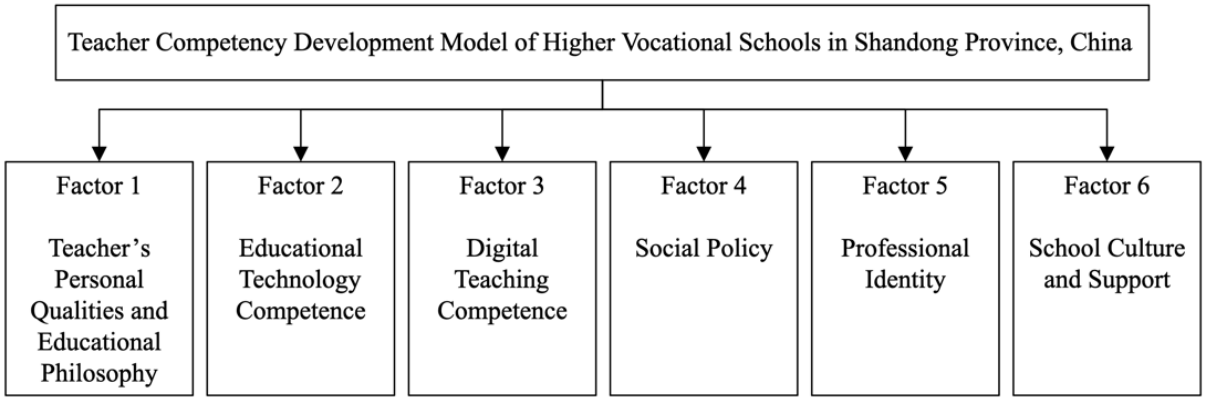

Figure 3.
Teacher competency development model based on EFA.

4.4. Results of the Guidelines for the Teacher Competency Development Model of Higher Vocational Schools in Shandong Province: Content Analysis by in-Depth- Interview

What sets our model apart is its integration of local context with established theoretical principles. While existing frameworks offer valuable insights, our data revealed unique patterns in how Shandong's VTs develop their professional capabilities through hands-on experience, reflection, and technology use. The model's strength lies in its empirical foundation - our quantitative findings gained deeper meaning through expert interviews, helping us understand how theoretical concepts translate into daily teaching practices. Our proposed competency development model provides a systematic framework for enhancing VTs' competencies in Shandong Province. Through focusing on critical developmental areas and incorporating expert validation, this model aims to elevate vocational education quality and facilitate educational reforms effectively. Our model will serve as a foundation for developing specialized training programs and policies, thereby contributing to the advancement of vocational education in the region.

5. Discussion

5.1. The Competency Development Level of VTs in Shandong Province

To meet higher vocational education standards required by MVE reform in Shandong Province, a lot of policies have been implemented to develop the VTs' competency. While VTs in Shandong generally have high-level competency including strong work ethic, professional skills, and digital ability. There are still several challenges (Maruyama, 2020). In recent years, vocational schools in Shandong Province have recruited a lot of novel teachers, they have a high level of digital ability. However, they need to improve their technical knowledge and pedagogical practice. This will be solved by their ongoing professional development. Experienced teachers have valuable teaching experience and professional ethics, but they usually hard to update their skills to match industry advancements. Notably, most of the VTs' motivation for continuous learning and interdisciplinary knowledge is low. Furthermore, collaboration between schools and enterprises remains superficial (Zhou et al., 2024). Additionally, in vocational schools, tools like generative AI are rarely used to instrument. Because VTs lack proficiency, while schools lack ethical guidelines and training support. Addressing these gaps is crucial for aligning educational outcomes with industry demands, as well as enhancing the overall quality of vocational education in Shandong Province(UNESCO, 2018).

Edelweiss Applied Science and Technology
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5.2. Factor Structure of VTs competency in Shandong Province

Based on the result of EFA, we identified six principal factors that significantly contribute to the competency development of VTs in Shandong Province. These factors the teacher's personal qualities and educational philosophy, educational technology competence, digital teaching competence, social policy, professional identity, and school culture and support. Our statistical analysis revealed robust factor loadings and communalities, lending strong empirical support to these dimensions of teacher competency. We strengthened our quantitative findings through in-depth interviews with management staff, whose perspectives aligned with and enriched our statistical results. Notably, our data revealed intriguing generational patterns in technology adoption. Novice VTs demonstrated greater openness toward generative AI tools, while their senior colleagues showed more hesitation. We also found unexpected gaps in 'Dual-qualified' standard requirements, with considerable variation in teacher responses. Such disparities suggest a need for more nuanced, age-sensitive approaches to professional development, especially in emerging technological areas.

5.3. Development and Validation of a Competency Development Model for Vocational Teachers in Shandong Province

Drawing on both our EFA results and management interviews, we developed a context-specific model for VT competency development in Shandong Province. Our approach builds on several foundational frameworks: UNESCO's ICT Competency Framework (2018) and Zhou et al.'s (2024). Teaching Competency Development model, and Cheng et al.'s (2024) work on higher education teaching competencies. Our framework revealed unique patterns in how Shandong's VTs develop their professional capabilities through hands-on experience, reflection, and technology use. The detailed description of our model is shown in Table .

Table 3.
Teacher competency development model of higher vocational schools in Shandong province, China.

Key areas	Explanation	Support measures
Teacher's personal qualities and educational philosophy	Encompasses intrinsic motivation, dedication to student service, continuous learning, and professional development.	Implement programs for further education, professional training, and create a supportive environment that encourages personal and professional growth.
Educational technology competence	Focuses on the application of educational technology in teaching.	Provide training on educational technology, workshops, seminars, and address ethical implications.
Digital teaching competence	Involves the use of digital tools and AI in teaching activities.	Provide training on digital tools and AI, workshops, seminars, and address ethical implications.
Social policy	Involves understanding and applying current educational policies and meeting dual-qualification requirements.	Provide resources and support for understanding and applying educational policies.
Professional identity	Supports career planning and the development of a strong professional identity.	Facilitate career development resources, comprehensive student development, and recognition programs.
School culture and support	Represents the support and environment provided by the school to enhance teachers' professional growth.	Provide administrative support, foster a positive school culture, encourage collaboration among teachers, and establish platforms for research and professional development.

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5.4. Limitations and Future Directions

The primary limitation of this study stems from the inherent nature of self-administered questionnaires, which may introduce response bias and potentially affect data accuracy. Longitudinal studies would be valuable in tracking the temporal development of teachers' competencies and establishing causal relationships more definitively. Further research priorities should focus on examining the correlation between teachers' competency development and student learning outcomes, investigating factors influencing teacher motivation in professional development, exploring institutional responses to emerging educational technologies, and developing frameworks for technology integration in vocational education. Additionally, developing comprehensive guidelines for AI implementation and establishing professional development frameworks that incorporate technological competencies.

6. Conclusions

In this work, we measured the competency levels of VTs in Shandong Province. Then, we identified six key factors contributing to their development based on the result of EFA. Finally, we proposed a competency development model tailored specifically for VTs in Shandong Province. This model is a particular development for VTs in Shandong Province, special attention is paid to the integration of industry and education, using generative Gen AI in the instrument. Because in Shandong Province, industry is the foundation of the economy, and generative Gen AI is changing the class. Our model provides a systematic framework for enhancing VTs' competencies, as well as supporting the effective implementation of vocational education reforms, and ultimately improving the quality of vocational education in Shandong Province.

This research makes substantial contributions to vocational education development in Shandong Province through two key aspects. First, it establishes an evidence-based foundation for designing targeted professional development initiatives, where training programs can be tailored to address specific competency gaps identified in our investigation. Second, the findings provide empirical support for policymakers to formulate data-driven strategies that align with the province's vocational education modernization goals. The model's incorporation of expert validation enhances its practical applicability, while its focus on critical developmental areas ensures resources are directed towards the most impactful aspects of teacher professional growth. These features position the research as a valuable tool for advancing institutional reform efforts in Shandong's vocational education system.

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