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How Are Educational Outcomes of Talent Training Generated in Higher Vocational Education for the Health Industry? The Pathways of Industry-Education Integration, Curriculum Matching, and Two-Mentor Collaboration

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Abstract

The development of the health industry has promoted a shift in talent training in higher vocational education from single-skill training to the generation of compound occupational ability and competence. Focusing on how industry-education integration is transformed into educational outcomes of talent training, this study constructs a structural equation model of "Institutional Support and Resources-Industry-Education Integration-Curriculum Matching-Two-Mentor Collaboration-Occupational Ability and Competence-Educational Outcomes of Talent Training" and conducts empirical tests based on 80 pre-test samples, 197 exploratory samples, and 232 validation samples. The findings show that the overall scale has good reliability and validity, and all 44 items meet the criteria for retention. Institutional Support and Resources significantly affects Industry-Education Integration Depth, Curriculum Matching, and Health-Industry Occupational Ability and Competence. Industry-Education Integration Depth not only directly affects Educational Outcomes of Talent Training, but also produces indirect effects through Curriculum Matching, Two-Mentor Collaboration, and Health-Industry Occupational Ability and Competence. The direct effect of the Two-Mentor Collaboration Mechanism on Educational Outcomes of Talent Training is unstable, and its influence is mainly realized through Health-Industry Occupational Ability and Competence. The study indicates that the key to improving the quality of talent training in health-related pro-

fessional clusters in higher vocational education is not simply to increase school-enterprise cooperation projects or mentor allocation, but to form a continuous mechanism among institutional guarantee, curriculum translation, mentor empowerment, and competence generation. Based on this, the study proposes a competence generation model of the "micro dual-subject community," providing empirical evidence for improving the quality of industry-education integration in higher vocational professional clusters.

Keywords

Health Industry, Industry-Education Integration, Micro Dual-Subject Community, Two-Mentor Collaboration, Occupational Ability and Competence, Structural Equation Model

1. Introduction

The development of the health industry is changing the structure of talent demand in related professional clusters of higher vocational education. New forms of business, such as elderly care services, health management, smart elderly care, traditional Chinese medicine rehabilitation, and community health services, continue to expand. Occupational ability and competence requirements have also shifted from single operational skills to compound abilities involving professional techniques, communication services, interdisciplinary collaboration, and digital applications. For higher vocational colleges, talent training is no longer merely about sending students to job positions, but about enabling students to complete tasks, solve problems, and continuously adapt to industrial changes in real service scenarios.

Industry-education integration is an important pathway for higher vocational colleges to respond to industrial needs. In recent years, school-enterprise cooperation, industrial colleges, modern apprenticeship, the two-mentor system, and the joint construction of training bases have continued to advance. However, some issues in practice still deserve attention. Enterprise participation sometimes remains at the level of agreements, while real projects and job tasks do not enter the curriculum system deeply enough. There is still a gap between curriculum content and industrial needs, and the knowledge students acquire may not be effectively transformed into occupational ability and competence. Although the two-mentor system has been widely adopted, the boundaries of responsibility, frequency of collaboration, and evaluation mechanisms between on-campus mentors and enterprise mentors are not always clear. Therefore, whether school-enterprise cooperation has been established is not the only criterion for evaluation. What is more critical is whether the cooperation process can enter the links of curriculum, practical training, evaluation, and mentor collaboration, and further be transformed into students' occupational ability and competence and educational outcomes of talent training.

Against this practical background, this study focuses on three questions. First,

how do Institutional Support and Resources, Industry-Education Integration Depth, Curriculum Matching, and the Two-Mentor Collaboration Mechanism jointly affect the Health-Industry Occupational Ability and Competence of higher vocational students? Second, does occupational ability and competence play a key transformative role between collaborative education mechanisms and Educational Outcomes of Talent Training? Third, does the Two-Mentor Collaboration Mechanism directly improve Educational Outcomes of Talent Training, or does it play an indirect role through competence generation?

To answer these questions, this study proposes a competence generation model of the "micro dual-subject community." The so-called "micro dual-subject community" does not generally refer to the macro-level school-enterprise cooperation relationship. Rather, it refers to a small-scale, strongly connected, and deeply collaborative educational unit formed around specific professional clusters, specific curriculum projects, specific job tasks, specific practice platforms, and specific mentor teams. Its operating logic is not to simply increase the number of enterprise participation activities or mentors, but to promote the continuous generation of students' occupational ability and competence through institutional guarantee, curriculum translation, mentor collaboration, and real task training.

2. Literature Review and Research Hypotheses

The development of the health industry has brought new competence requirements for talent training in higher vocational education. Students not only need to master basic skills in elderly care services, health management, and traditional Chinese medicine rehabilitation, but also need to possess communication service ability, interdisciplinary collaboration ability, and digital application ability. Existing studies show that work-based learning can place students in real work contexts, enhance their learning engagement and professional identity, and thereby promote the development of vocational competence [1]. Stable collaboration between vocational education institutions and workplaces also helps improve the responsiveness of curricula, teachers, and practice resources to industrial changes [2]. From this perspective, Institutional Support and Resources is not simply an external condition, but an important foundation for the sustainable operation of industry-education integration.

Curriculum is the key link through which industrial needs enter the talent training process. Research on work-integrated learning points out that practical teaching should not only allow students to enter enterprises or institutions. More importantly, through curriculum design, work experience should be transformed into clear learning tasks, evaluation standards, and reflection processes [3]. Assessment methods also affect how students understand and integrate work experience, thereby influencing the formation of learning outcomes [4]. Therefore, Curriculum Matching should not only examine whether curriculum content covers industrial skills, but also whether practical training projects, job tasks, and evaluation standards are mutually connected. For health-related professional clus-

ters, real tasks such as elderly care services, health management, smart elderly care, and community health services can truly be transformed into students' competence only when they enter the curriculum and practical training process.

Research on education in health-related professions also emphasizes the importance of real scenarios. Clinical placement models affect students' learning environments, feedback opportunities, and competence development [5]. Service learning can enhance students' health education competence, communication service ability, and practical reflection ability in community health tasks [6]. These studies show that talent training for the health industry cannot remain at the level of classroom knowledge transmission and simulated training, but should rely more on real service scenarios so that students can form professional technical competence and comprehensive vocational literacy through specific tasks.

Two-Mentor Collaboration is an important mechanism connecting school teaching and enterprise practice, but it does not automatically produce effects. Existing studies have found that competence development is a complex process, and short-term mentoring interventions alone are insufficient to stably improve the professional competence of students or new employees [7]. Although clinical preceptors play an important role in the transformation of theoretical knowledge, problem solving, and practical evaluation, they also face issues such as unclear boundaries of responsibility, inconsistent evaluation standards, and heavy workload [8]. This suggests that the key to the two-mentor system lies not in whether two types of mentors are assigned, but in whether on-campus mentors and enterprise mentors can carry out continuous guidance and joint evaluation around the same set of real job tasks.

Occupational ability and competence itself is also compound in nature. Competence in vocational education should not be understood merely as a certain operational skill, but should include knowledge, skills, attitudes, professional judgment, and contextual application [9]. The competence development of students in health-related majors is closely related to curriculum learning, clinical practice, and the matching of work tasks [10]. At the same time, digital transformation has further expanded vocational competence to information literacy, digital collaboration, digital problem solving, and reflective judgment [11]. Based on this, this study divides Health-Industry Occupational Ability and Competence into three dimensions: professional technical competence, comprehensive vocational literacy, and innovation and digital competence.

Overall, existing studies provide an important foundation for understanding talent training for the health industry in higher vocational education, but there is still room for further expansion. Existing research pays more attention to one aspect among work-based learning, practical teaching, mentor guidance, or digital competence, and less often places Institutional Support and Resources, industry-education integration, Curriculum Matching, Two-Mentor Collaboration, and occupational ability and competence in the same model for examination. Especially in health-related professional clusters of higher vocational education, how

industry-education integration is transformed into Educational Outcomes of Talent Training through curriculum and mentor mechanisms still requires further empirical testing. Based on this, this study constructs a structural equation model of "Institutional Support and Resources-Industry-Education Integration-Curriculum Matching-Two-Mentor Collaboration-Occupational Ability and Competence-Educational Outcomes of Talent Training" and proposes the following research hypotheses:

H1: Institutional Support and Resources positively affects Industry-Education Integration Depth, Curriculum Matching, and Health-Industry Occupational Ability and Competence.

H2: Industry-Education Integration Depth positively affects Curriculum Matching, the Two-Mentor Collaboration Mechanism, Health-Industry Occupational Ability and Competence, and Educational Outcomes of Talent Training.

H3: Curriculum Matching positively affects the Two-Mentor Collaboration Mechanism and Health-Industry Occupational Ability and Competence.

H4: The Two-Mentor Collaboration Mechanism positively affects Health-Industry Occupational Ability and Competence.

H5: Health-Industry Occupational Ability and Competence positively affects Educational Outcomes of Talent Training.

H6: Curriculum Matching, the Two-Mentor Collaboration Mechanism, and Health-Industry Occupational Ability and Competence play multiple mediating roles between Industry-Education Integration Depth and Educational Outcomes of Talent Training.

3. Research Design

3.1. Variable Measurement

This study adopts a five-point Likert scale to measure variables including Institutional Support and Resources, Industry-Education Integration Depth, Curriculum Matching, the Two-Mentor Collaboration Mechanism, Health-Industry Occupational Ability and Competence, and Educational Outcomes of Talent Training. Among them, 1 indicates "strongly disagree," and 5 indicates "strongly agree." The variables and measurement dimensions are shown in Table 1.

Table 1. Variable measurement and item composition.

Variable type	Variable name	Variable symbol	Measurement dimensions/item composition	Number of items
Independent variable	Institutional Support and Resources	IS	Institutional guarantee, policy support, financial support, training platform construction, regional industrial collaboration	5
Mediating variable	Industry-Education Integration Depth	IE	Enterprise participation EP, degree of dual-subject collaboration SC	9

Continued

Mediating variable	Curriculum Matching	CM	Curriculum content matching, curriculum cluster collaboration, practical training course alignment, coverage of skill needs, authenticity of practical training project scenarios	5
Mediating variable	Two-Mentor Collaboration Mechanism	TM	On-campus mentor guidance, enterprise mentor guidance, division of work between two mentors, communication frequency, improvement of practical ability	5
Mediating variable	Health-Industry Occupational Ability and Competence	AC	Professional technical competence PT, comprehensive vocational literacy CQ, innovation and digital competence ID	15
Dependent variable	Educational Outcomes of Talent Training	OE	Job competence, employment matching, career development potential, satisfaction with training quality, perceived career growth	5
Sample background variable	Individual background information	—	Gender, identity, professional direction, whether participated in enterprise practice, duration of practice, grade	—

In Table 1, Industry-Education Integration Depth is jointly represented by enterprise participation and the degree of dual-subject collaboration, while Health-Industry Occupational Ability and Competence is jointly represented by professional technical competence, comprehensive vocational literacy, and innovation and digital competence. In the formal analysis, this study combines EP and SC into Industry-Education Integration Depth, and combines PT, CQ, and ID into Health-Industry Occupational Ability and Competence, in order to test the pathways among variables.

3.2. Sample and Data Processing

This study first uses 80 pre-test samples for item analysis, reliability testing, and exploratory factor analysis to examine the preliminary applicability of the questionnaire. Subsequently, the formal sample is divided into exploratory sample A and validation sample B. Among them, exploratory sample A consists of 197 responses and is used for formal exploratory factor analysis and the fixation of the item structure. Validation sample B consists of 232 responses and is used for confirmatory factor analysis, convergent validity, discriminant validity, structural equation modeling, and mediation effect testing.

It should be noted that the role of the pre-test stage is not to revise the items, but to examine the overall applicability of the original questionnaire. Since the formal questionnaire had already been distributed at the same time, on the basis that the pre-test results showed the overall usability of the scale, this study retained

the original items for formal sample analysis and further confirmed the item structure in exploratory sample A according to unified criteria.

3.3. Analytical Methods

This study adopts a combination of EFA, CFA, and SEM. First, the pre-test sample is used to examine the preliminary reliability and structure of the scale. Second, exploratory sample A is used to conduct formal EFA and fix the final item structure. Third, validation sample B is used to conduct CFA and examine measurement model fit, standardized factor loadings, composite reliability CR, average variance extracted AVE, and discriminant validity. Finally, after the measurement model passes the test, a structural equation model is constructed, and the Bootstrap method is used to test indirect effects.

4. Empirical Results

4.1. Pre-Test and Exploratory Factor Analysis

The results of the 80 pre-test samples show that the Cronbach's α of the total scale is 0.953, and the Cronbach's α values of each dimension range from 0.795 to 0.902, all reaching acceptable standards. The KMO value is 0.832, and Bartlett's test of sphericity is significant, indicating that the sample data are suitable for factor analysis. The item analysis results show that the corrected item-total correlations of all items are higher than 0.30, and the differences between the high and low groups are significant.

The exploratory factor analysis shows that dimensions such as professional technical competence, comprehensive vocational literacy, Curriculum Matching, enterprise participation, and Educational Outcomes of Talent Training demonstrate good convergence, while individual items in dimensions such as innovation and digital competence and Institutional Support and Resources show certain risks of low loading or cross-loading. Given that the overall reliability and validity meet the research requirements, this study did not delete items at the pre-test stage, but continued to examine the scale structure in the formal exploratory sample.

Formal exploratory sample A consists of 197 responses. The analysis results show that the Cronbach's α of the total scale is 0.950, and the Cronbach's α values of each dimension range from 0.837 to 0.900, all higher than 0.80. The KMO value is 0.9145, and Bartlett's test of sphericity is significant, indicating that the data are suitable for exploratory factor analysis. After conducting EFA according to theoretical modules, it is found that the competence structure module, industry-education integration module, Curriculum Matching, the Two-Mentor Collaboration Mechanism, Educational Outcomes of Talent Training, and Institutional Support and Resources all meet the requirements for factor loadings, communalities, and cumulative explained variance. The corrected item-total correlations within each item dimension are all higher than 0.30, and deleting any item does not significantly improve the Cronbach's α of its corresponding dimension. Therefore, no items are deleted in exploratory sample A.

Finally, all 44 items are retained, and the same structure is used in validation sample B for CFA and SEM analysis.

4.2. Confirmatory Factor Analysis and Convergent Validity

Validation sample B consists of 232 responses. Based on the 44-item structure fixed by sample A, this study conducts confirmatory factor analysis. The fit results of the measurement model are as follows: $\chi^2/df = 1.093$, CFI = 0.987, TLI = 0.985, RMSEA = 0.020, and SRMR = 0.042. All indicators meet commonly used judgment standards, indicating that the measurement model fits well.

The standardized factor loadings of all items are higher than 0.50, with the lowest loading being 0.643. Among them, the standardized loadings of items such as TM2, TM1, ID1, CM2, and IS4 are slightly lower than 0.70, but all are clearly higher than 0.50, and the CR and AVE of their corresponding latent variables meet the requirements. Therefore, they are retained.

As shown in Table 2, the CR values of all latent variables are greater than 0.70, and the AVE values are greater than 0.50, indicating that the scale has good composite reliability and convergent validity. Among them, the AVE of TM is 0.504, which is at a critical level but still reaches the acceptable standard.

Table 2. CR and AVE results of each latent variable.

Variable	CR	AVE	Judgment
PT Professional technical competence	0.872	0.577	Qualified
CQ Comprehensive vocational literacy	0.915	0.682	Qualified
ID Innovation and digital competence	0.879	0.593	Qualified
CM Curriculum Matching	0.871	0.575	Qualified
EP Enterprise participation	0.913	0.678	Qualified
SC Dual-subject collaboration	0.883	0.654	Qualified
TM Two-Mentor Collaboration	0.835	0.504	Qualified
OE Educational Outcomes of Talent Training	0.884	0.603	Qualified
IS Institutional Support and Resources	0.846	0.523	Qualified

4.3. Discriminant Validity Test

Considering that innovation and digital competence may have relatively strong correlations with Educational Outcomes of Talent Training and Institutional Support and Resources in the pre-test and full-sample EFA, this study focuses on testing the discriminant validity between ID and OE, and between ID and IS.

Table 3 results show that although innovation and digital competence has certain correlations with Educational Outcomes of Talent Training and Institutional Support and Resources, no measurement confusion occurs. In particular, the correlation between ID and IS is relatively high, indicating that the development of students' innovation and digital competence is closely related to institutional guarantee, training platforms, and regional industrial resources. However, the two

remain distinguishable in terms of measurement structure.

Table 3. Discriminant validity test of ID with OE and IS.

Variable relationship	Latent variable correlation coefficient	Comparison of AVE square roots	HTMT	Judgment
ID-OE	0.575	Lower than ID √AVE = 0.770 and lower than OE √AVE = 0.776	0.575	Passed
ID-IS	0.705	Lower than ID √AVE = 0.770 and lower than IS √AVE = 0.723	0.709	Passed

4.4. Structural Equation Model Test

After the measurement model passes the test, this study further constructs the structural equation model. In the structural model, PT, CQ, and ID are combined into Health-Industry Occupational Ability and Competence AC, while EP and SC are combined into Industry-Education Integration Depth IE, in order to test the pathways among Institutional Support and Resources, Industry-Education Integration Depth, Curriculum Matching, the Two-Mentor Collaboration Mechanism, Health-Industry Occupational Ability and Competence, and Educational Outcomes of Talent Training.

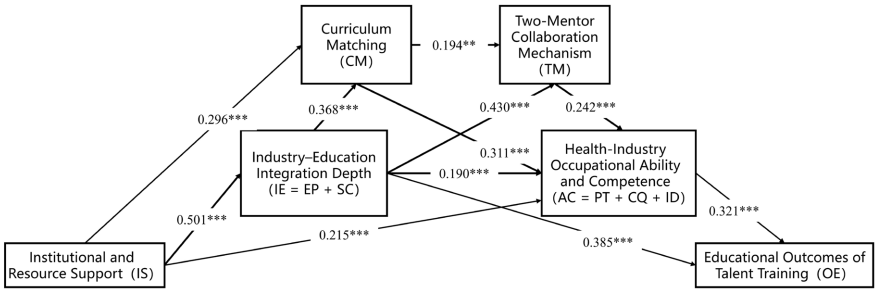
The fit results of the structural model are as follows: χ^2/df = 2.744, CFI = 0.987, TLI = 0.952, RMSEA = 0.087, and SRMR = 0.035. Except that RMSEA is slightly high, χ^2/df, CFI, TLI, and SRMR all reach a good level. Considering that the degrees of freedom of the structural model are relatively small, RMSEA may be relatively high. Therefore, this study considers that the overall fit of the model basically reaches an acceptable level and can be used to explain the pathways among variables.

As shown in Table 4, Institutional Support and Resources significantly and positively affects Industry-Education Integration Depth, Curriculum Matching, and Health-Industry Occupational Ability and Competence. Industry-Education Integration Depth significantly and positively affects Curriculum Matching, the Two-Mentor Collaboration Mechanism, Health-Industry Occupational Ability and Competence, and Educational Outcomes of Talent Training. Curriculum Matching significantly and positively affects the Two-Mentor Collaboration Mechanism and Health-Industry Occupational Ability and Competence. The Two-Mentor Collaboration Mechanism significantly and positively affects Health-Industry Occupational Ability and Competence. Health-Industry Occupational Ability and Competence significantly and positively affects Educational Outcomes of Talent Training.

This indicates that Educational Outcomes of Talent Training are not determined by a single institutional investment or a single form of cooperation, but are the result of the continuous effects of institutional support, curriculum translation, mentor collaboration, and occupational ability and competence improvement. (in Figure 1)

Table 4. Path coefficients of the structural model.

Path	Standardized coefficient β	p-value	Conclusion
IS → IE	0.501	<0.001	Supported
IS → CM	0.296	<0.001	Supported
IE → CM	0.368	<0.001	Supported
IE → TM	0.430	<0.001	Supported
CM → TM	0.194	0.003	Supported
CM → AC	0.311	<0.001	Supported
TM → AC	0.242	<0.001	Supported
IE → AC	0.190	0.001	Supported
IS → AC	0.215	<0.001	Supported
AC → OE	0.321	<0.001	Supported
IE → OE	0.385	<0.001	Supported



*Note. The coefficients are standardized path coefficients. **p < 0.01, ***p < 0.001.

Figure 1. Path model of industry-education integration promoting educational outcomes of talent training in higher vocational education for the health industry.

4.5. Mediation Effect Test

This study uses the Bootstrap method to test mediation effects. Table 5 results show that multiple indirect pathways are significant. Institutional Support and Resources can affect Educational Outcomes of Talent Training through Industry-Education Integration Depth, Curriculum Matching, and Health-Industry Occupational Ability and Competence. This indicates that institutional support is not merely an external guarantee condition, but can be transformed into training outcomes through the collaborative education process. Industry-Education Integration Depth can affect Educational Outcomes of Talent Training through Curriculum Matching, Two-Mentor Collaboration, and Health-Industry Occupational Ability and Competence. This shows that the key to industry-education integration is not whether enterprises participate, but whether enterprise participation can enter the process of curriculum, mentors, and job task training. Curriculum Matching can affect Educational Outcomes of Talent Training through Health-Industry Occupational Ability and Competence, indicating that the curriculum system is an important mechanism for translating industrial needs into students' competence.

Table 5. Test results of multiple mediating pathways.

Mediating pathway	Standardized indirect effect	Bootstrap test result	Conclusion
IE → CM → AC → OE	0.037	Significant	Supported
IE → TM → AC → OE	0.033	Significant	Supported
IE → CM → TM → AC → OE	0.006	Significant	Supported
CM → AC → OE	0.100	Significant	Supported
CM → TM → AC → OE	0.015	Significant	Supported
TM → AC → OE	0.078	Significant	Supported
IS → IE → OE	0.193	Significant	Supported
IS → CM → AC → OE	0.030	Significant	Supported
IS → IE → CM → AC → OE	0.018	Significant	Supported
IS → IE → TM → AC → OE	0.017	Significant	Supported

It is worth noting that the Two-Mentor Collaboration Mechanism indirectly affects Educational Outcomes of Talent Training through Health-Industry Occupational Ability and Competence. Further model comparison shows that the direct effect of the Two-Mentor Collaboration Mechanism on Educational Outcomes of Talent Training is unstable, while its indirect effect through Health-Industry Occupational Ability and Competence is clearer. This means that the effectiveness of the two-mentor system does not depend on the formal addition of mentor types, but on whether on-campus mentors and enterprise mentors can carry out continuous guidance around the same set of real tasks and jointly promote the improvement of students' occupational ability and competence.

5. Further Discussion

5.1. The Key to Industry-Education Integration Is Not Only Cooperation, but Competence Generation

This study finds that Industry-Education Integration Depth not only directly affects Educational Outcomes of Talent Training, but also plays an indirect role through Curriculum Matching, Two-Mentor Collaboration, and Health-Industry Occupational Ability and Competence. This shows that the quality of industry-education integration cannot be measured simply by the number of cooperation agreements, the frequency of enterprise participation, or the scale of training bases. A more explanatory question is whether enterprise resources enter curriculum content, whether real projects are transformed into practical training tasks, and whether students thereby form transferable, evaluable, and developable occupational ability and competence.

In this sense, the evaluation of industry-education integration needs to shift from a "cooperative relationship orientation" to a "competence generation orientation." If enterprise participation does not enter the processes of curriculum, practical training, evaluation, and mentor collaboration, cooperation may remain

at the formal level. Conversely, only when real enterprise projects, job tasks, service processes, and professional norms are translated into curriculum projects and practical training content can industry-education integration truly promote students' competence development.

5.2. Two-Mentor Collaboration Is Not Naturally Effective, but Becomes Effective through Competence Transformation

The two-mentor system is an important mechanism in the reform of higher vocational education. However, this study finds that the Two-Mentor Collaboration Mechanism mainly affects Educational Outcomes of Talent Training indirectly through Health-Industry Occupational Ability and Competence, rather than directly and stably affecting Educational Outcomes of Talent Training. This result suggests that the two-mentor system cannot simply be understood as the personnel addition of "school mentor + enterprise mentor."

In some practices, enterprise mentors may only occasionally give lectures, lead students on visits, or participate in stage-based evaluation. Such forms of participation may not truly change students' competence structure. For Two-Mentor Collaboration to play its role, on-campus mentors and enterprise mentors need to form stable cooperation around common curriculum projects, real job tasks, and student competence evaluation. In other words, the effectiveness of Two-Mentor Collaboration lies not in "whether it exists," but in "how collaboration is carried out"; not in the "number of mentors," but in "competence transformation."

5.3. Curriculum Matching Is the Translation Mechanism through Which Industrial Needs Enter Talent Training

The results show that Curriculum Matching significantly affects Health-Industry Occupational Ability and Competence and promotes the Two-Mentor Collaboration Mechanism. This indicates that curriculum is not a passive receiving link in industry-education integration, but the core translation mechanism connecting industrial needs and students' competence.

The new positions, new tasks, and new technologies in the health industry are changing rapidly. In particular, fields such as smart elderly care, health management, community elderly care, traditional Chinese medicine rehabilitation, and digital health services have put forward new requirements for curriculum systems. If curriculum content remains at the level of traditional knowledge modules and static skill training, it will be difficult to form effective Educational Outcomes of Talent Training even if schools have enterprise cooperation resources. The key to curriculum reform is to translate industrial standards, service processes, enterprise cases, real projects, and new-industry skills into curriculum content, project tasks, and evaluation standards.

5.4. Innovation and Digital Competence Show Obvious Institutional Embeddedness

The discriminant validity test shows that innovation and digital competence has

acceptable discriminant validity with Educational Outcomes of Talent Training and Institutional Support and Resources. Among them, the correlation between ID and IS is relatively high but does not lead to measurement confusion. This result indicates that in talent training for the health industry, innovation and digital competence is not an isolated ability naturally formed by individual students, but is highly dependent on support from school institutional guarantees, training platforms, digital tools, regional industrial collaboration, and real service scenarios.

Therefore, to improve students' innovation and digital competence, higher vocational colleges should not merely increase information-based courses or digital tool training. They also need to provide support at the levels of institutions, platforms, projects, and scenarios. For example, embedding health management data analysis, the use of smart elderly care equipment, and the optimization of digital service processes into real projects and practical training tasks can truly make innovation and digital competence an important component of Health-Industry Occupational Ability and Competence.

6. Conclusions and Implications

Based on 80 pre-test samples, 197 exploratory samples A, and 232 validation samples B, this study constructs and tests a competence generation model of the "micro dual-subject community" for health-related professional clusters in higher vocational education. The study finds that, first, the scale constructed in this study has good overall reliability and validity, and all 44 items can be retained. Second, Institutional Support and Resources, Industry-Education Integration Depth, Curriculum Matching, and the Two-Mentor Collaboration Mechanism all have significant effects on Health-Industry Occupational Ability and Competence and Educational Outcomes of Talent Training. Third, Health-Industry Occupational Ability and Competence is the key variable through which collaborative education mechanisms are transformed into Educational Outcomes of Talent Training. Fourth, the Two-Mentor Collaboration Mechanism does not directly and stably improve Educational Outcomes of Talent Training, but mainly plays an indirect role by improving students' occupational ability and competence. Fifth, Curriculum Matching is an important mechanism for translating industrial needs into occupational ability and competence, while innovation and digital competence shows strong institutional embeddedness.

These findings indicate that research on industry-education integration needs to move further from "cooperation forms" to "competence generation mechanisms." In the construction of health-related professional clusters in higher vocational education, school-enterprise cooperation, curriculum construction, mentor guidance, and institutional support are not separate reform measures. Rather, they jointly constitute a continuous chain of occupational ability and competence generation. Institutional support provides the foundation for school-enterprise collaboration, industry-education integration promotes the entry of industrial resources into the teaching process, Curriculum Matching completes the translation

of industrial needs into teaching content, and Two-Mentor Collaboration promotes students' competence improvement through real task guidance, ultimately affecting Educational Outcomes of Talent Training.

Based on the research conclusions, this study proposes three practical implications.

First, an evaluation system for industry-education integration should be reconstructed with occupational ability and competence as the core. Higher vocational colleges should not evaluate the effectiveness of industry-education integration only by the number of cooperation agreements, the frequency of enterprise participation, or the scale of training bases. Instead, they should pay more attention to the actual improvement of students' professional technical competence, comprehensive vocational literacy, and innovation and digital competence. Evaluation indicators should shift from "resource input" to "competence output," and from "cooperation form" to "education quality."

Second, micro dual-subject communities should be built with curriculum projects as the carrier. Industry-education integration in health-related professional clusters should not rely only on macro-level school-enterprise cooperation platforms. Instead, around typical scenarios such as elderly care services, health management, traditional Chinese medicine rehabilitation, community health services, and smart elderly care, small educational units of "school teachers + enterprise mentors + curriculum projects + real tasks + practice platforms" should be formed. Such communities do not necessarily need to be large in scale, but they should have close connections, real tasks, and clear evaluation.

Third, the Two-Mentor Collaboration Mechanism should be improved through real job tasks. The two-mentor system should shift from "mentor allocation" to "mentor collaboration." Schools need to clarify the responsibility boundaries of on-campus mentors and enterprise mentors, and establish mechanisms for regular communication, joint lesson preparation, joint guidance, joint evaluation, and joint feedback. Enterprise mentors should not participate only through lectures or visits, but should provide continuous guidance around real job tasks, service norms, professional contexts, and practical problems.

The main contribution of this study lies in advancing the focus of industry-education integration research from "cooperation forms" to "competence generation mechanisms," and revealing through structural equation modeling the multiple pathways among Institutional Support and Resources, industry-education integration, Curriculum Matching, Two-Mentor Collaboration, occupational ability and competence, and Educational Outcomes of Talent Training. The competence generation model of the "micro dual-subject community" proposed in this study helps explain how industry-education integration in health-related professional clusters in higher vocational education can be transformed from external cooperative relationships into students' real occupational ability and competence.

Of course, this study still has certain limitations. First, this study uses cross-sectional questionnaire data, which cannot fully reveal the dynamic process of

competence generation. Future research may combine follow-up surveys, interview data, and teaching practice cases for in-depth analysis. Second, this study mainly measures Educational Outcomes of Talent Training from the perceptions of students, teachers, and enterprise mentors. Future studies may further introduce objective indicators such as employment quality, job performance, and enterprise evaluation to enhance the explanatory power of the conclusions.

Overall, in the context of the health industry, the key to talent training in higher vocational education is not simply to increase school-enterprise cooperation projects or two-mentor allocation, but to establish micro dual-subject communities that can continuously promote the generation of students' occupational ability and competence. Only when institutional support, industry-education integration, Curriculum Matching, mentor collaboration, and real task training form a continuous closed loop can industry-education integration truly be transformed into the quality of talent training.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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