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Research on the Construction of a Five-Dimensional Model for Enhancing Teachers' Core Competencies and Its Implementation Strategies in the AI Era

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Abstract

This paper explores the issues and countermeasures for enhancing the core teaching competencies of teachers in higher vocational colleges (HVCs) in the AI era. By constructing a five-dimensional model, encompassing AI technology integration capability, cross-disciplinary group integration capability, AI ethical reasoning capability, tiered development capability, and human-machine collaboration capability, it analyzes the existing problems in the teaching capabilities of HVC teachers, such as superficial technology application, disciplinary barriers, superficial ethical teaching, lack of tiered development mechanisms, and imbalance between technological tools and the essence of education. In response to these issues, innovative countermeasures are proposed, including implementing a tiered AI teaching capability certification system, constructing a school-enterprise data fusion laboratory, establishing an "AI + Professional" dual-mentor collaboration platform, building an AI ethical risk assessment toolbox, establishing a three-dimensional capability coordinate tiered development model, and constructing a certification system for "emotion-enhancing AI teaching aids." These measures aim to provide references for the construction of teaching capabilities in HVC teachers and promote the transformation and innovation of vocational education.

Keywords

Higher Vocational College Teachers, Teaching Core Competencies, Five-Dimensional Model, AI Era

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1. Introduction

Geoffrey Hinton, the 2024 Nobel Prize winner in Physics, holds numerous visions for AI education reform. He emphasizes the importance of fundamental research, cultivating students' innovative thinking and practical abilities, and advocates for interdisciplinary education. He believes that the cross-disciplinary integration of AI can drive its application in various industries, aligning with China's educational policy trends in the AI era (Yao, 2024; Chen & Yao, 2024). In the AI era, enhancing the teaching capabilities of HVC teachers is the core driving force for vocational education reform. With the rapid development of high-tech represented by artificial intelligence technology, industrial forms are being reshaped, posing new requirements for the cultivation of skilled talents (Gao & Li, 2025). As a key node in the educational ecosystem, teachers need to achieve capability leaps in multiple aspects: 1) Technology integration capability. AI tools are deeply reconstructing teaching scenarios, and teachers need to master intelligent teaching design capabilities, accurately identify students' knowledge gaps with data-driven methods, and dynamically adjust teaching content. For example, using intelligent recommendation systems to customize learning paths for students or solving practical training difficulties through virtual simulation technology to transform abstract theories into immersive experiences (Wang, 2025). 2) Interdisciplinary Innovation Literacy. The cross-border integration of technologies requires teachers to break through disciplinary barriers. Non-AI-specialized teachers should incorporate AI cases into their specialized courses to guide students in applying technological tools to solve practical problems. AI-specialized teachers, on the other hand, need to keep abreast of the technological frontier and transform industry practices into teaching resources through industry-university-research cooperation, so as to prevent course content from being out of sync with technological advancements (Wei et al., 2025). 3) Ethical reasoning and educational wisdom. Given the double-edged sword effect of AI, teachers shoulder the responsibility of ethical guidance and need to critically assess the boundaries of technology applications, such as data privacy protection and algorithm bias risks, and cultivate students' technological reflection abilities in teaching. For example, discussing the social impact of "machine replacement of human labor" in intelligent manufacturing courses and internalizing technological ethics into professional qualities to promote sustainable development education (Li et al., 2025). 4) Tiered development capability. The HVC teacher population has significant differences in teaching age, professional background, and technological application levels, necessitating the construction of a differentiated training mechanism to adapt to the development needs of different teachers (Li, 2024). 5) Human-machine collaboration capability. The in-depth application of AI requires teachers to reposition the roles of humans and machines, establish trust between teachers and students, focus on the cultivation of high-order abilities, and control the boundaries of technology applications (Jing & Zhou, 2024; Huang et al., 2024).

The authors construct a five-dimensional model for teachers' core competencies, investigate existing problems in 56 HVCs in Zhejiang and other provinces, explore countermeasures for implementing the five-dimensional model, and point out feasible paths for enhancing and developing the teaching capabilities of HVC teachers in the AI era, providing theoretical references and practical guidance for teacher team construction.

2. Construction of a Five-Dimensional Model for Core Competencies

The core teaching competencies model for HVC teachers in the AI era can be integrated into a structured framework containing five key dimensions.

2.1. AI Technology Integration Capability

HVC teachers need to master AI tools and data analysis skills to achieve precise teaching design and become builders of intelligent educational scenarios. 1) Intelligent teaching design involves using knowledge graphs and learning analysis systems to diagnose students' knowledge gaps and dynamically adjust teaching content, such as customizing personalized learning paths based on learning situation data; utilizing VR/AR technology to construct immersive practical training scenarios to solve practical training difficulties such as "high-risk, difficult-to-observe" operations, for example, virtual fault diagnosis of mechanical and electrical equipment. 2) Data-driven decision-making involves pushing appropriate resources through intelligent recommendation systems, optimizing teaching strategies, and achieving real-time feedback based on teaching behavior data. For example, the TAFE system in Australia requires teachers to complete "AI teaching sandbox simulations" each semester to simulate technology adaptations in different professional scenarios, such as agricultural professional data analysis combined with drones.

2.2. Cross-Disciplinary Group Integration Capability

Teachers need to break through disciplinary barriers, promote technology-enabled professional innovation across disciplines and professional groups, and become builders of bridges between AI and professions. 1) Non-AI professional teachers should integrate AI cases into courses, such as introducing AI customer service data analysis in business and trade majors and combining intelligent production line modeling in manufacturing majors to guide students in using technology to solve real problems. 2) AI professional teachers should convert industry practice resources through school-enterprise cooperation to ensure that courses keep pace with technological developments. For example, the Fraunhofer Institute in Germany jointly develops "Industry 4.0 cross-disciplinary modules" with HVCs, with mechanical, IT, and management teachers jointly designing intelligent factory practical training projects.

2.3. AI Ethical Reasoning Capability

Teachers need to critically assess AI technology risks, cultivate students' sense of responsibility, and become gatekeepers of technology applications. 1) Embed ethical issues by discussing ethical topics such as data privacy and algorithm bias in teaching, such as discussing the social impact of "machine replacement of human labor" in intelligent manufacturing courses. 2) Establish boundary awareness by guiding students to internalize ethical norms into professional qualities. For example, British Columbia in Canada includes "AI ethics workshops" in the mandatory continuing education credits for teachers, containing interactive forms such as mock court debates.

2.4. Tiered Development Capability

HVCs need to construct a classified training mechanism to match teachers' differentiated needs and become leaders in tiered development. 1) AI professional teachers should deepen their knowledge of cutting-edge technologies, lead curriculum development, and enhance their capabilities through school-enterprise cooperation and technological research and training. 2) Ordinary professional teachers should strengthen their digital literacy and innovative teaching methods and enhance their capabilities through hybrid training and school-based workshops. For example, the German "dual system" tiered model designs "digital competence passports" based on teaching age and professional types, with senior teachers focusing on "technological ethics reviews" and new teachers completing "AI teaching design" module certifications.

2.5. Human-Machine Collaboration Capability

Human-machine collaboration will become the norm in education, and teachers need to balance technological tools with the essence of education and become guides for human-machine collaboration. 1) Emotional interaction is irreplaceable, and teachers should stimulate learning motivation through eye contact, facial expressions, and physical interactions to compensate for the emotional shortcomings of AI. 2) Focus on the cultivation of high-order abilities: Use AI to handle mechanical tasks, freeing up time to deepen the training of innovative thinking and critical thinking. For example, Singapore's "human-machine collaboration framework" clearly divides the responsibilities of AI and teachers, incorporates them into teacher assessment indicators, and requires teachers to systematically use the time saved by AI to carry out critical thinking training.

3. Analysis of Existing Problems in Teachers' Teaching Capabilities

From May to June 2025, the authors conducted a survey on the application and impact of AI in the teaching of HVC teachers, covering 17 questions such as basic information, AI awareness, and AI technology application. The survey objects were teachers from 56 HVCs inside and outside Zhejiang Province. A total of 475 questionnaires were distributed, and 419 valid questionnaires were recovered. Through statistical analysis, the following outstanding problems were found in the development of teachers' teaching capabilities.

3.1. Superficial Technology Application and Resource Mismatch

Problems in AI technology integration capability include: 1) Technology application stays at the tool level. Only 34.6% of teachers frequently use AI technology, and the teaching design capability score is the lowest at 61.7 points. Intelligent diagnosis is lacking, with only 18% of HVC teachers able to use learning analysis systems to dynamically adjust teaching content, and most relying on empirical judgment of learning situations. The utilization rate of immersive technologies is low, with 76% of VR/AR practical training scenarios only used for demonstrations and not achieving the repeated training function of "high-risk operations". 2) Data-driven decision-making capabilities remain underdeveloped, with behavioral data utilization proving insufficient. Teachers' average rating for "instructional optimization strategies based on teaching data" was only 62.3, reflecting significant implementation gaps. Compounded by prevalent data silos, 89% of institutions have failed to integrate academic management systems with AI analytics platforms, resulting in fragmented learning analytics data that hinders holistic insights. Recommendation systems further exhibit rigidity, as intelligent resource delivery primarily relies on predefined tags (e.g., disciplinary classifications) without dynamic identification of learners' cognitive styles (e.g., adapting to visual/auditory preferences), thereby limiting personalized support. 3) Training and demand are mismatched. 58.7% of teachers believe that "teacher strength" is the main constraint. Actual training focuses on tools over logic, with 72% of training focusing on software operations and neglecting AI educational theory. School-enterprise collaboration is lacking, with few institutions introducing real enterprise production data for teaching case development.

3.2. Disciplinary Barriers and Industry-Education Disconnection

Problems in cross-disciplinary group integration capability include: 1) Non-AI professional integration is formalized. 42% of AI customer service cases in business and trade majors only analyze call duration and do not combine with professional core issues such as supply chain optimization; intelligent production line modeling in manufacturing teaching mostly uses standardized demos and lacks local adaptation by institutions. 2) AI professional teachers are disconnected from industry practice. Cutting-edge technologies are missing in HVC AI courses, with only 31% of courses covering generative AI, far lower than enterprise application rates. Industry-academia-research is disconnected, with 67% of AI teachers having no enterprise internship experience, resulting in difficulties in converting practical projects into teaching resources. 3) Organizational mechanism obstacles. Cross-disciplinary collaboration platforms are lacking, with few HVCs establishing "AI professional group collaboration centers," resulting in scattered resources and repeated purchases of similar AI tools by different majors. Evaluation is fragmented, with cross-disciplinary project outcomes often classified under single-discipline assessments, inhibiting teacher participation and enthusiasm.

3.3. Insufficient Risk Identification and Educational Transformation

Problems in AI ethical reasoning capability include: 1) AI ethics teaching is superficial. The coverage of topics is narrow, with 66.4% of teachers focusing on data privacy, but algorithm bias discussions are insufficient, with only 12% of courses analyzing gender/regional discrimination in recommendation systems. Social impact is lacking, with only 8% of intelligent manufacturing courses involving discussions on the impact of "machine replacement of human labor" on employment structures. 2) Teachers' own ethical literacy is insufficient. 54% of teachers believe that "AI decisions are completely objective," ignoring data biases in model training; only 29% of institutions clearly require AI teaching tools to pass ethical reviews. 3) Students' internalization mechanisms are lacking. 91% of practical training does not set up ethical conflict scenarios; evaluation standards are vague, with only "whether it is illegal" and other bottom-line requirements, lacking high-order indicators such as "algorithm fairness design".

3.4. Lack of Tiered Development and Differentiated Training Mechanisms

Problems in tiered development capability include: 1) Teaching age-based tiering is ineffective. The compliance rate of digital skills for teachers with 26 or more years of teaching experience is only 31.6%, while that for new teachers (1 - 5 years of teaching experience) is 50%. Training content is mostly general-purpose technological operations, lacking in-depth integration with professional teaching. 2) Structural contradictions exist. Senior teachers have cognitive inertia and lower adaptability to technological changes (such as weak capabilities in constructing VR/AR practical training scenarios); current training does not divide difficulty gradients based on teaching age, resulting in resource mismatches. 3) Professional type-based tiering is blank. Only 12% of HVCs have established enterprise practice bases for AI teachers, resulting in curriculum development lagging behind industry demands; non-AI professional teachers have weak cross-disciplinary integration capabilities, with less than 35% able to independently design AI teaching cases.

3.5. Imbalance between Technological Tools and the Essence of Education

Problems in human-machine collaboration capability include: 1) Mechanical substitution and high-order ability cultivation are disconnected. Teachers' scores for "using AI to handle homework grading" and other mechanical tasks are only 61.7 points; 68% of teachers still use pure manual methods to grade subjective assignments; only 29% of teachers can systematically use the time saved by AI to carry out critical thinking training. 2) Human-machine role cognition is blurred. 66.4% of teachers are concerned about data privacy, but only 14% of institutions offer "AI teaching ethics" workshops; some young teachers overly rely on intelligent recommendation systems but lack the ability to correct algorithm biases. 3) Collaborative scenario construction is lagging. Hardware and teaching design are disconnected, with only 23% of teachers able to combine virtual simulation practical training rooms with professional teaching objectives; emotional compensation mechanisms are lacking, with intelligent teaching aids generally lacking non-verbal interaction designs, and teachers also rarely receive training in "emotional communication in human-machine collaborative scenarios".

4. Countermeasures and Suggestions for Enhancing Core Competencies

There are five outstanding problems in the development of teaching capabilities for HVC teachers in the AI era, which urgently need to be enhanced and continuously upgraded. The relevant countermeasures are as follows.

4.1. Enhancement of AI Technology Integration Capability

In response to the pain points of superficial technology application, insufficient data-driven decision-making, and mismatched training supply and demand, and centered on the construction of a "certification system - data laboratory - closed-loop training," the following countermeasures are proposed: 1) Implement a tiered AI teaching capability certification system. Construct a three-tier certification system of "tool application - data decision-making - system innovation." The primary certification assesses VR/AR device operations, etc., requires completing intelligent teaching cases, and comes with an "AI tool first aid kit"; the intermediate certification requires using enterprise data to optimize teaching design and developing dynamic adjustment plans; the advanced certification leads cross-platform system development and requires submitting technological patents or teaching and research achievements. 2) Construct a school-enterprise data fusion laboratory. Build laboratories jointly with industry leaders, deploy real-time data sandboxes, and teaching behavior analysis engines. Develop a "five-step data conversion method" training module, covering data collection to effect verification. 3) Create a diagnosis - training - certification closed-loop system. Use AI assessment tools to analyze teachers' technological blind spots in the pre-diagnosis stage, generate personalized development path maps; practical assessment certifications include teaching recordings and have key indicator requirements; continuously track certified teachers and establish a "red-yellow-blue" early warning mechanism.

4.2. Enhancement of Cross-Disciplinary Group Integration Capability

In response to the pain points of disciplinary barriers, industry-education disconnection, and lack of cross-disciplinary collaboration mechanisms, and centered on the construction of a "dual-mentor system" and industry case library, the following countermeasures are proposed: 1) Establish an "AI + Professional" dual-mentor collaboration platform. Set up a school-level "cross-disciplinary AI integration center," form collaboration groups, formulate cross-disciplinary case development standards, and develop a shared resource library. 2) Establish a case update mechanism integrating industry, academia, and research Ensure that the case library is updated in sync with industry technologies. Implement the "dual - tutor enterprise practice system": AI teachers are required to complete one month on the job training in technical positions (such as algorithm engineers) every year; professional teachers participate in enterprise technological transformation projects (such as intelligent production line upgrades); jointly develop teaching - oriented cases (such as converting production line fault logs into training modules). Establish a dynamic elimination mechanism, with an annual update rate of at least 40% of the case library, and eliminate outdated content (for example, replace traditional customer service data analysis with AIGC dialogue optimization). 3) Implement a two dimensional performance appraisal system. Stimulate the internal motivation for cross professional collaboration. Quantify assessment indicators, including the depth of technology integration (the proportion of machine learning applications), professional suitability (the matching degree of cases with curriculum standards), and teaching effectiveness (the increase in the passing rate of students' enterprise internships); innovate incentive measures. Give double scoring for cross professional achievements (include them in the performance appraisals of both parties), provide "priority recommendation rights for industry academia research projects" to high quality case developers, and set up the "Golden Bridge Award" to honor the best cross professional teams of the year (with a bonus of 50,000 yuan per team).

4.3. Enhancement of AI Ethical Reasoning Capability

In response to the pain points of superficial ethical teaching, insufficient risk identification, and lack of professional quality integration, and centered on a "risk assessment - conflict simulation - norm transformation" three-stage training path, the following countermeasures are proposed: 1) Build an AI ethics risk assessment toolkit Enhance teachers' technical critical thinking abilities through standardized tools and dynamic case libraries. Develop an ethical checklist for AI applications in vocational colleges (including indicators such as data legality assessment and algorithm transparency scoring); Collaborate with leading enterprises (such as Sense Time) to establish an "industry warning case library", which updates real - life events (such as cases of gender discrimination in intelligent recruitment) on a quarterly basis; Implement a lesson planning system based on "ethical risk levels", requiring teaching plans to mark the risks of technology applications (such as psychological safety ratings for VR training) and corresponding response plans. 2) Conduct immersive ethical conflict simulation training. Strengthen teachers' teaching transformation abilities through multi-role scenario drills. Design conflict scenario packages related to different majors: For manufacturing majors, organize debates on "utilitarianism VS human rights ethics" in the fault prediction of intelligent production lines; For medical majors, hold mock courts on the privacy boundaries of health monitoring data sharing; Introduce real controversial events from enterprises (such as the attribution of liability in autonomous driving accidents), and require teachers to design teaching plans on site; Deploy an ethical decision making simulator (generating dynamic scenarios based on GPT-4) to train teachers in real-time to handle sudden ethical issues. 3) Establish a professional norm transformation certification system. Formulate a professional AI ethical capability map (such as mechanical majors needing to master the ethical weights of equipment safety redundancy design); implement a "dual-track certification," with teachers needing to submit classroom ethical discussion recordings (such as student debate videos on algorithm bias) and student works needing to include ethical compliance proofs (such as unbiased recommendation system design documents), jointly issue AI ethical teaching teacher certificates with the China Association for Artificial Intelligence, with certified teachers' courses enjoying enterprise priority adoption.

4.4. Enhancement of Tiered Development Capability

In response to the pain points of ineffective teaching age-based tiering, significant professional differences, and mismatched training resources, and centered on the construction of a "teaching age-professional matrix training system," the following countermeasures are proposed: 1) Establish a three-dimensional capability coordinate tiered development model. Construct a precise training system through three dimensions of teaching age groups, professional groups, and technological application scenarios. Teaching age tiering: 0 - 5-year teachers focus on basic AI tool operations and hybrid teaching design (such as micro-lesson production); 6 - 15-year teachers strengthen data-driven decision-making capabilities (such as learning situation analysis system applications); 16-year-and-above teachers focus on technological ethics reviews (such as AI lesson plan compliance assessments). Professional adaptation: AI majors offer "technological frontier tracking workshops" (such as monthly updates on AIGC tools); manufacturing majors customize "intelligent production line modeling certification courses" (including digital twin practical training); service majors develop "digital marketing analysis modules" (connecting to real e-commerce data platforms). 2) Implement a cell division-style precise training model. Break down traditional 8-hour courses into 15-minute "micro-ability capsules"; form "1 + 1 + 1" mentoring groups, with enterprise engineers (technological updates), teaching masters (experience transfer), and young teachers (tool generation transfer); construct professional AI sandbox laboratories (such as automotive maintenance majors configuring AR diagnosis and traditional tool hybrid workstations). 3) Implement a capability currency incentive mechanism. Establish a digital credit bank, with basic skill certifications = 100 EDU coins, cross-disciplinary case development = 300 EDU coins, and enterprise project conversion = 500 EDU coins (exchangeable for core journal publication guidance); set up dual-track promotion channels, with the traditional path being assistant lecturer → lecturer → associate professor and the innovative technological path being assistant lecturer → AI teaching engineer → intelligent education architect; dynamic allowance matrices (issuing differentiated subsidies based on teaching age/professional types, such as +1500 yuan/month for manufacturing teachers with 20 or more years of teaching experience).

4.5. Enhancement of Human-Machine Collaboration Capability

In response to the pain points of lack of emotional interaction, confusion between human-machine roles, and blurred ethical boundaries, and centered on the development of an "AI tool emotional compensation" training module and the setting of educational red lines, the following countermeasures are proposed: 1) Construct a certification system for "emotion-enhancing AI teaching aids." Promote school-enterprise cooperation to develop AI teaching tools with basic emotional interaction functions and establish a graded certification standard. Key elements include: facial expression recognition modules (such as capturing students' confused micro-expressions), physiological indicator monitoring (such as heart rate warnings during VR practical training), and manual takeover channels (teachers can interrupt AI processes at any time). 2) Implement a "three-line four-stage" educational red line training. Develop a boundary guideline for AI teaching ethics in HVCs, clarifying three core bottom lines: technological applications must not weaken teacher-student interactions (such as limiting AI question-answering time to ≤30 minutes per day); data collection is limited to teaching necessities (prohibiting the analysis of irrelevant information such as family backgrounds); teachers have the final decision-making power (such as requiring manual review of AI scores). Develop a typical conflict case bank with scenarios such as "AI misjudging student status" and "addressing algorithm bias", and incorporate these into teachers' annual evaluations. 3) Establish a "double helix" assessment and development system. Promote the continuous evolution of human-machine collaboration capabilities through dynamic assessments, constructing a two-way evaluation system for technological efficiency and humanistic care. Quantify indicators such as AI usage duration and knowledge point coverage efficiency; improve indicators such as student classroom participation and innovative thinking cultivation. Establish "human-machine collaborative teaching demonstration posts," with teachers successfully balancing technology and education receiving additional points in evaluation of technical positions (up to 5 points) and priority recommendation rights for enterprise cooperation projects.

5. Conclusion

In the AI era, enhancing the core teaching competencies of HVC teachers has become the key driving force for vocational education reform. By constructing a five-dimensional model, this paper deeply analyzes the existing problems in the teaching capabilities of HVC teachers and proposes targeted innovative countermeasures. These countermeasures not only focus on the integration and application of technologies but also emphasize the cultivation of core competencies such as cross-disciplinary integration, ethical reasoning, tiered development, and human-machine collaboration. The future has arrived, and HVCs should continuously deepen the construction of teachers' teaching capabilities, promote the in-depth integration of AI and education, and lay a solid foundation for cultivating high-quality skilled talents that adapt to the demand of the times. At the same time, teachers should also actively embrace changes, continuously enhance their own core teaching competencies, and jointly promote the innovative development of vocational education.

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Conflicts of Interest

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

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