

Innovation and Practice of a Talent Cultivation Model for AI Technical Skills in Higher Vocational Education Based on "Four-Stage Progression, Dual Integration, and Virtual-Physical Symbiosis"

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Abstract: The exponential iteration of artificial intelligence technology has posed three structural challenges to talent cultivation in higher vocational education: the widening technological generation gap, increasingly fragmented student profiles, and deepening superficiality in industry-education collaboration. This study constructs a theoretical model of "Four-Stage Progression, Dual Integration, and Virtual-Physical Symbiosis," achieving a paradigm breakthrough through a three-dimensional governance framework. A dynamic stratification mechanism based on competency models resolves the contradiction between student heterogeneity and teaching homogeneity; a curriculum transformation path relying on decomposed industrial work orders establishes a rapid translation channel from technical knowledge to educational elements; and a certification closed-loop ecosystem is built to form a value feedback chain between teaching and work driven by competency certification. This model provides innovative theoretical contributions in reconstructing educational governance structures, mechanisms for translating technical knowledge, and the evolution of industry-education integration ecosystems. Its scaling requires overcoming challenges such as gradient dependence on regional industrial innovation capacity, high-level technology reliance in virtual training platforms, and institutional rigidity constraints. Future development paths must deconstruct institutional barriers through flexible academic system reforms, leverage cross-regional vocational education communities to dilute resource disparities, and innovate digital education infrastructure supply

models via public-private partnership paradigms.

Keywords: Artificial Intelligence Technology; Talent Cultivation Model; Higher Vocational Education; Industry-Education Integration; Educational Governance

1. Introduction

The rapid advancement of artificial intelligence (AI) technology is reshaping the global industrial landscape. According to the Artificial Intelligence Industry Talent Development Report (2023) issued by the Ministry of Industry and Information Technology, the talent gap in China's AI sector has reached 5 million, with an annual growth rate exceeding 30% [1]. Against this backdrop, higher vocational institutions, as the main base for cultivating technical skills talents, are confronted with the acute contradiction between "technological leaps" and "talent lag." This contradiction has been explicitly highlighted in the Implementation Plan for National Vocational Education Reform, which states that "teaching content lags behind industrial iterations, and industry-education collaboration remains superficial"[2]. Particularly in the field of AI, the conflict between accelerated technological update cycles and the rigidity of traditional teaching systems has become increasingly pronounced. There is a growing demand across various industries for practical talents proficient in cutting-edge technologies such as AIGC and edge computing. However, higher vocational institutions commonly face issues such as disconnection between curriculum content and industrial practices, mismatch between heterogeneous student profiles and homogeneous teaching approaches, and perfunctory industry-academy

cooperation [3]. This phenomenon of "technology sprinting ahead while talent limps behind" not only constrains the regional development of the digital economy but also hinders vocational education's effective response to national strategic needs. Therefore, exploring innovative talent cultivation models aligned with the characteristics of the AI industry has become a critical issue in vocational education reform [4]. This study proposes a talent cultivation model based on "Four-Stage Progression, Dual Integration, and Virtual-Physical Symbiosis," aiming to address the core challenges in current vocational education through triple innovative logic. The four-stage progressive education system breaks the rigid framework of traditional class-based teaching via dynamic ability stratification. Based on students' programming foundations, mathematical thinking abilities, and project interests, it constructs a progressive competency development path from tool application to industrial practical combat, achieving precise alignment between individual learning profiles and teaching resources. The dual-integration curriculum system reform leverages the decomposition of authentic enterprise work orders to transform industrial-grade technical requirements into quantifiable teaching tasks, forming an innovative development mechanism where "demand becomes curriculum," thereby bridging the technological generation gap. The virtual-physical symbiotic industry-education integration ecosystem combines virtual simulation and physical equipment training platforms to simulate the complexity of industrial scenarios. Through a feedback loop involving teaching, certification, and employment, it realizes a value closed loop between talent cultivation and industrial needs. The objective of this study is to explore the effectiveness of this model through both theoretical construction and practical validation. This paper first elucidates the theoretical feasibility of the "Four-Stage Progression, Dual Integration, and Virtual-Physical Symbiosis" model in addressing core issues such as adaptability to technological iteration, governance of fragmented student profiles, and value closed-loop in industry-education integration. Through reform practices in the Computer Application Technology program at Guangan Vocational and Technical College, a widely applicable paradigm for AI talent

cultivation in higher vocational institutions in Western China is extracted. The research methodology combines qualitative analysis and case studies to deconstruct the operational mechanisms of key components. By utilizing qualitative materials such as policy texts, curriculum documents, and school-enterprise agreements, the study validates the practical efficacy of the model within the regional vocational education ecosystem, providing a referential theoretical framework and practical experience for similar institutions.

2. Practical Dilemmas in AI Talent Cultivation in Higher Vocational Education

The cultivation of technical skills talents in the field of artificial intelligence faces multiple structural contradictions, rooted in the misalignment between the vocational education system and the dynamic evolution of the industry [5]. The main dilemmas can be summarized into three aspects:

Conflict between fragmented student profiles and teaching homogeneity. The student population in higher vocational institutions is complex, exhibiting significant heterogeneity in programming foundations, mathematical logical abilities, and levels of technical cognition. Some students possess preliminary algorithmic understanding, while others start from scratch [6]. This fragmentation in student profiles fundamentally conflicts with the rigid framework of traditional class-based teaching models. Unified teaching progress and standardized curriculum designs struggle to meet diverse learning needs, leading to advanced learners becoming weary of low-level repetitive training, while those with weaker foundations gradually become marginalized due to cognitive gaps. This negative ecology of "the advanced grow weary, the struggling abandon learning" in the teaching process not only undermines individual motivation but also severely impacts the overall efficacy of talent cultivation.

The rapidity of technological iteration exacerbates the adaptability crisis of the curriculum system, resulting in a generational gap between technological evolution and teaching content. AI technology exhibits Moore's Law-like exponential updates, with cutting-edge technologies such as generative AI (AIGC) and multimodal large models redefining industry tech stacks [7]. However, curriculum development in vocational education still

follows protracted traditional processes involving industry research, program revision, textbook development, and teaching implementation. The update cycle of textbook content lags far behind technological changes. While the industry widely adopts Transformer architectures to optimize industrial models, some curricula still focus on traditional machine learning basics, creating a significant disconnect between what students learn and actual industry needs. This "generational gap" prevents curricula from promptly responding to technological innovations. The rigidity of course modules within traditional credit-based systems also limits the flexible integration of emerging technologies, further intensifying the passive catch-up dilemma of higher vocational education in the face of technological iteration.

The superficiality of industry-education collaboration mechanisms, the formalization of school-enterprise cooperation, and the distortion of talent cultivation value. Currently, most school-enterprise collaborations remain at the level of agreement signing and symbolic internship arrangements, lacking deep technical synergy such as stationed guidance by enterprise technical backbones, application of real-world projects, and data resource sharing [8]. The root cause lies in the absence of incentive mechanisms. Enterprises face hidden costs such as core technology leakage risks, human resource costs, and data security concerns when participating in collaborations, without directly obtaining benefits from talent alignment. This leads them to prefer social recruitment over deep involvement in collaborative education. This situation of "enthusiastic agreements, lukewarm execution" confines training content to idealized open-source datasets and laboratory environments, far removed from the complex industrial scenarios characterized by multi-source heterogeneity, high noise, and strong constraints [9]. Although graduates may master standardized algorithm invocation skills, they generally lack practical engineering capabilities such as dirty data cleaning, distributed deployment, and model lightweighting—core skills essential in real-world settings. This results in a competence mismatch where excellent classroom performance fails to translate into effective industrial combat, forming a systemic obstacle to the precise alignment between industrial demand and talent supply [10].

3. Model Innovation: Theoretical Framework and Implementation Pathway

To address the structural challenges faced by higher vocational institutions in cultivating AI technical skills talents, this study constructs a talent cultivation model based on "Four-Stage Progression, Dual Integration, and Virtual-Physical Symbiosis," achieving systematic reconstruction from three dimensions: the education system, curriculum generation mechanism, and industry-education collaborative ecosystem. This forms a logically closed-loop, theoretically self-consistent composite innovation framework. The model employs "dynamic adaptation" to address student heterogeneity, "rapid response" to bridge the technological generation gap, and "value closed-loop" to open up industry-education collaboration pathways, establishing a new talent cultivation ecosystem that covers assessment, teaching, training, and employment across the entire process, all elements, and multiple stakeholders.

3.1 "Four-Stage Progression" Dynamic Stratified Education System

The traditional uniform class-based teaching system exhibits significant structural adaptation barriers in the field of AI, particularly in addressing the highly fragmented spectrum of learner abilities. This study introduces a "Four-Stage Ability Progression" model to precisely pinpoint student abilities, dividing them into four progressive stages: Tool Application Layer (Level C), Algorithm Optimization Layer (Level B), System Design Layer (Level A), and Industrial Practical Combat Layer (Level S), forming a continuous and transferable growth path. Level C focuses on the application of basic toolchains and data processing skills; Level B emphasizes algorithm tuning and project practice training; Level A concentrates on system-level architecture design and complex engineering modeling; and Level S connects with real industrial tackling tasks, achieving deep integration of "learning," "research," and "production."

This stratification system is not static labeling but relies on a dynamic assessment mechanism across three dimensions—programming ability, mathematical logic, and project interest—to generate and update personalized ability profiles in real time. To promote mobility and progression, the model establishes a triple-

challenge mechanism involving theory, practical operation, and defense, enabling cross-stage leaps based on performance. Simultaneously, a "credit bank" incentive mechanism is introduced to quantify students' informal learning outcomes, such as participation in technical competitions, open-source contributions, and project development, into redeemable virtual credits. These can be used for enrolling in advanced courses and applying for enterprise internships, forming a complete closed loop of assessment positioning, stratified teaching, dynamic promotion, and incentive feedback, fundamentally resolving the persistent issue of teaching homogeneity.

3.2 "Dual Integration" Innovative Curriculum Development Mechanism

Against the backdrop of increasingly compressed technological evolution cycles, the lag in curriculum content response has become a key bottleneck constraining the adaptability of higher vocational education. To break the dilemma of "textbooks being outdated upon publication," this study proposes a dual-integration curriculum development paradigm combining industrial work orders and teaching modules. By constructing a work order pool covering typical industry needs, such as battery health prediction, industrial visual inspection, and power load modeling, it gathers real technical scenarios to serve as the original driver for curriculum content generation.

Work orders are decomposed by an industry-education joint working group into a four-level task chain—data preprocessing, model construction, deployment optimization, and performance iteration—based on the principles of teachability and technical decomposability. These undergo a three-level translation process to become teaching modules: the first level involves enterprise engineers constructing knowledge graphs from work orders; the second level sees teachers developing modular micro-lesson content based on these graphs; and the third level aggregates the development of virtual-physical integrated training packages, achieving rapid mapping of technical semantics to teaching units. This mechanism reconstructs the curriculum life cycle—demand input, task decomposition, teaching packaging, and validation iteration—ensuring high-frequency resonance between teaching content and industrial tech stacks, and building a dynamic

curriculum ecosystem centered on work orders.

3.3 "Virtual-Physical Symbiosis" Industry-Education Integration Closed-Loop Ecosystem

Traditional industry-education collaboration models suffer from long-standing structural maladies of "superficial cooperation" and "detachment from real practice" due to the lack of authentic engineering scenarios and sustainable value feedback mechanisms. To address this, this model constructs a training environment with industrial-context complexity based on an integrated platform combining virtual simulation, edge computing, and cloud training, promoting the reshaping of scenarios for virtual-physical collaborative teaching.

At the virtual layer, digital twin production lines are built to simulate multi-source heterogeneous data flows and complex device constraints; the edge layer provides a lightweight deployment environment, supporting students in model compression and optimization under resource-constrained scenarios; the cloud layer relies on elastic computing power pools to facilitate large-scale model training and performance iteration, meeting industrial-grade model development needs. Students must complete full-process training in this hybrid environment, including data cleaning, model deployment, and system integration—such as handling sensor anomalies and deploying lightweight YOLO models in simulated factory scenarios—thereby cultivating applied talents with engineering thinking and systemic capabilities.

More critically, this system is directly linked to enterprise certification mechanisms. Enterprises release competency standards, based on which institutions deconstruct core knowledge points and embed them into the curriculum. Students obtain dual credentials—academic certificates and enterprise certifications—through certification assessments, gaining access to enterprise priority recruitment channels. This forms an integrated ability value chain encompassing teaching, certification, and employment. Enterprises achieve precise talent selection through this certification system, reducing pre-employment training costs; institutions optimize teaching content based on employment feedback loops, thereby constructing a new symbiotic industry-education collaboration ecosystem based on competency signals and value feedback. This promotes a

structural leap in higher vocational education from "cooperative overlay" to "value synergy."

4. Analysis of Practical Effectiveness

The "Four-Stage Progression, Dual Integration, and Virtual-Physical Symbiosis" model demonstrated breakthrough value in addressing the dilemmas of AI technical skills talent cultivation during its systematic implementation in the Computer Application Technology program at Guangan Vocational and Technical College. Its practical effectiveness can be distilled into three dimensions: leap in education quality, restructuring of curriculum resources, and activation of the industry-education ecosystem, confirming the practical feasibility of the theoretical framework.

4.1 Qualitative Leap in Talent Cultivation Efficacy

The dynamic stratified education system effectively alleviated the structural contradiction between fragmented student profiles and teaching homogeneity. Through precise positioning via the four-stage ability model and the cross-layer incentive mechanism of the credit bank, the student population exhibited significant ability differentiation and adaptation characteristics. Those with weaker foundations solidified their development basics through case-based training at the tool application layer, while advanced learners participated in enterprise tackling projects from the algorithm optimization to industrial practical combat layers. This flexible framework of "teaching according to ability" significantly enhanced the alignment between students' technical skills and industrial needs. The outcomes were concretely reflected in three aspects: students' technical competitiveness gained industry recognition, with historic breakthroughs in the number and level of awards won in AI tracks of provincial and above vocational skills competitions; the holding rate of industry-authoritative certifications (e.g., Huawei ICT certification) increased steadily, serving as markers of student capability; and the employment rate in relevant fields of graduates rose steadily, with employer feedback indicating significantly superior engineering thinking and problem-solving skills compared to traditional cultivation models. Particularly, the credit bank-driven cross-layer mobility mechanism shifted student development momentum from external

discipline to endogenous drive, forming a virtuous ecology of "mutual enhancement in teaching and learning, with the capable advancing."

4.2 Paradigm Restructuring of the Curriculum Resource System

The dual-integration mechanism catalyzed a rapid resource generation model where "demand becomes curriculum." The curriculum development path based on the industrial work order pool ensured dynamic synchronization between teaching content and enterprise technological frontiers. Typical achievements included the development of multiple enterprise demand-oriented modular courses covering cutting-edge areas like intelligent system integration and AI model optimization, and the compilation and publication of a series of loose-leaf textbooks—characterized by encapsulating technical points in minimal teaching units, allowing flexible reorganization along with technological iterations. More critically, the construction of the virtual-physical symbiotic training platform marked a fundamental transformation in the form of curriculum resources. This platform simulated industrial data noise and computing power constraints through virtual production lines, enabling students to complete full-process training—data cleaning, model lightweighting, and cloud deployment—in a highly realistic environment. This virtual-physical integrated training mode not only broke through the physical limitations of outdated equipment in traditional labs but also significantly optimized the efficiency of training resource allocation, providing a new paradigm for higher vocational institutions to resolve the high-cost dilemma of training.

4.3 Sustainable Evolution of the Industry-Education Integration Ecosystem

The virtual-physical symbiosis mechanism reconstructed the logic of school-enterprise collaboration through a closed loop of teaching, certification, and employment. With leading enterprise competency certifications as the hub, an industry-education value feedback chain was formed. Enterprises released certification standards and deeply participated in curriculum design; schools integrated certification knowledge points into teaching modules; students obtained dual credentials through assessments; enterprises prioritized hiring

certified individuals and provided feedback on talent quality data. This closed loop completely reversed the suspended state of "emphasizing agreements over execution" in school-enterprise cooperation, significantly boosting enterprise participation enthusiasm and achieving a qualitative breakthrough in project conversion rates. At the regional radiation level, the model was extended to multiple higher vocational institutions in Eastern Sichuan through teaching seminars and teacher training programs, promoting the co-construction of regional AI talent cultivation standards. A more profound impact was that institutions leveraged the virtual platform to undertake enterprise technical challenges, transforming industrial-level challenges into teaching cases. This directly empowered the talent cultivation process to contribute to regional industrial upgrading, forming a new vocational education ecology of "education as the foundation, feeding back to industry."

5. Conclusion

This study proposes a talent cultivation model based on "Four-Stage Progression, Dual Integration, and Virtual-Physical Symbiosis," offering an innovative solution to the multiple structural dilemmas faced by higher vocational institutions in cultivating technical skills talents in the field of artificial intelligence. Through dynamic stratified education, dual integration of curriculum content and enterprise needs, and a virtual-physical symbiotic platform for industry-education integration, the model effectively resolves the contradiction between fragmented student profiles and teaching homogeneity, bridges the technological generation gap, and promotes the transformation of school-enterprise cooperation from formalism to deep collaboration. Practical results demonstrate that the model has achieved significant outcomes in enhancing talent cultivation quality, optimizing the curriculum system, and activating the industry-education ecosystem, particularly exhibiting strong adaptability and sustainability in aligning talent technical capabilities with industrial demands. However, the scaling of the model still faces challenges such as disparities in regional industrial innovation capacity, reliance on advanced technologies in virtual training platforms, and the rigidity of the current educational system. Future research should focus on further optimizing the implementation

pathway of this model through policy innovation, collaborative advancement of cross-regional vocational education communities, and diversified strategies for cost restructuring, ensuring its universal applicability and sustainable development nationwide.

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