

# AI Empowering the High-Quality Development of Vocational Education: Opportunities, Challenges, and Practical Paths

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**Abstract:** Against the dual backdrop of the full implementation of the national education digitalization strategy and the intelligent transformation of industries, the deep integration of artificial intelligence (AI) and vocational education has become the core driver for advancing the high-quality development of vocational education. As an education type most closely aligned with industrial development, vocational education is undergoing systematic reforms in its cultivation model, teaching form, evaluation system, and governance mechanism with the support of big data, generative AI, digital twin, and other intelligent technologies. Intelligent technologies have effectively addressed long-standing pain points in traditional vocational education, such as homogeneous training, limited practical training resources, difficulties in implementing personalized instruction, and mismatches between industry supply and educational demand. Nevertheless, technology-enabled development carries significant dual attributes: while unleashing reform momentum, it also gives rise to practical problems including disembodied teaching risks, algorithmic ethical imbalance, insufficient digital competence of teachers, lagging institutional support, and weakened innovative competence of students. Grounded in the theories of embodied cognition and human-AI collaborative education, this paper systematically explains the internal logic of AI empowering the high-quality development of vocational education, sorts out the development opportunities and realistic dilemmas in the current integration process, and analyzes the deep-seated causes behind these problems. Finally, it constructs a practical path suitable for the development of vocational education in China from five dimensions: education philosophy, faculty development, technology adaptation, institutional governance, and innovation cultivation, so as to provide theoretical references and practical guidelines for the digital transformation of vocational education and the construction of a high-quality education system in the new era.

**Keywords:** Artificial intelligence; Vocational education; High-quality development; Human-AI collaboration; Education digitalization

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## 1. Introduction

With the accelerated iteration of a new round of artificial intelligence (AI) technologies, educational digitalization has become a core strategy for the modernization of China's education system<sup>[1]</sup>. The state has issued a series of policy documents, explicitly requiring the deep integration of AI with vocational education scenarios and the reshaping of the modern vocational education system through intelligent technologies to cultivate high-quality technical and skilled personnel for the transformation and upgrading of the real economy and the high-quality development of the manufacturing industry. The *Action Plan for "AI + Education"* jointly issued by five ministries (the Ministry of Education, the National Development and Reform Commission, the Ministry of Industry and Information Technology, the Ministry of Science and Technology, and the National Data Bureau) clearly states that it is necessary to "timely assess the structural impact of artificial intelligence on vocational education, adjust and optimize the requirements for skilled personnel training, promote the intelligent upgrading of traditional majors, scientifically design the 'AI +' major system, curriculum system and teaching system, and improve the adaptability of major setup to industrial development."

For a long time, traditional vocational education in China has suffered from structural shortcomings such as the imbalance between large-scale training and personalized education, limited practical teaching scenarios, slow iteration of teachers' capabilities, superficial integration of industry and education, and rigid and single education evaluation. These shortcomings make it difficult to adapt to the demand for talent under the rapid iteration of emerging industrial technologies<sup>[2]</sup>. Compared with general education, vocational education is characterized by distinct practicality, professionalism, and industrial adaptability, and the quality of its talent training is directly related to regional industrial upgrading and economic and social development<sup>[3]</sup>. With its unique advantages such as intelligent portrait diagnosis, virtual simulation training, dynamic data analysis, and precise resource matching, artificial intelligence provides a brand-new technical solution to solve the pain points in the development of vocational education<sup>[4]</sup>. However, the blind application of technological tools has also disrupted the traditional educational ecology of vocational education, leading to new problems such as technology overriding the essence of education, algorithmic interference with educational equity, and misalignment of human-machine collaboration<sup>[5]</sup>. Against this background, a systematic study on the opportunities, challenges, and optimization paths of AI empowering the high-quality development of vocational education is of great theoretical and practical significance for promoting the categorized, digital, and high-quality development of vocational education.

## 2. Realistic opportunities for AI to empower the high-quality development of vocational education

The deep integration of artificial intelligence and vocational education has reshaped the development ecology of vocational education in terms of education model, teaching form, evaluation mechanism, industry-education collaboration, and faculty development, providing new opportunities for vocational education to break through traditional constraints and achieve high-quality development.

First, intelligent technologies reconstruct the traditional education model and promote the implementation of large-scale personalized instruction. The traditional classroom teaching model of vocational education is difficult to take into account the differentiated characteristics of students' skill foundations, learning rhythms, and cognitive abilities, making personalized instruction a mere formality for

a long time<sup>[6]</sup>. Based on the collection of all-round learning data and the construction of dynamic student portraits, artificial intelligence can accurately identify students' knowledge gaps and weak skill points, automatically match personalized learning resources and training programs, and provide real-time Q&A guidance with generative AI. This effectively solves the core contradiction between large-scale teaching and personalized education, and greatly improves the accuracy of talent training<sup>[7]</sup>. In addition, intelligent technologies have innovated practical teaching forms and effectively broken the bottleneck of practical resources. Vocational education focuses on the cultivation of practical skills, while traditional practical training faces problems such as high equipment costs, large consumable losses, inaccessible high-risk scenarios, and limited training hours. With digital twin and virtual reality technologies, artificial intelligence can build highly simulated job training scenarios, allowing students to conduct immersive practical operations repeatedly, avoiding safety risks and resource loss. Meanwhile, real-time error correction is realized through intelligent monitoring systems, making practical teaching normalized, precise, and efficient.

Second, artificial intelligence optimizes the education evaluation system and achieves whole-process dynamic empowerment. Traditional vocational education evaluation is dominated by final outcome assessment, featuring single evaluation dimensions, strong subjectivity, and a lack of process tracking, which cannot fully reflect students' skill growth and quality changes. The intelligent evaluation system can record students' data in classroom learning, practical operation, teamwork, and innovative practice throughout the process. Combining quantitative calculation and qualitative judgment, it constructs a multi-dimensional and dynamic comprehensive evaluation mechanism, shifting education evaluation from "outcome judgment" to "process empowerment" and providing an accurate basis for teaching optimization and student growth<sup>[8]</sup>. Furthermore, artificial intelligence deepens the level of industry-education integration and promotes precise matching between supply and demand. Intelligent data platforms can break down data barriers between education and industry, capture regional industrial iteration trends, job capability requirements, and technology update directions in real time, helping vocational colleges dynamically adjust major layout, curriculum system, and teaching content. This achieves precise docking between major clusters and industrial chains, and between talent training and job demand, solving problems such as information asymmetry, supply-demand mismatch, and superficial cooperation in traditional industry-education integration.

Third, artificial intelligence empowers the construction of "dual-qualification" teachers and helps upgrade teachers' digital literacy. Intelligent teaching and research platforms gather high-quality teaching resources and cutting-edge industrial content, which can push personalized training content for teachers, helping them update their industrial cognition and improve their intelligent teaching capabilities<sup>[8]</sup>. At the same time, cross-regional collaborative teaching and research carriers can be built to solve the problems of weak faculty resources and insufficient teaching and research capacity in grassroots vocational education.

### **3. Realistic challenges in AI empowering vocational education development**

While intelligent technologies empower and enhance the efficiency of vocational education, problems such as technology abuse, insufficient adaptation, and lack of governance have given rise to multiple development dilemmas that restrict the high-quality development of vocational education.

From the teaching perspective, the risk of disembodied teaching has become increasingly prominent, weakening the essential nature of vocational education. Some vocational colleges over-rely on virtual training and online intelligent teaching, completely replacing offline practical training and face-to-face interaction

between teachers and students, which violates the core laws of embodied learning and practical education in vocational education. Standardized and programmed virtual operations lack the complexity and uncertainty of real scenarios, leading to insufficient practical adaptability and problem-solving abilities of students, and easily causing skill rigidity<sup>[9]</sup>. Meanwhile, one-way human-machine interaction weakens the emotional connection and ideological collision between teachers and students, inhibits students' innovative thinking and independent exploration ability, resulting in shallow cognition and homogeneous thinking, and dilutes the humanistic value of craftsmanship cultivation.

From the faculty perspective, teachers' digital literacy is insufficient, and their ability in human-AI collaborative education is weak. Most current vocational education teachers have solid professional teaching and practical guidance abilities, but generally suffer from insufficient AI cognition, a single application of intelligent tools, and a lack of data analysis abilities. Most teachers only use AI for basic auxiliary work such as homework correction and courseware production, and fail to carry out personalized teaching design, training optimization, and teaching research innovation based on intelligent technologies. Meanwhile, the existing faculty training system lags behind technological development, lacking special training for human-AI collaborative education, algorithm risk research and judgment, and intelligent scene design, making it difficult for teachers to achieve deep integration of technology and teaching, and the human-AI collaborative education model is hard to implement<sup>[10]</sup>.

From the technical and ethical perspective, algorithm imbalance and digital divide are prominent problems. Most existing intelligent platforms for vocational education adopt general algorithm models, which highly rely on high-frequency standardized learning data. For students with weak foundations and low digital participation, these platforms are prone to problems such as distorted portraits and mismatched resource adaptation, leading to algorithm discrimination and digital exclusion, and exacerbating educational stratification. Meanwhile, machine learning has the problem of an algorithm black box with opaque decision-making logic. Some intelligent education programs focus on short-term performance improvement while ignoring students' long-term innovative literacy and professional ability cultivation. In addition, there are significant gaps in digital construction between regions and colleges. High-quality intelligent resources are concentrated in central cities and key colleges, while vocational education resources in county and remote areas are scarce, and the digital divide further aggravates unbalanced educational development<sup>[11]</sup>.

From the institutional and educational perspective, the governance system lags behind and technology dependence is prominent. At present, the intelligent construction of vocational education lacks unified construction standards, algorithm ethical norms, and data security systems. Intelligent platforms of various colleges are inconsistent in ports and fragmented in data, forming a large number of data islands. Moreover, supervision mechanisms such as data privacy protection, technology access, and algorithm audit are missing, leading to prominent risks of technology abuse<sup>[12]</sup>. Meanwhile, the imperfect assessment and incentive mechanism make it difficult to mobilize the enthusiasm of colleges and teachers for intelligent reform. In educational practice, students over-rely on generative AI to complete learning tasks, and their abilities of independent thinking and innovative exploration continue to weaken. Teachers rigidly use intelligent standardized teaching plans, resulting in insufficient classroom innovation, which is difficult to adapt to the cultivation requirements of innovative technical and skilled talents<sup>[13]</sup>.

#### **4. Analysis of the causes of dilemmas in AI empowering vocational education**

Comprehensively, the various dilemmas of AI empowering vocational education result from the combined effects of multiple factors: philosophical cognition, faculty development, technology adaptation, and institutional governance.

First, there is a deviation in education philosophy, emphasizing technological form over educational essence. Some colleges and managers fall into the misunderstanding of “technological omnipotence,” simplifying intelligent construction to equipment renewal and platform building, one-sidedly pursuing the advancement of technological form, and ignoring the core nature of practical education and moral cultivation in vocational education<sup>[14]</sup>. They over-amplify the value of technological tools and weaken teachers’ functions of value guidance, emotional cultivation, and ideological shaping, leading to the reversal of technology application and education goals, and ultimately triggering a series of problems such as disembodied teaching and lack of humanism.

Second, the faculty development system lags behind and cannot adapt to the needs of intelligent education. Traditional vocational education faculty development focuses on traditional abilities such as professional teaching and practical guidance, and does not include digital literacy, human-AI collaboration, algorithm ethics, and other content in the normalized development system. The training content is backward, single in form, and insufficient in pertinence, and there is a lack of supporting assessment, incentive, and growth mechanisms. Teachers lack motivation and the ability to carry out independent intelligent teaching innovation, resulting in a serious disconnect between teachers’ digital abilities and the needs of intelligent<sup>[15]</sup>.

Third, general technologies are insufficiently adapted to vocational education scenarios. Most artificial intelligence applied in vocational education is general-purpose technology. R&D teams lack experience in vocational education and industrial practice, and technology design focuses on standardized and general services, failing to carry out customized adaptation based on the core characteristics of vocational education such as practicality, professionalism, and job orientation. This leads to redundant functions and insufficient practicability of intelligent platforms, making it difficult to solve personalized problems in vocational education teaching, training, and industry-education integration, and greatly reducing the effect of technological empowerment.

Fourth, the top-level institutional governance system is missing. Although the national macro policies for vocational education digitalization are complete, detailed construction standards, implementation rules, and supervision norms are not yet sound. The intelligent construction of colleges in various regions is in a fragmented and disorderly state. Meanwhile, there are gaps in special systems such as algorithm ethics, data security, and school-enterprise intelligent collaboration, and a lack of effective risk constraints and incentive mechanisms, making it difficult to regulate and guide the healthy development of AI applications in vocational education<sup>[16]</sup>.

#### **5. Practical paths for AI to empower the high-quality development of vocational education**

Based on the current development opportunities and realistic dilemmas, the intelligent development of vocational education must adhere to the core principles of people-oriented and human-AI collaboration, and make coordinated efforts from multiple dimensions such as philosophy, faculty, technology, institution, and education to achieve deep integration and sound development of intelligent technology and vocational

education.

First, reshape the scientific education philosophy and adhere to the essence of human-AI collaborative education. Vocational colleges should abandon the thinking of technological instrumentalization and formalization, and establish an intelligent education philosophy of “teacher-oriented, technology-assisted, virtual-real integration and education-first.” Based on the theory of embodied cognition, a hybrid teaching mode of “virtual pre-training + offline practical training” should be constructed, clarifying the auxiliary tool positioning of artificial intelligence, and retaining core education links such as teacher-student emotional interaction, independent exploration, and innovative practice. Balance the relationship between technological empowerment and students’ subjective development, prohibit technology from completely replacing manual teaching, and adhere to the vocational education nature of moral cultivation and craftsmanship cultivation.

Second, improve the digital faculty development system and enhance the ability of human-AI collaborative education. Optimize the vocational education faculty training system, and include basic AI application, intelligent teaching design, learning data analysis, algorithm ethical norms, and human-AI collaboration mode into the core content of pre-job training and continuing education. Innovate the development mode of “online research + offline practice + enterprise training,” and build faculty digital ability training platforms jointly with technology enterprises and leading industries to improve teachers’ technology application and teaching innovation abilities. Meanwhile, improve the assessment and incentive mechanism, incorporate intelligent teaching reform, digital curriculum construction, and human-AI collaborative education achievements into performance assessment and professional title evaluation, and fully mobilize teachers’ initiative and creativity in intelligent reform.

Third, promote customized adaptation of technology scenarios and build an exclusive intelligent ecology for vocational education. Deepen school-enterprise collaborative technology R&D, and customize and develop intelligent training systems, virtual simulation platforms, and personalized education modules suitable for vocational education scenarios according to the job characteristics, training needs, and industrial standards of different majors. Optimize intelligent algorithm models, correct algorithm biases, build a hierarchical and classified intelligent service system, provide differentiated education programs for students with different foundations, and ensure educational equity. Coordinate and promote the balanced development of regional vocational education digitalization, increase investment in digital resources for grassroots and county colleges, build a globally shared intelligent resource platform, and break data islands and resource barriers. Meanwhile, optimize intelligent scene design, add open and innovative training modules, and avoid students’ thinking solidification.

Fourth, improve the institutional governance system and build a solid guarantee for intelligent development. Perfect the top-level design of vocational education intelligent construction, issue unified construction standards, implementation rules, and technology access norms, and coordinate and standardize the intelligent construction of various colleges. Establish an algorithm ethical governance and audit mechanism, carry out regular algorithm risk checks, and eliminate algorithm discrimination and technology abuse. Improve the security protection and privacy management system of teaching data and student information, and build a solid line of defense for data security. Improve the incentive system for intelligent industry-education integration, clarify the rights, responsibilities, and benefit distribution mechanism of enterprise participation, and stimulate the motivation of enterprises for collaborative education. Reconstruct the education evaluation, college assessment, and teacher evaluation system under an intelligent background

to adapt to the new mode of human-AI collaborative education.

Fifth, optimize the education model and balance technological empowerment and innovation ability cultivation. Clarify the boundary of intelligent technology use, limit artificial intelligence to instrumental scenarios such as basic Q&A, training assistance and resource push, and retain core teaching links such as independent exploration, project design and innovative R&D. Construct a three-stage education mode of “virtual training to consolidate foundation, offline practice to temper skills, project practice to cultivate innovation,” guide students to establish a correct concept of technology use, and eliminate technology dependence. Strengthen the cultivation of students’ innovative thinking, professional literacy, and craftsmanship, build innovative practice carriers based on intelligent platforms, promote students’ independent thinking and creation, and comprehensively improve technical skills and innovative abilities.

## 6. Conclusion

AI empowering the high-quality development of vocational education is an inevitable trend of vocational education reform in the digital era, and also an inevitable choice to adapt to the intelligent transformation of industries and cultivate high-quality technical and skilled talents. Intelligent technologies provide new momentum for vocational education to break through traditional development bottlenecks in multiple dimensions such as education model, teaching form, evaluation system, and industry-education collaboration. However, they also bring multiple dilemmas such as disembodied teaching, algorithmic ethical imbalance, insufficient faculty ability, and weakened innovation cultivation. To promote the deep integration of artificial intelligence and vocational education, we must not one-sidedly pursue technological iteration and formal innovation, but adhere to the essential nature of vocational education, take human-AI collaboration as the core, faculty development as the support, technology adaptation as the key, and institutional governance as the guarantee, and continuously optimize the intelligent education ecology to avoid the risks of technological empowerment. In the future, with the continuous iteration of technology, improvement of systems, and steady improvement of faculty abilities, the human-AI collaborative education model will become more mature, continuously promoting the quality improvement and value-added empowerment of vocational education, and providing solid talent support and intellectual guarantee for China’s industrial transformation and upgrading and high-quality economic development.

## Disclosure statement

The authors declare no conflict of interest.

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