# Paradigm Reconstruction and Practice Path of Smart Teaching in Vocational Education Empowered by Artificial Intelligence: An Action Research Based on Mechanical Majors

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**Abstract:** The in-depth advancement of the educational digitization strategy has provided technical conditions for the teaching reform of vocational education, and also forced the systematic upgrading of the traditional teaching paradigm. At present, the construction of smart teaching in vocational colleges generally suffers from superficial technology application, homogenized teaching supply, limited training scenarios, and one-sided evaluation dimensions. The disconnection between technology and teaching has not been fundamentally improved. Supported by constructivist learning theory, Outcome-Based Education (OBE) concept and the Technological Pedagogical Content Knowledge (TPACK) framework, this study adopts the action research method and takes two core courses of mechanical design and manufacturing major in higher vocational colleges as the practice carrier to construct and verify the smart teaching paradigm empowered by artificial intelligence. The research shows that the supporting role of artificial intelligence in vocational education teaching is reflected in the holistic reconstruction of teaching objectives, scenarios, processes, evaluation and education mechanisms, rather than the superposition of single technical tools. The five-in-one smart teaching paradigm of "environment-resource-process-evaluation-education" can adapt to the practical training needs of engineering majors, and help improve students' practical operation proficiency and learning autonomy through closed-loop implementation. This study can provide a referable practical framework for vocational colleges to promote digital teaching reform.
***Keywords***: Artificial Intelligence; Vocational Education; Smart Teaching; Teaching Paradigm; Action Research

## 1. Introduction

The report to the 20th National Congress of the Communist Party of China clearly put forward "advancing educational digitization and building a learning society and a learning country with lifelong learning for all", marking that educational digitization has entered a stage of comprehensive deepening and systematic advancement from the exploratory application stage. As the type of education most closely connected with industrial development, the digital transformation of vocational education is not only an inherent part of building an educational powerhouse, but also an inevitable requirement for supporting the upgrading of the manufacturing industry and cultivating high-quality technical and skilled talents. In recent years, most higher vocational colleges in China have completed the basic hardware construction of smart campuses, and technologies such as artificial intelligence, virtual simulation and digital twin have gradually entered classrooms and training places. However, from the perspective of actual teaching effects, most colleges still focus on equipment procurement and platform construction, and the deep enabling effect of technology on teaching has not been fully released.

A review of existing research findings shows that domestic academia has carried out multi-dimensional discussions on the integration of artificial intelligence and vocational education. At the application scenario level, technologies such as generative AI, VR/AR and intelligent assessment have been widely integrated into the teaching of language and engineering courses, forming a number of typical application cases[1-2]. At the model innovation level, relevant studies have been conducted on the "artificial intelligence + X" compound talent training, intelligent teaching under the OBE concept, and the "three educations" reform empowered by AI, initially forming diversified teaching models[3-5]. At the level of faculty and evaluation, scholars have focused on the construction of teachers' digital competence framework and the design of smart classroom evaluation systems, providing theoretical reference for practical promotion[6-7].

On the whole, however, existing research still has three shortcomings. First, most studies focus on the application effect analysis of a single technology, and few conduct systematic reconstruction of the teaching system from the paradigm level, so the theoretical depth needs to be strengthened. Second, most practice paths are designed for general use, with insufficient attention to the practical characteristics of "post-course-competition-certificate integration" in vocational education, and the adaptability of technology to practical training teaching and post needs is not strong. Third, the educational value is often overshadowed by technical rationality. The integration of curriculum ideology and politics with smart teaching is mostly an external addition, failing to form an embedded collaborative education mechanism.

Accordingly, based on the school-running orientation of higher vocational education and taking mechanical majors as the specific field, this study focuses on three core issues: What is the internal reconstruction logic of smart teaching in vocational education empowered by artificial intelligence? What core dimensions does the smart teaching paradigm adapted to the type characteristics of vocational education include? What are the implementation paths and actual effects of this paradigm in professional courses? Through the combination of theoretical construction and practical verification, this study attempts to provide a feasible reference scheme for the digital teaching reform of vocational education.

# 2. Concept Definition and Theoretical Foundation

## 2.1 Definition of Core Concepts

### 2.1.1 Artificial Intelligence in Educational Scenarios

Artificial intelligence in the field of education is not a simple transplantation of general technology, but a set of intelligent applications transformed around educational goals, specifically including intelligent teaching tools, virtual simulation training systems, learning situation diagnosis platforms, digital twin teaching environments and other forms. In this study, artificial intelligence is positioned as a teaching auxiliary tool rather than a teaching subject. Its core value is to optimize teaching processes, expand training boundaries and improve teaching accuracy through data collection and algorithm analysis, ultimately serving the ability growth of students and the teaching efficiency improvement of teachers.

### 2.1.2 Smart Teaching Paradigm

The smart teaching paradigm is a new teaching system formed by the in-depth integration of artificial intelligence technology and the teaching laws of vocational education, covering multiple levels such as teaching philosophy, goal setting, content organization, implementation methods and evaluation mechanisms. Compared with specific teaching models, the paradigm is more inclined to the underlying operation logic and overall framework. Its core feature is not the richness of technical equipment, but the realization of student-centered teaching, promoting the transformation from standardized supply to personalized adaptation, and from knowledge instruction to ability cultivation.

### 2.1.3 Technology-Empowered Teaching

"Empowerment" emphasizes the two-way interaction between technology and teaching, rather than one-way technology implantation. On the one hand, by embedding in all links of teaching, artificial intelligence reconstructs the organizational form and implementation path of teaching, reduces the burden of teachers' transactional work, and supports teachers to focus on high-level teaching activities. On the other hand, real problems and feedback data in teaching practice will also promote the scenario-based optimization of intelligent tools, forming a virtuous cycle of technology supporting teaching and teaching feeding back technology iteration.

## 2.2 Theoretical Basis

### 2.2.1 Constructivist Learning Theory

Constructivist learning theory holds that knowledge is not imparted by teachers, but acquired by learners through meaning construction with the help of others and learning resources in specific situations. This theory is highly consistent with the characteristics of vocational education that emphasizes practice and "learning by doing", and also provides an epistemological basis for the scenario design of smart teaching. Artificial intelligence technology can create highly realistic production and work scenarios, support students to carry out inquiry-based and project-based learning in virtual scenarios, and complete the construction of knowledge and skills in operation and trial and error. Intelligent collaboration platforms can support group knowledge construction and promote learners to improve their cognitive structure in interaction.

### 2.2.2 Outcome-Based Education (OBE)

Outcome-Based Education takes students' final learning outcomes as the core, and reversely designs teaching objectives, content and evaluation systems, emphasizing "student-centered, outcome-oriented and continuous improvement". For vocational education, the core measure of learning outcomes is post competence requirements. Artificial intelligence technology provides technical support for the implementation of the OBE concept. Through systematic analysis of post competence requirements, it can more accurately anchor the corresponding relationship between course objectives and graduation requirements. Through full-cycle data tracking of the learning process, it can monitor the achievement of learning outcomes in real time and dynamically adjust teaching strategies, forming a closed-loop improvement mechanism of teaching quality.

### 2.2.3 TPACK Technological Pedagogical Content Knowledge Framework

The TPACK framework proposes that the core competence of teachers to effectively integrate technology is the in-depth integration of technical knowledge, pedagogical knowledge and subject content knowledge. This framework provides an analytical basis for the transformation of teachers' roles in the context of smart teaching. Vocational education teachers in the era of artificial intelligence do not need to master complex algorithm development technologies, but must have the ability to organically combine intelligent tools with professional teaching and educational laws, and realize the transformation from a single knowledge imparter to a learning designer, process guide and literacy cultivator.

# 3. Practical Dilemmas and Reconstruction Logic of Smart Teaching in Vocational Education

## 3.1 Main Dilemmas in Current Practice

From the overall status of digital construction in vocational colleges, the integration of artificial intelligence and teaching is still in the initial stage, and multiple deep-seated contradictions restrict the actual effect of smart teaching.

First, technology application is superficial, with obvious instrumental rationality tendency. According to relevant research by the Vocational Education Development Center of the Ministry of Education, the current higher vocational education generally has the problem of "emphasizing hardware investment while neglecting teaching transformation". Most colleges apply AI to transactional functions such as attendance management, online answering and classroom interaction, without touching the core transformation of curriculum system, teaching process and evaluation mechanism. Technology application is often divorced from the real work process of posts and does not fully follow the teaching laws of vocational education. In some scenarios, there is even a tendency of "applying technology for technology's sake", and the actual teaching effect is not proportional to the construction investment.

Second, teaching supply is homogenized with insufficient personalized adaptation ability. Students in vocational colleges have great differences in learning foundation and cognitive style, and their career development directions are also diversified. However, traditional teaching has long been dominated by standardized supply with unified progress and content. Most existing AI teaching systems focus on personalized push of general theoretical knowledge, lacking accurate diagnosis and layered guidance for vocational practical skills. The supply of customized intelligent resources for different majors and posts is seriously insufficient, which can hardly meet the personalized learning needs of "theory + practice" in engineering majors.

Third, practical training scenarios are limited, and core pain points have not been effectively solved. Practical training teaching for engineering majors such as machinery and mechatronics has long been restricted by high equipment costs, limited workstations and inability to repeatedly practice high-risk operations. Most traditional virtual simulation resources are demonstration content with preset processes, with insufficient interactivity and openness, which can hardly restore complex problems and emergencies in real production scenarios. The application of new technologies such as digital twin is still mostly at the display level at present, and has not been deeply integrated into the daily training teaching process, so its effect on improving students' engineering practice ability and problem-solving ability is limited.

Fourth, the evaluation system is one-sided with biased education orientation. Existing smart teaching evaluation systems generally take technical usage data, online learning duration and test scores as core indicators, focusing on quantifiable behavioral data, while ignoring the evaluation of high-level educational goals such as students' professional literacy, innovative thinking and collaboration ability. Meanwhile, most evaluation methods are summative and static result judgments, lacking dynamic tracking and value-added evaluation of the whole learning process. It is difficult to play the continuous improvement role of "promoting teaching and learning through evaluation", and may even force students to study for data brushing, deviating from the essential goal of education.

## 3.2 Core Logic of Paradigm Reconstruction

The smart teaching of vocational education empowered by artificial intelligence is essentially a systematic upgrading of the teaching paradigm, rather than element repair on the traditional teaching framework. Its core logic of reconstruction is to realize three fundamental transformations and finally return to the educational essence of "education-oriented and technology-supported".

First, the value logic shifts from "technology-centered" to "education-centered". The starting point of paradigm reconstruction is not "applying whatever technology is available", but "matching technology for the talent cultivation objectives". We always take the fundamental task of fostering virtue through education and the training goal of technical and skilled talents as the fundamental principle, and take artificial intelligence as a tool and means to achieve educational goals. We should avoid the expansion of technical rationality overshadowing educational value, so that smart teaching can truly serve the all-round development and career growth of students.

Second, the structural logic shifts from "element superposition" to "system integration". Paradigm reconstruction is not to scatter AI tools in all teaching links, but to carry out holistic design of all elements such as teaching objectives, scenarios, resources, processes, evaluation and education, open up the internal connection between various elements, form a logical and coherent organic whole with collaborative linkage, give play to the system integration effect, and realize the essential leap from "tool application" to "paradigm upgrading".

Third, the relational logic shifts from "teacher-led" to "human-machine collaboration". Paradigm reconstruction does not pursue replacing teachers with artificial intelligence, but reshapes the subject relationship in teaching: teachers transform from one-way knowledge imparters to learning designers, guides and literacy cultivators; artificial intelligence undertakes auxiliary and repetitive work such as data collection, basic answering, personalized push and process management, becoming a teaching partner for teachers and a learning partner for students. Through human-machine collaboration, it can not only improve teaching operation efficiency, but also ensure the humanistic nature and temperature of education.

Based on the above logic, the smart teaching paradigm realizes five transformations in specific dimensions: in terms of objectives, from single skill objectives to compound objectives of "professional skills + digital literacy + professional literacy"; in terms of scenarios, from a single physical classroom to a full-domain teaching scenario integrating virtual and real; in terms of resources, from static and solidified textbooks to a dynamically adaptive digital resource ecology; in terms of processes, from teacher-led instruction to human-machine collaborative inquiry learning; in terms of evaluation, from summative evaluation to multi-dimensional dynamic value-added evaluation.

## 4. Paradigm System of AI-Empowered Smart Teaching in Vocational Education

Combined with the type characteristics and educational laws of vocational education, this study constructs a five-in-one smart teaching paradigm system of "environment layer – resource layer – process layer – evaluation layer – education layer". The five levels are not independent of each other, but support each other and operate collaboratively to form a complete teaching operation system.

### 4.1 Environment Layer: Full-Domain Virtual-Real Integrated Teaching Scenarios

Breaking the physical space limitation of traditional teaching, we will build a full-domain smart teaching environment linked by "classroom – training – enterprise – online".

First, intelligent physical classrooms are equipped with intelligent interactive terminals, learning situation collection equipment and practical operation data collection systems to support real-time classroom interaction, dynamic learning situation monitoring and practical operation process recording, completing the intelligent upgrading of physical classrooms. Second, for digital twin training scenarios, relying on VR/AR and digital twin technologies, we will build virtual workshops, digital twin factories and simulation laboratories to restore real production operation processes, equipment operation status and troubleshooting scenarios, support students to repeatedly practice high-risk and high-cost operations, and make up for the resource limitations and safety risks of physical training. Third, the ubiquitous online learning space builds an online platform integrating course learning, Q&A, collaborative discussion and skill breakthrough, supporting students to carry out independent learning and ubiquitous learning, and opening up the complete learning chain before, during and after class. Fourth, for industry-education integration scenarios, we will link the real production line data of cooperative enterprises, introduce real enterprise project cases, and build diversified teaching forms such as "workshop classrooms + innovation workshops + virtual teaching and research offices" to promote the seamless connection between teaching content and post standards.

### 4.2 Resource Layer: Dynamic Adaptive Digital Resource Ecology

With the core principle of "post-course-competition-certificate integration", we will build a hierarchical, dynamically updated and accurately pushed smart teaching resource system. First, for the structured basic resource library, we will integrate basic resources such as online high-quality courses, digital textbooks, virtual simulation resources, real enterprise cases and skill competition question banks, and sort out the relationship between knowledge points, skill points and post competence points in the form of knowledge graphs to form a structured resource network. Second, for scenario-generated resources, relying on generative AI technology, we will dynamically generate customized exercises, cases, practical operation guidance and learning supports according to students' learning situations. At the same time, it supports teachers to quickly generate teaching plans, courseware, test banks and training guides, reducing the cost of teaching resource development and improving resource update efficiency. Third, for school-enterprise co-constructed industry-education resources, we will cooperate with leading enterprises in the industry to develop training projects, skill assessment standards and cutting-edge industry cases aligned with post standards, and integrate real production processes, technical standards and process specifications of enterprises into teaching resources to ensure the professionalism, timeliness and practicability of resources.

## 4.3 Process Layer: Closed-Loop Teaching Process of Human-Machine Collaboration

Adhering to the principle of "teacher as the leader, student as the subject and technology as the support", we will reconstruct the closed-loop teaching process of "accurate pre-class learning – in-class deep interaction – after-class layered expansion". In the pre-class stage, the intelligent system diagnoses students' knowledge foundation and weak skill points through pre-tests and historical learning data, and generates personalized preview tasks and learning resources. Teachers adjust classroom teaching design and key points according to the overall class learning situation report, truly realizing "teaching determined by learning". In the in-class stage, for theoretical teaching links, intelligent teaching assistants undertake transactional work such as real-time Q&A, interaction statistics and attention monitoring, and teachers focus on key and difficult point explanation, thinking guidance and classroom organization. For practical teaching links, the mode of "virtual rehearsal + physical operation" is adopted: students first familiarize themselves with operation procedures and avoid common mistakes in virtual simulation scenarios, the system captures operation problems in real time and gives feedback, then they enter physical laboratories for practical training, and teachers focus on personalized guidance and literacy cultivation. In the after-class stage, the system generates layered homework and expansion tasks according to classroom learning data, pushes targeted reinforcement resources for weak knowledge points, and supports students to repeatedly carry out practical exercises on the virtual platform. Teachers accurately identify students with learning difficulties through learning situation data, carry out targeted tutoring, and design expansion projects to meet the improvement needs of advanced students.

## 4.4 Evaluation Layer: Multi-Dimensional Dynamic Value-Added Evaluation System

Breaking the traditional evaluation mode of "score-only and result-only", we will build a three-in-one dynamic evaluation model of "process evaluation + result evaluation + value-added evaluation". At the data collection level, three types of data are fully collected: learning behavior data, including learning duration, interaction frequency and task completion; skill operation data, including practical operation accuracy, process standardization and problem-solving efficiency; literacy performance data, including collaboration participation, professional norms and sense of responsibility, forming a comprehensive student learning profile. At the evaluation implementation level, the system analyzes learning data in real time, generates periodic learning situation reports, pushes personalized learning improvement suggestions to students and teaching optimization directions to teachers, and promotes the transformation of evaluation from post-event summary to real-time intervention. At the value orientation level, we highlight the concept of value-added evaluation, focusing on students' learning progress and ability growth trajectory rather than a single horizontal ranking. By evaluating the actual effect of teaching through vertical comparison, it is more in line with the growth law of vocational education students.

## 4.5 Education Layer: Full-Infiltration Mechanism of Curriculum Ideology and Politics

We will embed the fundamental task of fostering virtue through education into all links of smart teaching, realize the simultaneous resonance of technical support and value guidance, and avoid the disconnection between curriculum ideology and politics and professional teaching. In the resource design link, ideological and political elements such as craftsmanship spirit, professional ethics, safe production and patriotism are integrated into teaching cases and virtual training scenarios. For example, in the virtual training of mechanical assembly, cases of great country craftsmen, quality awareness and standardized operation education are integrated, so that students can accept value guidance imperceptibly in skill learning. In the teaching process link, observation points such as professional norms, team cooperation and responsibility are set in collaborative learning and project practice. Through the combination of system records and teacher evaluation, students are guided to form good professional literacy and behavior habits. In the assessment link, ideological and political literacy is included in the comprehensive evaluation system of students, which is considered together with professional skills and knowledge mastery, realizing the organic unity of "skill cultivation" and "moral cultivation".

# 5. Practice Verification: An Action Research Based on Mechanical Majors

To verify the feasibility and actual effect of the above paradigm, this study takes the mechanical design and manufacturing major of a higher vocational college in Jiangsu as the field, selects two core professional courses Mechanical Drawing and Mechanical Measurement Technology, and carries out a one-semester action research.

## 5.1 Research Design

### 5.1.1 Research Objects

Two parallel teaching classes of the same grade in this major are selected as research objects. The two classes have similar student numbers, admission foundation and pre-course scores, with comparable baseline levels. The two classes have the same teachers, teaching content and total class hours, and only differ in teaching implementation modes.

### 5.1.2 Research Methods

The action research method is mainly adopted, following the cycle of "plan – action – observation – reflection" to promote practice, with a four-week cycle, and continuously optimizing the implementation path of the paradigm according to practical feedback. It is supplemented by academic performance analysis, learning experience survey and semi-structured interview to verify the teaching effect from multiple dimensions.

### 5.1.3 Implementation Arrangement

The experimental class fully adopts the above five-in-one smart teaching paradigm, supporting the use of course intelligent learning system, digital twin measurement training platform, online learning space and other tools. The control class adopts the traditional multimedia teaching mode, supplemented by conventional online course resources.

## 5.2 Implementation Process of Practice

In the pre-class link, teachers release pre-learning tasks and basic assessments on the learning platform every week, and the system automatically corrects them and generates a class learning situation report and a list of personal weak points. Taking the unit of "coordinate measuring machine" in Mechanical Measurement Technology as an example, the system can identify students' mastery differences in knowledge points such as geometric tolerance foundation and coordinate system establishment, and push targeted micro-lecture explanations and basic exercises. Teachers adjust the focus and time allocation of classroom practical training according to the overall weak points of the class.

In the in-class link, theoretical courses rely on smart classrooms to carry out interactive teaching. Intelligent teaching assistants answer students' basic questions in real time, automatically count answer situations and classroom participation, and assist teachers to dynamically adjust teaching rhythm. The practical training course adopts the two-step method of "virtual rehearsal + physical operation": students first complete the whole virtual operation of workpiece measurement in the digital twin measurement laboratory, and the system corrects problems such as non-standard clamping, wrong probe calibration and unreasonable path planning in real time. After the operation proficiency and standardization meet the preset requirements, they enter the physical laboratory for practical operation. From the operation of practical training, this mode can help students familiarize themselves with the operation process in advance and avoid common mistakes, which helps reduce the error rate of the first physical operation and plays a positive role in improving the overall operation efficiency of practical training.

In the after-class link, the system generates layered homework according to classroom performance: students with weak foundation are pushed knowledge consolidation exercises and basic virtual practical training tasks, and advanced students are pushed real enterprise measurement cases and advanced practical training projects. Students can log in to the virtual training platform to practice repeatedly at any time, and the system automatically records the operation process and error points and generates a personal skill growth curve. Teachers conduct centralized explanations on common problems and one-on-one tutoring on individual problems according to the background learning situation data every week.

In the evaluation link, the total course score consists of three parts: process evaluation, practical training assessment and final theoretical assessment. Among them, process evaluation covers multiple sub-dimensions such as learning behavior, task completion quality, practical operation standardization, collaboration performance and professional literacy, and the assessment of ideological and political literacy is embedded in the process evaluation of practical operation to avoid empty ideological and political evaluation.

## 5.3 Analysis of Practical Effects

### 5.3.1 Comparison of Academic Performance

After one semester of teaching, a comparative analysis of the final assessment of the two classes was carried out. On the whole, the experimental class outperformed the control class in both theoretical and practical assessment, and the improvement effect of practical ability was more prominent. This result shows that the smart teaching paradigm plays a positive role in strengthening students' practical ability and consolidating theoretical knowledge, which is especially in line with the practice-oriented education characteristics of engineering majors.

### 5.3.2 Feedback on Learning Experience

After the course, students' learning experience was investigated through a combination of questionnaires and interviews. The results show that most students in the experimental class believe that the new teaching mode improves learning interest and practical operation confidence, helps enhance learning autonomy, and can better meet the learning needs of students with different foundations. Some students reported that repeated practice of virtual simulation reduced the fear of difficulty in practical training learning, and targeted learning guidance made review more directional.

### 5.3.3 Teachers' Teaching Perception

Semi-structured interviews with the teaching teachers show that intelligent tools effectively undertake repetitive transactional work such as homework correction, basic Q&A and data statistics, which can reduce teachers' daily transactional burden to a certain extent, so that they can devote more energy to teaching design, key and difficult point breakthrough and personalized student guidance. At the same time, the full-cycle learning situation data also provides a reference for teaching decision-making, which helps improve classroom interaction and training management efficiency.

Some problems to be optimized are also found in the practice process: some students with weak digital literacy adapt to the smart teaching mode slowly and need additional introductory guidance and support; the simulation of complex working conditions and sudden faults in virtual training scenarios is still insufficient, and there is a certain gap with real production scenarios. These problems will be gradually improved through iterative optimization in follow-up research.

# 6. Conclusion and Prospect

## 6.1 Research Conclusions

Based on the practical problems of digital transformation of vocational education, this study systematically discusses the reconstruction logic, system framework and practice path of smart teaching in vocational education empowered by artificial intelligence from the paradigm level, and mainly draws three conclusions.

First, the in-depth integration of artificial intelligence and vocational education teaching is essentially a systematic reconstruction of the teaching paradigm, rather than the application upgrading of single technical tools. Its core is to realize the triple transformation of value logic, structural logic and relational logic, and finally promote the teaching of vocational education to leap from the traditional standardized paradigm to a new paradigm of smart, personalized and lifelong learning.

Second, the five-in-one smart teaching paradigm of "environment-resource-process-evaluation-education" conforms to the practical and vocational characteristics of vocational education, and can respond to the practical problems in traditional teaching such as insufficient training resources, insufficient personalized supply, biased evaluation orientation and weakened educational function. This paradigm not only highlights the supporting role of technology, but also adheres to the educational essence of education, with strong theoretical rationality and practical adaptability.

Third, human-machine collaboration is the core implementation path for the implementation of smart teaching. The value of artificial intelligence lies in empowering teachers rather than replacing them, and in optimizing the teaching process rather than eliminating the temperature of education. Through the closed-loop path of "accurate pre-class diagnosis – virtual-real collaboration in class – layered after-class expansion – full-cycle dynamic evaluation", it can achieve a balance between technical efficiency and educational value and help improve the quality of talent training.

## 6.2 Research Prospect

This study only conducted a pilot in two courses of mechanical majors, with a limited sample range. The universality of the paradigm in different majors and different levels of vocational colleges still needs to be further verified. At the same time, the professional scenario adaptability of the intelligent system and the accurate diagnosis ability of complex practical skills still have room for improvement.

Follow-up research can be promoted from three directions. First, expand the pilot scope, explore the adaptability and differentiated transformation paths of the smart teaching paradigm in different major categories, and form a more universal implementation plan. Second, deepen technical adaptation research, optimize the accuracy of algorithms in scenarios such as vocational skill diagnosis and training process evaluation, and improve the integration depth of technology and teaching. Third, focus on ethical and guarantee research, systematically discuss issues such as data security, algorithm fairness and technical ethics in smart teaching, and build a teacher digital literacy improvement system to support the sustainable promotion of smart teaching in vocational education.

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