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Construction and Practice of Smart Curriculum for "Optics and Laser Principle Technology" Driven by Key Element Reform in Vocational Education

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ABSTRACT

In 2026, the Ministry of Education issuedthe "Opinions on Deepening the Reform of Key Teaching Elements in Vocational Education" (Jiao Zhi Cheng [2026] No. 1), which explicitly identifies specialties, curriculum, textbooks, teachers, and practical training as the five core teaching elements of vocational education. The document proposes implementation pathways for systematic and coordinated reform, aiming to address practical challenges such as the disconnect between industry and education, closed-off school operations, and insufficient alignment between talent supply and industrial needs. As the core hub connecting specialty positioning, teaching resources, and practical training education, curriculum serves as the critical foothold for implementing element reform. Currently, fundamental engineering courses in higher vocational colleges generally face practical issues including outdated teaching content lagging behind industrial processes, monotonous teaching modes, insufficient digital teaching resources, and lack of process-oriented evaluation, making it difficult to meet the training needs of highly skilled talents in the intelligent equipment manufacturing industry. This paper takes the "Optics and Laser Principle Technology" course at Zhejiang Industry & Trade Vocational College as a real teaching reform carrier, combined with one semester of complete teaching operation data, and based on the requirements of coordinated reform of the five elements, explores a set of implementable and replicable smart curriculum transformation pathways tailored to the realities of higher vocational education. Through reconstructing the modular curriculum system, co-constructing school-enterprise digital teaching resources, building integrated online-offline smart classrooms, improving dual-qualified teacher cultivation and virtual-real integrated training systems, a data-driven whole-process teaching evaluation mechanism is formed. Teaching practice data shows that after systematic smart transformation, students' autonomous learning motivation, classroom participation, and comprehensive course pass rates have all been significantly improved, providing practical reference for the teaching reform of similar fundamental professional courses in optoelectronics and high-end equipment specialties.

KEYWORDS

Vocational education; Key teaching elements; Smart curriculum; Industry-education integration; Digital teaching; Optoelectronic technology.

1. INTRODUCTION

1.1. Policy Orientation and Reform Requirements

In February 2026, the Ministry of Education issued the "Opinions on Deepening the Reform of Key Teaching Elements in Vocational Education" (Jiao Zhi Cheng [2026] No. 1), explicitly proposing five core reform tasks: dynamically adjusting specialties, scientifically designing curricula, optimizing textbook supply, specifying teacher competency requirements, and building industry-education integrated training bases. The document requires coordinated reform following the inherent logic of specialties, curriculum, textbooks, teachers, and practical training. The document emphasizes that curriculum construction must keep pace with industrial technological iteration, align with real production tasks of leading enterprises, decompose post skills and knowledge points, map curriculum competency profiles, and promote comprehensive, modular, and project-based curriculum transformation. Simultaneously, it encourages the development of loose-leaf and digital textbooks, relies on digital teaching carriers to improve full-process learning data collection and diversified evaluation, and promotes two-way talent mobility between schools and enterprises as well as the co-construction of virtual-real integrated practical training scenarios.

The document sets phased development goals: by 2027, establish an advanced standard system for vocational education teaching covering all specialties, and create a number of demonstration bases for highly skilled talent cultivation; by 2035, form a vocational education practice model with Chinese characteristics[1]. As the core carrier of talent cultivation, curriculum directly determines the effectiveness of specialty implementation, the direction of teacher development, and the setup of practical training content. Therefore, carrying out smart curriculum transformation through digital means is an inevitable path for implementing the integrated reform of the five teaching elements.

With the continuous advancement of educational digitalization, smart teaching platforms, virtual simulation resources, and online hybrid teaching have gradually entered higher vocational classrooms. The traditional offline teaching mode dominated by textbook lectures and one-time final assessments can no longer adapt to the learning habits of current vocational students and the speed of technological update in the optoelectronic industry[2]. Processes related to laser processing and optical detection iterate rapidly, and a large number of abstract optical paths and resonant cavity principles are difficult to explain through static blackboard writing. Only through digital and scenario-based smart curriculum transformation can the barriers between specialties, curriculum, textbooks, teachers, and practical training be broken through, achieving simultaneous quality improvement of all five elements.

1.2. Original Teaching Pain Points of the Course

"Optics and Laser Principle Technology" is a 4-credit fundamental professional course for the Intelligent Optoelectronic Manufacturing Technology specialty at our college, with a total of 60 class hours. The course is divided into three major sections: geometrical optics, wave optics, and laser principles and engineering applications, serving as the prerequisite foundation for students' subsequent core practical training courses such as laser processing and optoelectronic detection equipment operation. Before this smart transformation, the course had long followed the traditional discipline-based teaching mode, and there are obvious shortcomings when compared with the reform requirements of the five teaching elements:

- First, course content is disconnected from real enterprise post requirements. Original textbooks are arranged according to theoretical discipline logic, focusing on formula derivation and theoretical explanation, lacking real project cases such as industrial laser equipment debugging and optical path calibration. No post-oriented competency profile has been formed, and knowledge, skills, and professional quality teaching are fragmented from each other.
- Second, teaching resources are monotonous in form. Teaching relies solely on paper textbooks, without supporting loose-leaf manuals, process pocket books, and visualized digital resources. Abstract content such as light interference, diffraction, and laser resonant cavities is difficult for students to understand.
- Third, teaching implementation forms are rigid. Classroom teaching is dominated by one-way teacher lectures, lacking layered learning design. Real-time understanding of the whole class's

learning situation is impossible, and there is a lack of standardized carriers for pre-class preview and after-class consolidation.

- Fourth, teachers' digital teaching capabilities have shortcomings. Instructors lack first-hand enterprise practical process experience, a normalized teaching mechanism for industry mentors has not been established, and capabilities in digital resource development and online classroom organization need improvement.
- Fifth, practical training and assessment systems are imperfect. There is a lack of virtual simulation training carriers, the number of physical equipment is limited, and practical operation opportunities are insufficient. Assessment is mainly based on final written assignments, lacking process-oriented data records throughout the semester, making it impossible to accurately identify students' real competency gaps.

1.3. Research and Practical Value

Theoretically, this paper strictly benchmarks the five-element coordinated reform framework of Document No. 1 [2026], takes the engineering optoelectronic course as an example, and sorts out the integrated digital transformation logic of "specialty positioning – curriculum reconstruction – resource construction – teacher improvement – practical training implementation", enriching the research content of smart reform of fundamental engineering courses in vocational colleges[3].

Practically, based on real data from one complete semester of teaching operation, a complete practical implementation plan is formed, including curriculum module design, school-enterprise resource co-construction, smart classroom processes, process evaluation weights, and training upgrade schemes. The transformation experience can be directly referenced by similar higher vocational colleges' optoelectronics and high-end equipment specialties, meeting the curriculum upgrade needs of emerging specialties such as low-altitude economy and intelligent manufacturing.

2. OVERALL ARCHITECTURE DESIGN OF SMART CURRICULUM TRANSFORMATION

This transformation strictly follows the four working principles of "coordinated reform, standard guidance, and industry-education driven approach" specified in the document, and establishes an overall transformation framework of "one core, five dimensions": with the job-oriented curriculum competency framework as the transformation core, simultaneously promoting five-dimensional transformation including curriculum system reconstruction, digital textbook resource construction, online-offline smart classroom establishment, dual-qualified teacher capability improvement, and virtual-real integrated training base construction, achieving closed-loop linkage and simultaneous upgrading of the five teaching elements[4].

The underlying logic of the overall transformation adheres to backward design: conducting post research in collaboration with laser equipment enterprises within the municipal industry-education consortium, reversely sorting out students' essential knowledge points, practical skills, and professional qualities from real enterprise work tasks to form a standardized competency profile, and then adjusting curriculum modules, supporting teaching resources, designing classroom activities, clarifying teacher competency requirements, and planning training projects based on this profile.

Teaching implementation uniformly adopts Chaoxing Xuexitong (Superstar Learning Pass) as the smart teaching carrier, fully supporting the entire process including preview resources, classroom interaction, after-class assignments, online quizzes, group discussions, learning statistics, and grade calculation. Meanwhile, curriculum ideological and political elements such as serving the country through science and technology, precision manufacturing, and great craftsmen of the nation are integrated into each module's teaching, integrating value guidance into all teaching links to implement the fundamental task of fostering virtue through education.

3. TRANSFORMATION IMPLEMENTATION MEASURES BASED ON THE FIVE TEACHING ELEMENTS

3.1. Dynamically Optimizing the Curriculum System and Building Modular Project-Based Teaching Content

In accordance with the document's requirement to "align with typical production tasks of leading enterprises and map curriculum competency profiles", post visits were conducted in collaboration with process engineers from local laser equipment manufacturing enterprises. Typical work content of frontline positions such as optical path debugging, laser operation and maintenance, and optical quality inspection was sorted out, and three types of teaching objectives – knowledge points, practical skills, and professional qualities – were decomposed to form the exclusive competency profile for this course.

3.1.1. Reconstructing Four Project-Based Teaching Modules

Breaking the original purely theoretical chapter division, course content is restructured with real enterprise production projects as carriers:

- Module 1: Geometrical Optics and Industrial Optical Path Systems, supported by lens assembly and simple optical path calibration training projects;
- Module 2: Wave Optics and Optical Detection Technology, supported by interferometry and diffraction quality inspection practical cases;
- Module 3: Laser Generation Principles and Various Laser Structures, covering debugging of mainstream industrial lasers including solid-state and fiber lasers;
- Module 4: Comprehensive Laser Engineering Applications, integrating typical processes in the laser cutting and 3D printing industries.

Each module is equipped with current industry process standards and cases of domestic optoelectronic equipment development, balancing STEM general content and humanistic quality expansion, achieving interdisciplinary integration of arts and sciences.

3.1.2. Setting Layered Step-by-Step Learning Tasks

Three levels of learning tasks – basic, advanced, and extended – are set up on the smart platform. The basic level requires completing principle videos and basic knowledge quizzes; the advanced level requires completing simulation training; the extended level opens enterprise process case discussions and cutting-edge industry materials to adapt to the learning pace of students with different foundations.

3.1.3. Simultaneously Building a Curriculum Ideological and Political Resource Database

Corresponding ideological and political entry points are explored in combination with the professional content of each module. For example, explaining cases of domestic lasers breaking through foreign technological barriers cultivates students' awareness of strengthening the country through science and technology, and explaining standardized equipment operation strengthens professional bottom lines. All ideological and political cases are uniformly organized into digital materials and embedded in corresponding online learning tasks.

3.2. School-Enterprise Collaborative Co-Construction of Diversified Teaching Resources and Enriching Digital Textbook Forms

Implementing the textbook development mechanism of "three chief editors – enterprise, industry, and school" required by the document, a joint resource development team was formed consisting of on-campus professional teachers, enterprise laser process engineers, and optical industry experts, constructing a dual supporting resource system of paper supporting materials + digital resources:

Project-based loose-leaf training manuals and laser process quick-reference pocket cards were compiled, allowing separate page additions when industrial processes are updated without needing to replace the entire textbook; 41 modular teaching videos were recorded, with a total duration of 264 minutes; 80 industry standards and equipment operation documents were sorted out, supplemented by dynamic demonstration animations of optical paths and resonant cavities to resolve difficulties in abstract theoretical teaching; a course question bank with 902 questions was built, supporting standardized assessment resources such as chapter assignments and in-class exercises; group discussion, online questionnaire, and quick-response interactive materials were designed; internal employee training courseware and equipment operation specifications from partner enterprises were desensitized, screened and optimized, then converted into extended course learning materials, realizing the transformation of enterprise technical resources into teaching resources. All resources are classified and uploaded to the smart teaching platform, allowing students to access and review at any time, and teachers to precisely push differentiated learning materials according to class learning conditions.

3.3. Building an Integrated Pre-Class – In-Class – After-Class Smart Classroom

Relying on Chaoxing Xuexitong, a closed-loop smart teaching process was established, changing the single offline lecture mode and achieving precise teaching through learning data collected by the platform[5]. The complete teaching operation data for this semester is as follows:

Pre-class preview session: Teachers release videos, document preview materials, and pre-quizzes in advance. The platform automatically counts preview duration and answer accuracy, generates a list of weak knowledge points for the class, and adjusts key and difficult points accordingly for offline teaching. The total course visits reached 9,723 times throughout the semester, with students' autonomous online learning becoming the norm.

In-class interaction session: Offline classrooms simultaneously use the platform for activities such as check-in, random student selection, quick response, and in-class exercises. This semester, 114 check-ins, 56 quick-response sessions, and 38 in-class exercises were initiated; simulation animations are played for abstract optical principles, paired with simple optical teaching aids for on-site demonstrations, and enterprise industry mentors are simultaneously invited for online connections to explain real frontline processing conditions.

After-class consolidation session: 22 sets of course assignments are arranged in layers. Objective questions are automatically graded by the platform, and subjective questions are graded online by teachers; a class discussion area is opened, with the Intelligent Optoelectronics Class D generating 37 student-led discussion entries. Teachers provide real-time online Q&A, extending the classroom learning space.

3.4. Refining Teacher Competency Lists and Improving the School-Enterprise Two-Way Cultivation Mechanism

In accordance with the document, four competency requirements for teachers are refined: professional theory, practical operation, teaching, and digital teaching research, establishing a normalized improvement mechanism for the course team[6]:

Developing course-exclusive teacher competency lists, clarifying detailed competency requirements such as digital resource production, smart classroom organization, learning data analysis, and virtual training guidance, and regularly conducting special on-campus teaching research training on platform operation and digital textbook production; implementing the school-enterprise two-way mobility system, with two course instructors going to partner laser enterprises for on-the-job practical training each semester, while simultaneously hiring enterprise skill masters and process engineers as industry mentors to participate in course resource compilation and project teaching;

Regularly organizing class observation, class evaluation, and teaching competition activities, conducting collective teaching research around hybrid teaching design and curriculum ideological and political integration, and continuously optimizing classroom implementation methods.

3.5. Building Virtual-Real Integrated Industry-Education Training Carriers

Closely following the reform requirements of the practical training element, a dual-line construction model of on-campus physical workstations + online virtual simulation is adopted:

Co-constructing optical path debugging training workstations relying on industry-education consortium resources, introducing enterprise-used lasers and optical detection equipment, supported by standardized operation loose-leaf manuals; embedding optical path and laser resonant cavity simulation resources in the smart platform, allowing students to repeatedly simulate operations online, reducing physical equipment wear and operational safety risks; converting enterprise equipment operation specifications into an online training test question bank, with students' training performance synchronously recorded on the platform. The entire training process is traceable, and skill levels can be quantitatively evaluated.

4. PRACTICAL RESULTS AND EXISTING SHORTCOMINGS OF CURRICULUM TRANSFORMATION

4.1. Overview of Practice Foundation

The pilot cycle of this smart curriculum transformation was the second semester of the 2025-2026 academic year, covering four classes – Intelligent Optoelectronics A, B, C, and D – with a total of 145 students. One semester of hybrid smart teaching was fully conducted through Chaoxing Xuexitong, with the platform automatically retaining all raw data on learning, classroom activities, assignments, and grades, enabling intuitive comparison of teaching effectiveness differences before and after transformation.

4.2. Teaching Implementation Results

Students' autonomous learning behavior has been significantly improved. The total course visits reached 9,723 times throughout the semester, with each class recording hundreds of classroom interaction participations. Among them, Class C had nearly 2,000 participations in quick-response and in-class exercises. Students' pre-class autonomous preview and after-class resource review have become regular learning behaviors, with learning initiative greatly enhanced.

Assignment completion quality shows layered characteristics. The average assignment completion rate of the four classes ranges from 67% to 97%. Classes C and D, which deeply participated in smart classrooms, had significantly more students in the high-score segment (80-100 points), with 29 students in Class C and 32 students in Class D scoring above 80 points, showing significant improvement in students' knowledge mastery.

The process-oriented evaluation system has initially achieved results. The comprehensive course grade cancels the single final written exam, with weight settings of 25% for chapter tasks, 25% for assignments, 15% for check-in, and 35% for course points, comprehensively determining learning effectiveness based on full-semester process data. Among 145 students, 83 passed the course; among them, Class C had a pass rate of 94.87% and Class D had a pass rate of 91.43%, with the two classes regularly participating in online-offline smart teaching having far higher compliance rates than the other two classes.

Comprehensive education effectiveness has been improved. With modular project teaching paired with virtual-real training, students have a more thorough understanding of practical content such as industrial lasers and optical path debugging, and enterprise internship feedback indicates that this cohort of students adapts to positions faster than previous cohorts; curriculum ideological and political materials are regularly integrated into classrooms, and students actively discuss domestic optoelectronic industry development in class discussions, with their awareness of patriotism and craftsman spirit strengthened.

4.3. Current Shortcomings

First, virtual simulation resource reserves are insufficient. There are only basic optical demonstration animations, lacking complete digital twin training modules for laser production lines, with insufficient support for online training of complex production line operations.

Second, industry mentor teaching lacks a normalized fixed mechanism. Enterprise engineers give lectures at school and participate in teaching research infrequently, and there is still room for improvement in the depth of school-enterprise collaborative education.

Third, some students with weak foundations lack motivation for autonomous online learning. The platform can only uniformly push resources, lacking supporting mechanisms for personalized layered tutoring.

Fourth, there is no fixed cycle for updating the curriculum competency profile and enterprise talent demand, with lag in updating new industrial processes and new equipment content.

5. LONG-TERM OPTIMIZATION AND GUARANTEE COUNTERMEASURES

Combined with the requirements for long-term element reform in Document No. 1 [2026], and targeting the shortcomings exposed in this pilot, a normalized iterative optimization mechanism is established:

Conducting annual industry talent demand research in collaboration with the municipal industry-education consortium, and simultaneously updating the post competency profile; quarterly supplementing videos, simulations, and loose-leaf resources related to new laser technologies and equipment to ensure teaching content keeps pace with industrial iteration.

Improving supporting policies such as class hour subsidies and evaluation awards for enterprise engineers' teaching and resource development participation, fixing monthly school-enterprise joint teaching research time, promoting industry mentors to regularly enter classrooms and teaching research groups, and implementing the long-term operation mechanism of the "three chief editors" resource development team.

Establishing student competency profiles based on platform learning data, automatically pushing adapted layered learning packages; setting fixed online Q&A sessions for low-scoring students, paired with after-school small offline tutoring sessions to make up for foundational gaps.

Incorporating curriculum resource construction, smart classroom implementation, dual-qualified teacher cultivation effectiveness, training base utilization, and industry-education alignment into annual course assessment indicators, linking them with specialty fund allocation, course project approval, and teacher evaluation awards, ensuring the long-term implementation of the five-element coordinated reform.

6. CONCLUSION

Against the policy background of the Ministry of Education deepening the reform of the five key teaching elements in vocational education, smart curriculum transformation cannot be simply equated with uploading videos to online platforms and adding online assignments. Instead, it is a systematic collaborative reshaping of specialty positioning, curriculum content, teaching resources, teacher cultivation, and practical training. This paper takes the "Optics and Laser Principle Technology" course as a real teaching reform sample, based on the actual situation of our college's optoelectronic specialty, and constructs a complete smart curriculum transformation path with post competency profiles as the core, digital platforms as the carrier, and industry-education collaboration as support. Verified by one semester of complete teaching practice, this transformation scheme can effectively alleviate long-standing problems of traditional courses such as industry-education disconnect, monotonous teaching forms, and one-sided assessment, with students' learning activity and post adaptation capabilities simultaneously improved.

Going forward, our college will continue to rely on the resources of the municipal industry-education consortium, improve long-term mechanisms such as dynamic curriculum updating, school-enterprise dual-teacher collaboration, and digital twin training construction, continuously optimize the hybrid smart teaching mode, and steadily deliver highly skilled talents adapted to industrial needs for intelligent optoelectronics and high-end equipment specialties. Through micro-level reform at the curriculum level, we will support the high-quality development of the overall vocational education system.

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