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Development and Practical Exploration of New Work-Process-Oriented Teaching Materials—Taking the Course "Engineering Materials" as an Example

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Abstract

Against the backdrop of accelerated digital transformation in vocational education, traditional textbooks have proven ineffective in cultivating students' innovative thinking and comprehensive workplace competencies. This study proposes a new textbook development model based on work process orientation, characterized by a dynamic and modular design that deeply integrates print and digital resources. Taking the Engineering Materials course as a case study, this paper examines the practical implementation of this new textbook model through its development logic, conceptual framework, and implementation steps, aiming to provide a reference for the development of new textbooks in secondary vocational institutions.

Keywords

New-form Textbooks, Vocational Education, Work Process Orientation

1. Introduction

In January 2025, the Central Committee of the Communist Party of China and the State Council issued the "Outline of the Plan for Building an Education Powerhouse (2024-2035)," which clearly stated that somebody must implement the national responsibility for textbook development. It involves establishing a high-quality textbook system that "nurtures character and cultivates wisdom," while accelerating the digital transformation of textbooks and improving tiered and categorized management. (Central Committee of the Communist Party of China & State Council, 2025). In April 2025, the Ministry of Education and eight other departments jointly issued the Opinions on Accelerating the Digital Transformation of Education, emphasizing that textbooks play a pivotal role in the development of vocational education through their functions of knowledge dissemination, learning support, and teaching guidance. (Ministry of Education of the People's Republic of China, 2025). The achievements of vocational education's digital transformation are reflected in the development and construction of each textbook. New-format textbooks are characterized by dynamism, interactivity, and personalization. Compared to traditional textbooks, they better align with the upgraded demands for talent cultivation driven by industrial transformation in the digital era.

The rapid advancement of intelligent and digital technologies is driving unprecedented demand for new talent across multiple industries, including machinery, materials, and aerospace, while simultaneously compelling the renewal and enhancement of material application capabilities. Concurrently, national policy direction is clear: the Ministry of Education's 14th Five-Year Plan for textbook development prioritizes materials in new materials, advanced manufacturing, and green low-carbon technology fields, emphasizing "digital-intelligent technology integration" and "industry-education collaborative development." The Engineering Materials course serves as a core professional subject for mechanical manufacturing technology programs at secondary vocational institutions. Its primary objective is to equip students with foundational knowledge of various materials—particularly metallic materials—and cultivate preliminary competencies in establishing process parameters, analyzing component failures, and conducting metallographic analysis of structure and performance. The interdisciplinary nature of materials textbooks, guided by a teaching philosophy emphasizing a solid foundation, broad scope, and strong interdisciplinary focus, makes the curriculum for materials-related majors particularly complex. Beyond essential foundational knowledge in mathematics, physics, and chemistry, the content encompasses multiple disciplines, including mechanical engineering, thermal energy, electronics, biology, architecture, chemical engineering, and environmental science, necessitating a deep integration with these fields (Tao, 2023). However, traditional textbooks for this course currently suffer from issues in vocational education settings, including a disconnect between knowledge and job requirements, a lack of personalization, outdated content, poor visual representation, and weak practical application. These shortcomings hinder students' comprehension of abstract concepts, such as microstructural evolution, heat treatment processes, and iron-carbon alloy phase diagrams.Moreover, the content fails to incorporate cutting-edge technologies, such as smart manufacturing and new energy vehicles, and struggles to provide resource simulation training. It hinders the development of students' innovation capabilities, practical skills, and overall professional competence. Consequently, new-format textbooks have gradually emerged to address these significant shortcomings of traditional materials. However, the development of new-format Engineering Materials textbooks remains immature in practice, with limited availability and notable deficiencies. These include relatively superficial content development, limited access to digital resources, and insufficient utilization of supporting platform resources. Furthermore, most existing new-format textbooks lack immersive interactive experiences, fail to replicate the depth of interaction found in real workplace scenarios, and neglect students' individualized development (Xie, 2025). Therefore, development efforts should prioritize enhanced interactive design, comprehensive utilization of digital resources, and personalized development tailored to the cognitive characteristics of vocational students. Work-process orientation remains the mainstream direction in vocational education research. Statistics indicate that this approach significantly improves the alignment between textbooks and job requirements. Thus, addressing the shortcomings of traditional textbooks and the inadequacies in new-format textbook development, creating a new-format textbook aligned with contemporary characteristics based on work-process orientation holds significant importance.

Scholars both domestically and internationally have conducted extensive research on defining the concept of new-form educational materials. American scholars Gia Fradinberg and Gary W. Matkin view it as an open, dynamic continuum (Shi, 2024), evolving from the simple digitization of traditional textbooks toward integrated open-resource collections that incorporate video, simulations, assessments, and other resources. They emphasize its inherently interactive and dynamic nature. However, current technological limitations mean new-form textbooks will remain at an intermediate stage for the foreseeable future. Domestic research generally identifies three developmental phases: the initial stage of electronic textbooks (e.g., PDFs), followed by the “integrated textbook” model that combines print materials with online courses and blended learning, and finally the “omni-media digital textbook” that encompasses content, software, and terminal devices. New-form textbooks in vocational education stem from the establishment of vocational education as a distinct educational category and the promotion of high-quality vocational education through policy documents, such as the Vocational Education Quality Enhancement and Excellence Action Plan, which advocates for “loose-leaf, workbook-style” textbooks (Zheng, 2023). Academic consensus holds that new-form textbooks should be grounded in vocational competencies, designing modular learning tasks based on typical work tasks and processes. Presentation formats include workbook-style, loose-leaf, and project-based textbooks. Integrating policy direction and academic consensus, these new-form textbooks adopt a learner-centered approach, embedding knowledge, skills, and competencies within typical work projects. They organically integrate print resources with digital teaching platforms such as VR/AR and virtual simulation technologies.

2. Development Logic and Approach for New-Format Textbooks

2.1 Establishing Development Logic for New-Format Textbooks Based on a Work Process Orientation

In 1996, work process-oriented curriculum theory emerged and gradually matured within the German educational community, becoming the core theoretical foundation for the development of modern vocational education curricula. This theory advocates integrating curriculum theory with practice by leveraging case studies, scenarios, and simulations of specific industry work processes, thereby effectively bridging the gap between theoretical knowledge and practical experience. In response to industrial upgrading and technological shifts in the new era, a new generation of teaching materials has emerged. Characterized by vocational contextualization, environmental interactivity, and timely knowledge updates, these materials simulate authentic work scenarios and tasks, providing a realistic learning experience. Centered on typical job duties, they reorganize instructional content according to occupational requirements and practical work tasks, ensuring student learning aligns with corporate needs (Wang, 2025). To enhance learning immersion and create more authentic scenarios, multimedia and virtual simulation technologies can be leveraged to build interactive, hands-on environments that foster deeper learning. Big data analytics can then be employed to respond promptly to industry technological advancements, ensuring content remains cutting-edge and timely. Thus, the work-process-oriented theory aligns closely with vocational education textbook requirements and resonates with the "competency-based" essence of vocational education. Consequently, developing a new-format Engineering Materials textbook grounded in work-process orientation necessitates a compilation logic centered on authentic engineering materials-related occupational activities and typical work tasks. The development logic should therefore follow this core path: job task analysis—deconstruction of knowledge and competency—digital reconstruction. Taking Engineering Materials as an example, this paper first analyzes tasks corresponding to typical job positions and extracts required core competencies. It then deconstructs and reorganizes relevant knowledge structures in a targeted manner. Subsequently, it employs appropriate technological means for digital analysis, presentation, and interactive design in a scientific manner. Finally, through digital channels, the textbook content achieves multidimensionality, modularity, and dynamism.

2.2 Development Approach for New-Format Teaching Materials

The development approach represents the practical implementation and execution strategy of the aforementioned development logic at the operational level. It aims to systematically realize key components within the logical chain by applying relevant theories and methodological tools.

2.1.1 Job Task Analysis for Anchor Task Design

To achieve the starting point of development logic—"job task mapping"—the core operation involves precisely analyzing job tasks and designing effective learning anchors. Situated Learning Theory provides key methodological support for this phase, emphasizing that knowledge is contextual, learning is social (relying on communities of practice), and learning activities must be anchored in real-world practice. Using learning scenarios as module introductions immerses learners in authentic or highly simulated professional environments from the outset. It enables action-oriented learning closely aligned with workplace processes, ensuring the achievement of vocational functionality goals in new-format vocational education materials. During the initial development phase of new-format textbooks, it is essential to clarify occupational competency requirements based on typical work tasks corresponding to the Engineering Materials course. Simultaneously, role-playing scenarios should be designed by integrating research findings on the characteristics and preferences of secondary vocational students. It creates learning contexts closely linked to students' prior knowledge, allowing knowledge to emerge naturally through community interaction. Ausubel's "advance organizer" strategy plays a crucial role in this process. By establishing connections between new and existing knowledge and using concrete examples to substantiate abstract concepts, it ensures that anchor tasks better serve the completion of real-world work tasks.

2.1.2 Dual-Theory-Driven Reconstruction of Knowledge Presentation Methods

A crucial step in realizing the development logic is “knowledge capability deconstruction,” whose core operation involves deconstructing the knowledge system and thoroughly reconstructing its presentation methods. Constructivism asserts that learners do not passively receive knowledge; instead, they actively construct meaning based on their prior experiences. It aligns to cultivate practical abilities in work-process orientation, as both emphasize learner agency. By integrating real-world learning patterns and breaking free from the linear constraints of traditional disciplinary knowledge systems, knowledge is reorganized around task flows and competency development, thereby improving its presentation. The overall approach involves reconstructing knowledge frameworks around anchor tasks, creating authentic problem scenarios tailored to each chapter's content, and guiding students through a spiral acquisition of knowledge and skills. Knowledge construction is achieved through group collaboration, with formative assessment embedded throughout to reinforce the transfer of skills across diverse work contexts. It ultimately cultivates the core competencies required in the work process.

2.1.3 Framework for Integrating Virtual and Physical Digital Resources

The core component of developing new-format teaching materials lies in integrating digital resources. To maximize the functionality of these materials, a work-process-oriented approach can leverage digital resources to simulate real-world workflows and tasks. Based on prior research into job positions, a systematic competency checklist and task anchor points have been established. Next, a simulation platform will be utilized to construct virtual team organizations and professional roles. Authentic enterprise engineering material production processes—particularly for chapters that are highly practical yet challenging to comprehend (such as steel heat treatment)—VR or AR technologies will transform these into highly interactive immersive virtual scenarios, enabling students to learn by doing within engaging contexts. Gamified learning mechanisms like “online knowledge challenges” will provide immediate, clear feedback, significantly boosting learner motivation. For complex, abstract theoretical concepts, engaging online forums and visually immersive, interactive scenario experiences are implemented to enhance knowledge visualization and interactivity. The key lies in ensuring that the learning challenges created by technology applications consistently fall within the learner’s “zone of proximal development.” It involves setting clear objectives, implementing tiered difficulty adjustments, and providing immediate feedback to maintain dynamic equilibrium and high engagement throughout the learning process. Additionally, AI technology can track and analyze individual learning process data to deliver personalized, precise content recommendations. It maximizes students’ fragmented time while addressing attention deficits. Simultaneously, leveraging big data to correlate industry standards with technological advancements dynamically ensures the timeliness and continuous updating of instructional materials. It enables new-format textbooks to fully leverage their advantages within vocational education.

3. Using Engineering Materials as an Example: Steps for Developing New-Format Textbooks

After completing foundational research (such as policies and regulations) prior to textbook development, follow a process-oriented paradigm. Anchor the content to job tasks and production processes, leveraging digital tools to innovate knowledge delivery. Traditional textbooks typically follow a linear development path, organizing subject knowledge sequentially and undergoing expert review. In contrast, new-format textbooks break conventional presentation models. They adopt a three-stage approach—deconstructing job tasks, reconstructing knowledge presentation, and integrating digital methods—to achieve the transformation from knowledge-centered to competency-centered learning.

3.1 Textbook Job Correspondence Table and Competency List

As a core professional course widely adopted across secondary vocational institutions nationwide, the Engineering Materials textbook plays a pivotal role in bridging foundational knowledge with practical skills, thereby supporting students' subsequent career development. Research indicates this textbook primarily aligns with five job categories: operational, quality inspection, technical support, equipment maintenance, and marketing/warehousing personnel. While each role emphasizes distinct skills and responsibilities, they share the standard requirement of a deep understanding of material properties and industry trends. Specific competency categories and their corresponding job skill requirements are detailed in Table 3-1.

Table 3-1 Core Competencies Cultivated by the Engineering Materials Textbook

Capability Category	Competency Description	Corresponding Job Group
Material Identification Capability	Identify common materials and understand how material states affect performance.	Machining Operators, Quality Inspectors, Warehouse Keepers
Material Selection Capability	Match materials based on the "performance-cost-processability" balance principle and identify common failure causes.	Production Support Staff, Maintenance Technicians, Quality Inspectors, Equipment Repair Technicians
Process Understanding Capability	Gain a qualitative understanding of microstructural transformations and performance changes during processing, and make preliminary	Heat Treatment Operators, Welders, Foundry Workers, Quality Inspectors

Capability Category	Competency Description	Corresponding Job Group
	judgments on defect causes.	
Quality Inspection Capability	Comprehend material technical requirements, master equipment inspection operations and result interpretation.	Quality Inspectors, Machine Operators, Test Technicians
Safety and Sustainability Capability	Recognize operational safety hazards and protective measures, understand the significance of scrap sorting and recycling, and develop a mindset for material conservation.	All Positions

3.2 Reconstructing Knowledge Presentation Formats

The Engineering Materials textbook comprises ten chapters, with Chapter 5—“Heat Treatment of Steel”—representing a key challenge due to its pronounced practicality and the complex process decision-making involved. This chapter demands two competencies from students: mastery of fundamental material theory and proficiency in applying process parameter design knowledge. The goal is to cultivate their ability to design process solutions independently. Common learning difficulties include selecting quenching temperatures and setting holding time parameters. Engineering textbooks commonly face constraints in practical resources. Based on job competency analysis, this textbook introduces “Automotive Connecting Rod Body Process Design and Fabrication” as an anchor to introduce subsequent knowledge. VR/AR virtual simulation technology recreates practical scenarios, such as industrial furnace temperature control and quenching medium selection. The Engineering Materials textbook content is divided into ten chapters. Each chapter possesses distinct content characteristics. Notably, Chapter 5, “Heat Treatment of Steel,” is widely regarded by students as the most challenging section due to its strong practicality and complex process decision-making. This type of knowledge not only requires students to master fundamental material theories but also demands flexible application of process parameter design knowledge. Consequently, it necessitates cultivating the ability to independently design process solutions, such as addressing issues like selecting quenching temperatures and setting holding time parameters. However, engineering textbooks often lack sufficient practical resources. To address the challenge of cultivating hands-on skills despite limited facilities, this study analyzes job competency lists to identify the most effective approaches. It selects “Automotive Connecting Rod Body Process Design and Fabrication” as an anchor topic. Utilizing VR/AR virtual simulation technology, it recreates practical scenarios such as industrial furnace temperature control and quenching medium selection. Students engage in role-playing (as heat treatment technicians or quality inspection engineers) to complete a closed-loop learning cycle: "understanding process principles → parameter calculation → virtual validation." This approach utilizes digital technology to reconstruct the "learning by doing" paradigm in vocational education, integrating theoretical knowledge deeply with job competencies.

This textbook integrates case studies, project-based learning, and virtual simulations on a digital platform to create a novel presentation format. As each chapter of the Engineering Materials course has distinct teaching objectives and emphases, different presentation formats are matched based on content characteristics, difficulty levels, and relevance to daily life. Beyond Chapter 5, which is recognized as a challenging section, the primary goal from Chapter 1 onwards is to cultivate students' material identification skills while sparking their interest and enthusiasm for the course. It can be achieved by incorporating case studies closely tied to the daily lives of students in this age group, supplemented by thematic forums. This approach maximizes the knowledge dissemination benefits of interaction, deepening students' understanding of various materials. The primary challenge in Chapter 2 lies in the limited spatial visibility of crystal structures, which students find difficult to grasp. Therefore, 3D animations are employed to address this difficulty. Subsequent chapters each possess distinct characteristics, necessitating the selection of appropriate knowledge presentation formats and reconstruction methods tailored to these spe.

3.3 Digital Empowerment Platform

Building upon the aforementioned foundation, we designed a digital empowerment framework using Chapter 5 of the new-format Engineering Materials textbook as a case study. This chapter adopts a project-task approach as its primary method for presenting knowledge, with the core objective of cultivating students' ability to design heat treatment process solutions. Therefore, "Automotive Connecting Rod Body Process Design and Practice" serves as the central anchor threading throughout the chapter.

3.3.1 Knowledge Acquisition Phase

This stage builds essential foundational cognitive frameworks for students, laying a solid groundwork for subsequent task progression. Utilizing knowledge graphs and 3D animations, it systematically guides learners from a holistic to a granular understanding of heat treatment processes. Following the comprehensive absorption of foundational knowledge, students engage in question-and-answer challenges, which effectively enhance their learning focus, participation in project-based activities, and retention of knowledge. Traditional textbooks typically plan learning paths based on the sequence of knowledge points in the material, lacking personalization and dynamism. Intelligent textbooks effectively address this issue.

a. Dynamic Resource Planning: Based on an initial assessment of the learner's knowledge foundation and dynamic tracking during the learning process, the system updates learning paths in a stratified manner and intelligently recommends them based on individual differences.

b. Differentiated Resource Recommendations: Tailored learning resources and explanation strategies are recommended based on individual learning bottlenecks. For instance, addressing challenges in defining and distinguishing the “Four Fires,” the system adapts its approach based on whether the learner passes or fails. Learners with stronger comprehension skills are prioritized for efficiency-focused resources, such as knowledge maps, operational flowcharts, and videos. For learners with weaker comprehension, more surface-level and concrete resources are prioritized—such as animated demonstrations, analogy-based examples, and interactive simulations—to deepen foundational understanding.When group knowledge mastery reaches a preset threshold (>85%), the system automatically advances to the next section of the curriculum.cific traits.

3.3.2 Project Implementation Phase

Centered on work-process-oriented theory and supported by contextual learning theory, this phase establishes fixed teams tailored to vocational students’ preferences. Role assignments are designed according to different course emphases, simultaneously cultivating students' communication skills and teamwork abilities. In the new-format Engineering Materials textbook, students simulate heat treatment operations through an AR laboratory, incorporating gamified elements (e.g., laboratory attire requirements, selection of cooling media, and rationale). The core project involves independently designing heat treatment solutions. This component utilizes a learning data-driven progress tracking system to unlock implementation information, employing micro-decisions and providing correct/incorrect feedback to adjust difficulty levels, ensuring that knowledge points remain within students' Zone of Proximal Development. This section incorporates intelligent assistance technology. When design progress stalls, the system tracks learning data to identify knowledge gaps and provides targeted guidance, facilitating smooth project advancement. Teams can establish virtual meeting rooms for collaborative information sharing, enhancing interactivity, and participate in diverse forums to strengthen ideological and political awareness. The specific design pathway is illustrated in Figure 3-2.

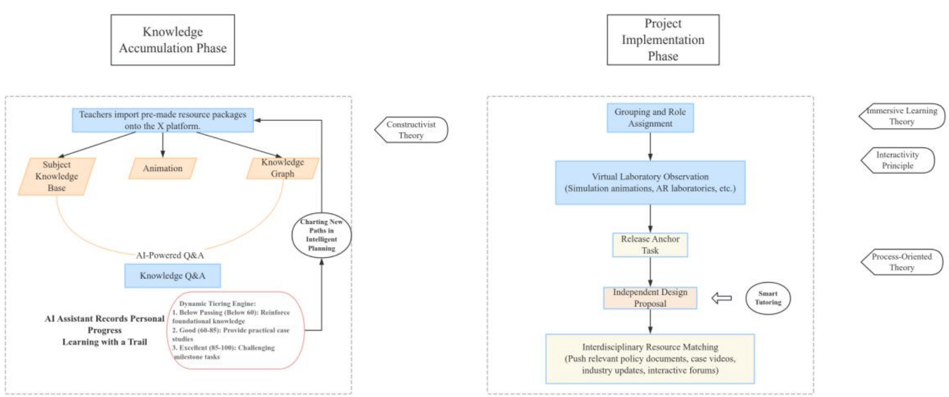

Figure 3-2 Design Framework for Digital Media of the New Format Textbook “Engineering Materials”

4. Conclusion

The development of new-format vocational education textbooks signifies a profound transformation in textbook development. This shift is reflected not only in continuous technological upgrades and innovations but also in the ongoing evolution of textbook application logic. Naturally, this developmental path presents new challenges: effectively integrating multimodal interactive experiences that encompass visual, auditory, and tactile elements; managing technological costs; and enhancing the digital literacy of teaching teams—all critical to the sustainable development of new-format textbooks.

Therefore, looking ahead, textbook development will advance several key directions simultaneously: strengthening digital competency training for educators, deepening industry-education collaboration mechanisms, establishing unified technical standards, and developing lightweight interactive frameworks. The ultimate goal is to elevate textbooks into intelligent hubs for industry-education integration and build dynamic data feedback loops. It will precisely forge “digital artisans” who meet the demands for highly skilled technical talent in the new era. Future new-format teaching materials will more closely align with industry frontiers, respond rapidly to evolving demands, and enable dynamic content updates. Their form will further evolve into comprehensive digital resource platforms that support diverse learning models, dedicated to maximizing the learner experience. Concurrently, an open-sharing educational ecosystem will promote sustainable resource utilization, cultivating technical and skilled talents equipped with both innovation and practical abilities—ready for the digital and intelligent era—thus laying a robust foundation for modern vocational education.

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