World Journal of Educational Studies
Print ISSN: 2959-9989
Online ISSN: 2959-9997
DOI: https://doi.org/10.61784/wjes3175

DESIGN OF INTERACTIVE MECHANISMS AND EFFECTIVENESS ENHANCEMENT PATHS FOR DIGITAL TEXTBOOKS IN HIGHER VOCATIONAL EDUCATION IN THE DIGITAL-INTELLIGENT ERA

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Abstract: The construction of digital textbooks in higher vocational education is currently at a critical turning point: while the number of platforms and resources continues to grow, actual student engagement rates and learning effectiveness improvements remain unsatisfactory. The crux of the problem lies not in the sophistication of technology, but in whether interactive design is truly grounded in the type-specific characteristics of higher vocational education. Drawing from the practical realities of higher vocational education, this paper proposes that the interactive design of digital textbooks should focus on three key dimensions: real-time technological responsiveness, immersive scenario reconstruction, and proactive behavioral activation. Centering on these three dimensions, the article elaborates mechanism design from four levels—intelligent interaction, content reconstruction, community collaboration, and evaluation feedback—and explores concrete pathways for enhancing textbook utilization effectiveness through lowering barriers, stimulating motivation, precise adaptation, and continuous updating.
Keywords: Digital textbooks; Interactive mechanism; Higher vocational education; Learning effectiveness

1 INTRODUCTION

1.1 Context and Motivation

In recent years, China has made sustained efforts to advance digital transformation in education. The Action Plan for Educational Informatization 2.0 explicitly calls for the deep integration of information technology with teaching and learning, while the 2021 Guiding Opinions on Promoting High-Quality Development of Modern Vocational Education further emphasizes the construction of high-quality digital teaching resources [1]. Driven by these policies, higher vocational colleges have witnessed notable progress in digital textbook development, with various digital platforms, rich-media courseware, and interactive resources emerging at a rapid pace.Yet digital textbook construction in this sector now stands at a critical turning point—from simply having resources to ensuring they actually work well in practice. Many digital textbooks currently in use possess an electronic form but fail to deliver satisfactory learning outcomes [2]. Although some platforms offer features such as rich media, interactivity, and mobile accessibility, the interactive design that genuinely motivates students to engage deeply remains inadequate [3,4]. The disconnect between pre-class, in-class, and post-class interactions in internet-based teaching often reduces digital textbooks to mere repositories of course materials [5]. Internationally, textbook digitization is gradually evolving toward the creation of interactive teaching environments, shifting the focus from piling up technologies to building an interactive ecosystem [6].

Higher vocational education differs markedly from general higher education in three respects. First, students enter with widely varying academic foundations, making a uniform teaching pace difficult to sustain. Second, skill development depends heavily on authentic contexts; students need repeated practice in work-like settings to master operational procedures [7]. Third, teaching content must keep pace with evolving industry standards and job requirements, and outdated textbooks risk leaving students behind [8,9]. These characteristics mean that interactive design for higher vocational digital textbooks cannot simply copy models from general universities; it must be built from the ground up around the distinctive features of vocational education.

1.2 Current Research and Its Limitations

Existing studies fall broadly into two orientations. The first is technology-centered, concentrating on the application of VR, AR, and AI in textbooks [10]. While these studies provide technical solutions, they rarely examine how interactive mechanisms systematically influence learning outcomes. The second is interaction-typology, classifying interactions into functional categories such as content interaction, test interaction, and encyclopedia interaction, or proposing interaction models from the perspective of scenario theory [11]. These typologies are well-structured but overly functional; they do not uncover the internal mechanisms through which interaction activates learning behavior.

Moreover, skill-training courses with a distinctly vocational character have received insufficient attention in interactive design. Under the requirement of industry-education integration, questions such as how enterprises can participate in textbook interaction and how real projects can be embedded into textbook content remain largely unexplored. Teachers also face practical challenges—limited time and inadequate support—when selecting and using digital textbooks [12], yet interactive design has paid little attention to this burden. In light of these gaps, this paper sets out to build a targeted interactive design framework grounded in the practical realities of higher vocational education.

2 THEORETICAL UNDERPINNINGS: THREE LAYERS OF INTERACTIVE LOGIC IN DIGITAL TEXTBOOKS

At its core, interactive design for digital textbooks must address a fundamental question: why would students choose to use this textbook, and how does using it help them learn better. Drawing on an analysis of current practice, this paper proposes three layers of interactive logic: technological responsiveness, contextual immersion, and behavioral activation.

2.1 Technological Responsiveness: Addressing Students' Immediate Confusion

Students may encounter problems at any point during learning. In traditional instruction, these problems often have to wait until a teacher's office hours, during which the learning rhythm is interrupted and students may even give up. Digital textbooks break this time gap through intelligent Q&A systems, allowing students to receive targeted answers immediately after raising a question. The questions posed by higher vocational students tend to be highly operational in nature—such as how to connect a circuit or how to debug a program—and intelligent systems must be able to understand such concrete questions and provide actionable step-by-step guidance. Automatic learning-path recommendation is another important form of technological responsiveness: the system judges mastery levels based on data such as homework completion and test accuracy, then automatically pushes learning resources suited to each student's level, enabling everyone to learn at their own pace.

2.2 Contextual Immersion: Recreating Authentic Work Settings

Skill development in higher vocational education depends heavily on context. The gap between what is taught in the classroom and what is done on the job—in terms of environment, equipment, and workflow—has long been a persistent challenge. Digital textbooks possess a unique advantage in building scenarios. Through VR and AR technologies, they simulate real work environments, allowing students to experience near-authentic settings in the classroom. For example, aviation maintenance students can practice wiring-diagram reading and fault diagnosis in a virtual environment, while nursing students can practice procedures in a virtual ward. In a plant physiology course, researchers developed an interactive digital textbook integrating AR and VR, achieving a validated effectiveness rate of 91.82% [13]. When textbook content is directly linked to students' professional needs, their engagement with the textbook is significantly higher than expected [14], suggesting that higher vocational digital textbooks should be tightly aligned with job tasks. Even without VR equipment, ordinary digital textbooks can enhance a sense of context through multimodal presentation such as operation videos, 3D animations, and interactive simulations. The key is that content design should stay close to real workflow, with cases drawn from actual enterprise projects to ensure that what students learn is transferable.

2.3 Behavioral Activation: Turning Spectators into Participants

The ultimate purpose of interactive design is to change learning behavior. Bikowski and Casal found that interactive digital textbooks can significantly influence students' reading behavior and learning process [15]. If students merely passively flip pages and watch videos, they are still engaged in receptive learning—only the medium has changed from paper to screen. Genuine interaction should make students active participants in the learning process. From the perspective of learning behavior, interaction should occur at least at three levels: first, student-content interaction, such as running code directly in a programming course to see results; second, student-student interaction, such as group tasks and peer review of work, forming a learning community; and third, student-teacher interaction, where digital textbooks help teachers identify each student's learning status through data analysis, enabling targeted guidance.

3 DESIGN DIMENSIONS OF THE INTERACTIVE MECHANISM FOR HIGHER VOCATIONAL DIGITAL TEXTBOOKS

Building on the three layers of logic outlined above, the interactive mechanism for higher vocational digital textbooks can be developed across four design dimensions.

3.1 Intelligent Interaction Layer: Making Technology an Instant Assistant for Students

The core positioning of intelligent interaction is assistance rather than replacement. Technology takes on high-frequency, standardized interactive tasks—such as instant Q&A, automatic grading, and progress pushing—freeing teachers to focus on in-depth guidance.

Intelligent Q&A systems should prioritize practical utility. The questions raised by higher vocational students are often highly specific, so the system must handle not only conceptual queries but also operational-level consultations. Knowledge-base construction should transform content into retrievable, matchable operational guides. When a student asks about a specific wiring method, the system should identify the corresponding circuit diagram and provide steps and precautions. Virtual teaching assistants, using digital-human technology to simulate a teacher's image for Q&A services, feel more approachable than plain-text replies and can serve multiple students simultaneously, addressing the problem of teachers being unable to be everywhere at once. However, their capability boundaries must be clearly defined, and complex questions still need to be transferred to human teachers. Automatic grading and feedback mechanisms are especially important for higher vocational students. The system records operation processes in real time, automatically judges right and wrong, and gives improvement suggestions. This instant feedback promotes learning far more effectively than a single end-of-term exam.

3.2 Content Interaction Layer: Breaking Linear Structure to Support Flexible Exploration

The linear structure of traditional textbooks suits systematic theoretical learning but often lacks flexibility for skill-training courses. Digital textbooks should support non-linear knowledge organization, linking related content through knowledge maps so that students can jump and explore on demand. For example, when studying aviation maintenance wiring diagrams, a student can start from a system wiring diagram and click associated links to view interface definitions, standard specifications, and common fault cases, forming a networked knowledge structure.

Multimodal presentation is another key to content interaction. Operation steps are clearer with video demonstrations, equipment structures are better understood through 3D rotatable animations, and theoretical knowledge gains from voice narration. The crucial point is that various media forms should blend naturally, serving to help students understand rather than to show off technical prowess. Embedded interactive elements should be placed appropriately, with each element having a clear educational purpose, avoiding interaction for interaction's sake.

3.3 Community Interaction Layer: Building a Learning Community

Learning is a social activity, and digital textbooks should not leave students isolated in front of a screen. The design goal of the community interaction layer is to make the textbook a bridge connecting students, teachers, and enterprise mentors.

Online learning groups are the basic unit of community interaction. Group members jointly complete project tasks, exchange questions in discussion areas, and share insights. The involvement of enterprise mentors is a distinctive feature of higher vocational community interaction. Digital textbooks can open dedicated Q&A channels for enterprise mentors, allowing students to consult directly with front-line industry professionals. Enterprise mentors can also suggest content revisions from the perspective of job requirements, ensuring the textbook stays grounded in practice.

Work sharing and peer-review mechanisms create a virtuous cycle. Student assignments and project works enter a resource library for later students to reference. Knowing that their work will be seen by others, students tend to produce higher-quality output. Cross-time collaboration extends learning beyond the classroom: pre-class online quizzes expose knowledge gaps, in-class group work completes hands-on tasks, and post-class video uploads of works receive evaluation. Data across these three stages connect to form a complete learning chain.

3.4 Evaluation and Feedback Layer: Letting Data Drive Continuous Improvement

Whether an interactive mechanism is well designed must ultimately be tested by its effects. The advantage of digital textbooks lies in collecting multi-dimensional process data, including dwell time, interaction frequency, video viewing progress, homework accuracy, and discussion-area participation. These data reflect the real learning process far better than a single end-of-term exam.

Evaluation should involve multiple stakeholders. Student evaluation focuses on learning experience, teacher evaluation on instructional implementation, and enterprise evaluation on job alignment. These three perspectives complement each other, avoiding the one-sidedness of a single evaluation. Data should serve improvement rather than merely assessment. Through analysis, weak links in the interactive mechanism can be identified. Once problems are found, the textbook development team makes targeted optimizations, forming a closed loop of design, use, feedback, and improvement.

4 PATHWAYS TO ENHANCING THE EFFECTIVENESS OF INTERACTIVE MECHANISMS

Once the interactive mechanism is designed, the next challenge is to ensure that students genuinely want to use it, persist in using it, and benefit from doing so. This paper proposes four pathways to achieve this.

4.1 Lowering the Technology Barrier: From Accessible to User-Friendly

The technology barrier is the first obstacle to the adoption of digital textbooks. If students must install plug-ins, create accounts, or learn complex operations before they can even open the textbook, many will abandon the attempt at the very first step. Higher vocational students vary widely in their information-technology literacy, so the design must accommodate the least tech-savvy users. Specific measures to lower the barrier include: using standard web browsers without requiring specific software; supporting multiple devices such as phones, tablets, and computers so that students can study with whatever device is at hand; keeping the interface clean and intuitive so that main functions are immediately obvious; and providing clear operational guidance with step-by-step prompts for first-time users. The guiding principle is to let students focus their energy on learning content rather than spending excessive time figuring out how the platform works. Network conditions must also be considered. Not every student has stable broadband, so video content should offer multiple resolution options, and core interactive functions should be able to degrade to static content when the network is poor, ensuring basic usability. No student should be excluded because of technical limitations.

4.2 Stimulating Motivation: From Passive to Active

Students often resist using digital textbooks simply because they lack motivation. If the textbook is merely an electronic version of the paper content, students see little difference between using it and not using it, and naturally feel no drive. Motivation must be embedded within the textbook itself through elements that genuinely attract students.

Gamification is one effective approach. Points, badges, and leaderboards tap into students' competitive instincts and need for achievement, but gamification must be tightly coupled with skill training. Points are awarded for completing operational tasks, badges for consecutive completions, and leaderboards are updated weekly to sustain a sense of ongoing competition. The key is that rewards must be tied to learning objectives—gamification should serve learning, not the other way around. Task-driven design is another way to stimulate motivation. Textbook content is organized around real project workflows. For example, in an IoT comprehensive training textbook, the introduction of task-based interaction mechanisms grounded in real projects raised students' hands-on pass rates to over 80%. This design gives learning a clear sense of purpose and accomplishment, so students know exactly what they have learned and what they can do. Granting choice also strengthens motivation. Allowing students to select their own learning paths, resource difficulty levels, and practice methods enhances intrinsic motivation when they feel a sense of control over their learning process, consistent with the basic tenets of adult learning theory on self-directed learning.

4.3 Precise Adaptation: From Ubiquitous to Targeted

Digital textbooks support personalized learning, but personalization does not mean a separate textbook for every student. Developing individual textbooks for each learner would be prohibitively expensive and impractical. A more feasible approach is multi-tier presentation of the same content: a basic version for students with weaker foundations, providing detailed step-by-step breakdowns and more demonstrations; a standard version for the majority of students, offering complete operational guidance; and an advanced version for high-achieving students, providing variant tasks and integrated projects. The core content is consistent across all three versions, but depth and breadth differ, and students can choose according to their own situation or progress through the tiers sequentially.

Dynamic adjustment is the advanced form of personalized adaptation. The system automatically judges a student's level based on learning data and then pushes appropriate resources. If a student achieves high accuracy on several consecutive assignments, the system automatically recommends more challenging cases; if a student repeatedly makes mistakes on a particular knowledge point, the system automatically pushes supplementary explanations and targeted exercises [16]. This dynamic adjustment allows the textbook to adapt to the student's learning pace, preventing content that is too difficult from causing frustration or content that is too easy from causing boredom. Synchronization between content updates and the system is also important. An automatic synchronization mechanism should be established so that when a teacher modifies the textbook, the system updates the knowledge base automatically, ensuring that students always receive accurate information [17].

4.4 Continuous Updating: From Closed to Open

Once traditional textbooks are published, their content is fixed, and reprint cycles often span two or three years or even longer. For fields where technology changes rapidly, the content may already be outdated by the time a new edition appears. Digital textbooks should break this closed nature by establishing a continuous updating mechanism.

Cloud-based publishing is a viable updating model. Campus-based textbooks are updated on the platform in real time without waiting for a publishing cycle. Teachers can replace outdated cases whenever they spot them, and enterprises can add new project materials at any time. This instant updating keeps the textbook aligned with industry changes and maintains content currency at all times. A loose-leaf structure makes updating even more flexible. The textbook adopts a modular design in which each module is relatively independent and can be replaced individually, so an entire textbook does not need to be rewritten just to update one case. This structure is particularly well suited to industry-education integration, allowing new enterprise projects and processes to be conveniently inserted into the textbook so that content always stays synchronized with the industry frontier. Data analysis should also feed back into textbook updates. By analyzing student learning data, developers can identify which content students generally struggle with and which stages frequently cause bottlenecks. Based on actual student learning conditions, targeted optimizations can be made, replacing decisions based on intuition or experience with evidence-based choices.

5 PRACTICAL CHALLENGES AND RESPONSES

Although the direction of interactive mechanism design for digital textbooks is clear, real-world challenges will still arise in practice and require proactive strategies.

5.1 Balancing Technology Investment with Actual Returns

New technologies such as VR, AR, and AI can indeed enhance interactive experiences, but their development and maintenance costs are substantial. For higher vocational colleges with limited budgets, blindly pursuing the latest technologies may lead to high input and low output. A more pragmatic approach is to prioritize mature, stable technical solutions and develop interactive content on existing platforms rather than building systems from scratch. The main effort should go into content design and instructional design, with technology serving merely as an enabler. Once interactive content has accumulated to a certain scale and its effectiveness has been validated, more advanced technologies can be introduced step by step.

5.2 The Trap of Formalistic Interaction

Formalism is the most common pitfall in interactive design. On the surface, the textbook may be packed with discussion boards, quizzes, and interactive animations, yet actual student engagement remains low. Discussion boards sit dormant for long periods, quizzes are completed carelessly with random clicks, and interactive animations are dismissed after a couple of clicks. Such formalistic interaction not only fails to deliver results but also wastes development resources. The key to avoiding formalism is to return to learning effectiveness. Before adding any interactive element, one must ask: will this interaction help students understand the content better, help them master skills more proficiently, or promote collaboration among students? If the answer is no, then the element should not be included. Interactive design should be judged by learning outcomes, not by the frequency of interactions or the number of features.

5.3 Safeguarding Content Quality

The quality of digital textbook content directly affects usability. Some textbooks perform well technically but suffer from content problems: inaccurate explanations of knowledge points, erroneous operational steps, cases that are disconnected from reality, and delayed updates. These issues are more damaging than technical flaws, because learning incorrect information is worse than learning nothing at all. Safeguarding content quality requires a multi-stakeholder collaboration mechanism. Teachers are responsible for the professionalism and accuracy of teaching content, enterprises for aligning job requirements and ensuring case authenticity, technical staff for platform functionality and operational stability, and publishers for content standardization and copyright management. Each party performs its own role and cooperates with the others, ensuring that the textbook meets high standards across content, technology, and application dimensions. Regular content review and updating mechanisms are also essential; a textbook cannot be left unattended once it goes live.

6 CONCLUSIONS

The construction of digital textbooks for higher vocational education has entered deep waters, and mere technology stacking cannot solve the fundamental problems. The interactive mechanism design framework proposed in this paper centers on three transformations: technology shifts from a presentation tool to an instant responsive assistant, scenarios shift from flat display to immersive experience, and students shift from passive reception to active participation. The four dimensions of intelligent interaction, content interaction, community interaction, and evaluation feedback constitute the concrete design pathways, while lowering barriers, stimulating motivation, precise adaptation, and continuous updating provide directions for enhancing effectiveness.

The ultimate goal of interactive mechanism design is learning effectiveness, not technological showmanship. The construction of higher vocational digital textbooks should always revolve around the distinctive characteristics of vocational education, guided by industry-education integration and centered on student skill development, allowing technology to genuinely serve education. Looking ahead, digital textbooks may evolve from auxiliary tools into learning companions, where intelligent systems not only respond to questions but also anticipate difficulties, offer proactive support, engage in deep dialogue with students, and guide their thinking. Yet no matter how technology develops, the essence of education will never change: helping students grow and enabling them to acquire real competencies.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

FUNDING

The research received funding by the Shanghai Education Scientific Research Project (2026) under Grant No. C2026022.

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