Engineering Technology Trends Vol 3 Issue 5 2025

Original Research Article

Open Access

Research on the Current Development Status of Educational Hardware Informatization and Teaching Application Innovation

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Abstract: Driven by the national strategy of education digitalization, the informatization of educational hardware has become a core pillar supporting instructional transformation and quality improvement. This paper clarifies the core connotations and category classifications of educational hardware informatization, and analyzes the current development status in China with respect to infrastructure development and technological iteration. It identifies key challenges, including mismatches between supply and demand, superficial application, insufficient coordination, and shortcomings in teachers' professional competencies. From four dimensions—scenario-based application, technological integration, ecosystem building, and user feedback–driven mechanisms—the paper proposes innovative pathways for teaching application. The study aims to address existing bottlenecks, promote the deep integration of educational hardware and teaching practices, and support the high-quality development of education.

Keywords: Educational hardware; informatization; teaching innovation

Introduction

The Ministry of Education and eight other departments have emphasized the need to enhance the level of informatization in educational equipment. As the physical carrier of education digitalization, educational hardware plays a decisive role in shaping the depth and breadth of teaching innovation through its level of informatization. In China, educational hardware has rapidly evolved from traditional instructional tools to intelligent terminals. However, prominent problems remain, such as "emphasis on procurement over application" and "equipment without scenarios." Teachers often experience "skills anxiety" and "application confusion," which further exacerbate integration challenges. Focusing on the informatization of educational hardware, this paper reviews the current situation, analyzes existing problems, and explores innovative pathways, with the aim of supporting instructional transformation and contributing to the construction of a high-quality education system

1. Core Connotations and Classification of Educational Hardware Informatization

1.1 Definition of Core Connotations

Educational hardware informatization is not merely the electronic transformation of hardware devices. Its core connotation lies in leveraging modern information technologies such as the Internet of Things (IoT), artificial intelligence (AI), and big data to achieve intelligent upgrading, networked interconnection, and data-driven empowerment of educational hardware, ultimately constructing a hardware support system adaptable to personalized learning and immersive teaching. Essentially, it is based on traditional educational hardware and realizes a closed-loop function of "perception–interaction–analysis–feedback" through technological embedding. This process breaks through the functional limitations of conventional hardware, transforming it from a single instructional aid into a collaborative participant in the teaching process and a collector of educational data. The fundamental objective is to optimize teaching processes, enrich instructional forms, and precisely match the needs of teaching and learning through the informatization upgrading of hardware. In this way, educational hardware informatization provides solid technical support for education and teaching reform oriented toward core competencies, and promotes the transformation of education from "knowledge transmission" to "competency cultivation" [1].

1.2 Classification of Core Categories and Functional Positioning

In combination with teaching scenario demands and technological characteristics, educational informatization hardware can be divided into four core categories, each with clear functional positioning and strong inter-category synergy. First, basic support hardware includes smart blackboards, multimedia teaching terminals, and campus network equipment. Its core function is to establish the foundational environment for informatized teaching, enabling the digital presentation of instructional content and basic teacher–student interaction, and serving as the fundamental infrastructure of educational hardware informatization. Second, precision teaching hardware covers student tablets, response systems, and learning analytics terminals. Focusing on personalized teaching needs, this category can collect students' learning data in real time and provide data support for teachers' precise lesson preparation and differentiated instruction. Third, immersive experience hardware, such as VR/AR teaching devices and virtual simulation experiment platforms, constructs virtual teaching scenarios to overcome constraints of time, space, and safety, thereby enhancing students' understanding of abstract knowledge and their practical abilities. Fourth, intelligent management hardware includes campus security equipment, asset management terminals, and energy consumption monitoring systems. Its core function is to realize digital control of campus operations and instructional management, improving the efficiency of educational and teaching administration.

2. Current Development Status and Core Issues of Educational Hardware Informatization in China

2.1 Analysis of the Current Development Status

In recent years, driven by policy support and technological advancement, China's educational hardware informatization has achieved remarkable progress, showing overall characteristics of "comprehensive basic coverage, accelerated technological iteration, and expanded application scenarios." In terms of infrastructure construction, the penetration rate of multimedia classrooms in primary and secondary schools nationwide has exceeded 98%, the coverage of smart campus initiatives has continued to expand, and the level of educational hardware informatization in rural areas of central and western China has improved significantly. The basic goal of "network access for every school and terminals for every classroom" has largely been achieved.

With regard to technological upgrading, educational hardware has been transformed from traditional multimedia equipment to intelligent hardware empowered by artificial intelligence and big data. The application proportion of new hardware such as AI teaching assistants and virtual simulation experimental devices has continued to increase across schools at all levels and of all types. In terms of application promotion, hardware informatization has extended from classroom teaching to multiple scenarios such as after-school services and home–school collaboration. For example, student tablets are used to deliver personalized homework assignments after class, while smart terminals are employed to build communication bridges between schools and families. Meanwhile, local governments and schools have continuously increased investment in educational hardware informatization, providing solid financial support for its sustained development.

2.2 Analysis of Core Issues

2.2.1 Mismatch Between Supply and Demand

Mismatch between supply and demand is a prominent issue in the current development of educational hardware informatization, mainly manifested in the disconnection between hardware supply and actual teaching needs. From the supply side, many hardware R&D enterprises focus primarily on improving technical parameters, while product design lacks in-depth alignment with teaching principles across different educational stages and disciplines. As a result, some high-end hardware functions do not match instructional needs, leading to resource waste in the form of "overqualified use." For instance, certain AI-based teaching devices purchased by schools can only perform basic projection functions due to the lack of subject-specific resource support. From the demand side, schools tend to follow trends blindly in hardware procurement, excessively pursuing high-end and intelligent equipment while neglecting their own teaching foundations and teachers' application capabilities. Consequently, a large amount of hardware remains idle for long periods after purchase [2]. In addition, imbalances in hardware allocation between urban and rural areas and among schools persist. Rural schools often lack high-end immersive experience hardware and precision teaching devices, whereas some urban schools suffer from repeated procurement of similar equipment. This further exacerbates the imbalance between supply and demand.

2.2.2 Superficial Application

The problem of superficial application of educational hardware informatization is widespread, making it difficult to achieve deep integration with teaching practices. In many schools, informatized hardware remains at a shallow level of application, merely "replacing traditional tools." For example, smart blackboards are often treated as simple "electronic blackboards" used only for displaying courseware and videos; student tablets are primarily used for assigning after-class homework, without fully utilizing their core functions such as learning analytics and personalized tutoring. Even emerging hardware such as AI- and VR-based devices is mostly applied in open classes or demonstration lessons, rather than being integrated into daily teaching routines. The root cause of this superficial application lies in the lack of corresponding teaching models and curriculum resources to support hardware use. Most supporting resources are highly generic and lack subject-specific relevance, making it difficult for teachers to deeply integrate hardware into concrete instructional content. This ultimately results in the dilemma of "equipment without methods" and "tools without scenarios."

2.2.3 Insufficient Coordination

The educational hardware informatization system lacks effective coordination, preventing its overall effectiveness from being fully realized. On the one hand, coordination among hardware devices is inadequate. Due to the absence of unified data interfaces and standards, hardware from different brands and of different types finds it difficult to achieve data interoperability and functional linkage. For instance, learning data collected by student tablets cannot be directly synchronized with teachers' instructional terminals and often require manual secondary input, increasing teachers' workload. On the other hand, coordination between hardware application and teaching and management processes is also weak. The massive amount of teaching data collected by hardware devices has not been effectively transformed into evidence for instructional improvement or management decision-making, resulting in the formation of "data silos." In addition, at the level of home–school collaboration, most informatized hardware focuses primarily on in-school teaching and fails to establish effective home–school collaborative application scenarios. Parents thus find it difficult to participate in students' learning processes through hardware terminals, and a synergistic home–school education mechanism has yet to be formed.

2.2.4 Shortcomings in Teachers' Professional Competencies

Insufficient informatization application competence among teaching staff has become a key bottleneck restricting the deep application of educational hardware informatization. Some teachers lack proficiency in operating new types of educational hardware. Even when they participate in relevant training programs, the focus is often limited to basic device operation, with insufficient emphasis on instructional design capabilities that integrate hardware with teaching. More notably, in the face of rapidly evolving information technologies, some teachers experience pronounced “skills anxiety” and “application confusion.” They worry about the impact of technology on traditional teaching methods and harbor concerns about the instructional effectiveness and ethical risks of hardware application, resulting in a low level of initiative in adopting such technologies. In addition, schools generally lack normalized training and professional guidance mechanisms for hardware application. Existing training is mostly short-term and intensive, lacking both specificity and continuity, and thus fails to meet teachers’ personalized needs in daily teaching. Consequently, teachers find it difficult to develop systematic and sustainable competencies in the application of educational hardware [3].

3. Innovative Pathways for Teaching Applications of Educational Hardware Informatization

3.1 Scenario-Based Application Innovation: Adapting to Diverse Teaching Needs

Scenario-based application innovation is a core pathway for addressing the problem of superficial hardware use. It requires aligning hardware applications with the needs of different educational stages, disciplines, and teaching phases in order to construct precisely adapted application scenarios. In terms of disciplinary adaptation, virtual simulation experimental equipment can be promoted to address challenges in science experiment teaching. For example, Zhengzhou University has introduced computer vision technology into chemistry laboratory instruction, using cameras to collect experimental data in real time and help students accurately understand experimental principles. For abstract knowledge in the humanities and social sciences, VR devices can be used to construct virtual environments such as historical settings and geographical landscapes, thereby enhancing students’ perceptual learning experiences.

With respect to educational stage adaptation, compulsory education focuses on basic cognition and interest cultivation, employing interactive teaching terminals to support gamified learning. At the senior secondary level, emphasis is placed on competency development, using learning analytics terminals to enable differentiated instruction and personalized tutoring. In higher education, the focus shifts to the cultivation of research and practical abilities, with advanced virtual simulation platforms supporting instruction in cutting-edge fields. Regarding adaptation across teaching phases, hardware terminals can be used to deliver preview resources and learning diagnostics before class; interactive devices can facilitate real-time feedback during class; and intelligent terminals can support precise tutoring, homework assessment, and feedback after class.

3.2 Technological Integration Innovation: Strengthening the Core Effectiveness of Hardware

Relying on technological integration innovation can further strengthen the core effectiveness of educational hardware and promote its transformation from an “auxiliary tool” to a “teaching hub.” First, deeper integration of artificial intelligence with educational hardware should be pursued by embedding functions such as AI-based learning analytics and intelligent question answering. This enables real-time collection and precise analysis of teaching and learning data, providing teachers with personalized instructional recommendations. Second, the coordination between the Internet of Things and educational hardware should be advanced. Through technologies such as sensors and radio-frequency identification (RFID), interconnection and intelligent management of hardware devices can be realized. For example, smart laboratories can be constructed in which hardware terminals monitor equipment operation status and students’ experimental procedures in real time. Third, the application of big data technologies in educational hardware should be strengthened by establishing a unified learning analytics data platform. This platform can integrate teaching data collected from different hardware devices and, through data mining, provide scientific evidence for instructional improvement and curriculum design. In addition, the integrated application of 5G technology with VR/AR hardware can be explored to enhance the fluency and immersiveness of virtual teaching scenarios, thereby further expanding the boundaries of hardware application.

3.3 Ecosystem Construction Innovation: Addressing Coordination and Support Challenges

Through ecosystem construction innovation, the problems of insufficient hardware coordination and weak application support can be addressed systematically, thereby building an integrated development ecosystem encompassing “hardware–resources–teachers–management.” At the level of standards and coordination, efforts should be made to establish unified data interfaces and technical standards for educational hardware, enabling interconnection among devices of different brands and types. Regional-level educational hardware informatization management platforms can be developed to integrate teaching, management, and home–school collaboration functions, thus breaking down “data silos.” At the level of resources and teaching staff, a diversified system of hardware-supporting resources should be constructed. Enterprises, schools, and research institutions should be encouraged to jointly develop discipline-specific resources. Meanwhile, normalized training and guidance mechanisms for teachers should be established, adopting a blended approach of “online + offline” and “theory + practice.” Priority should be given to enhancing teachers’ instructional design capabilities for hardware-integrated teaching, while dedicated technical support personnel should be appointed to provide targeted guidance for daily application [4]. At the level of support mechanisms, a collaborative investment model characterized by “government guidance, enterprise participation, and school leadership” should be established to optimize hardware procurement and allocation schemes. In addition, a comprehensive evaluation system for hardware application should be improved by linking application effectiveness with teacher appraisal and school evaluation, thereby stimulating the motivation of teachers and students to actively engage in hardware use.

3.4 User Feedback–Driven Innovation: Continuous Optimization of Hardware Experience

User feedback plays a crucial role in the continuous optimization of educational hardware informatization and serves as a key driving force for its sustained advancement. Establishing an effective user feedback mechanism enables timely and accurate identification of various problems that arise during practical application, thereby providing clear guidance for iterative hardware upgrading. To collect feedback comprehensively, diversified feedback channels should be established. In addition to traditional methods such as questionnaires and focus group discussions, informatization approaches should be fully utilized by building online feedback platforms and developing mobile application interfaces. After feedback data are collected, in-depth analysis should be conducted to identify common issues related to functional integrity, operational convenience, and system stability, as well as the personalized needs of different user groups. For example, based on feedback from teachers and students, the interface design of student tablets can be optimized to better align with instructional operation habits; in response to parents’ demands for enhanced home–school communication, home–school interaction modules can be added to student tablets. Moreover, user feedback should be effectively integrated into the processes of hardware research, development, and improvement, forming a virtuous cycle of “application–feedback–optimization–reapplication.” Through this closed loop, educational hardware can remain closely aligned with real teaching needs, continuously enhance user experience, and better serve educational and instructional practices, thereby promoting educational informatization to a new stage.

Conclusion

As a key support for the digital transformation of education, educational hardware informatization has achieved foundational coverage but still faces numerous challenges. Multi-dimensional innovation across scenarios, technologies, ecosystems, and user feedback represents an effective pathway to overcoming these constraints. Looking ahead, hardware research and application transformation should be promoted with teaching as the central focus, teachers’ informatization competencies should be enhanced, and support mechanisms should be further improved. By enabling educational hardware to fully release its instructional empowerment potential, a solid foundation can be laid for building a high-quality education system and cultivating innovative talents, thus driving education toward new heights.

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