

The Technology Evolution and Future Trend of Smart Blackboard



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ABSTRACT: As an important tool for educational digitization, the function of the smart blackboard has gradually evolved from a single teaching information-sharing tool to a smart system for knowledge expression, sharing and generation. Smart blackboard technology has been experienced from chalk + blackboard to projection equipment + blackboard, to interactive electronic whiteboard, and then to today's integrated touch, high-definition display and artificial intelligence technology. The evolution process of the smart blackboard is characterized by interactivity, effectiveness and intelligence. At present, the smart blackboard has become a collection of many advanced technologies. It is gradually integrated into modern technologies such as artificial intelligence, cloud computing, big data analysis and the Internet of Things, making remote collaboration and intelligent classroom management possible. It has become a smart system for big data collection, mining and analysis, evaluation and feedback, and teaching decision-making. Looking forward to the future, the smart blackboard will pay more attention to user experience design, provide an immersive learning experience through Augmented Reality and Virtual Reality technology, and optimize personalized teaching content in combination with machine learning, to lay a foundation for building an intelligent and personalized teaching environment.

KEYWORDS: Smart blackboard, Technology evolution, Education innovation, Smart learning system, Personalized learning.

I. INTRODUCTION

Digital technology is changing with each passing day, and the field of education is undergoing a profound change driven by technology. As a widely used teaching medium, the intelligent blackboard plays an important role in education and teaching. The development of blackboard has experienced traditional blackboard and electronic whiteboard, and modern intelligent blackboard integrating multi-touch, high-definition display and wireless interaction. Every progress of technology has greatly improved the materials and related technologies of blackboard, thus enhancing the interactivity, effectiveness and intelligence of teaching. Each evolution of the blackboard has its own unique advantages and makes up for some of the previous defects, but it also brings new drawbacks (Xin et al., 2020). The smart blackboard not only changes the traditional classroom teaching mode, but also promotes the optimal allocation of educational resources and the realization of personalized teaching. Today's smart blackboard has been able to seamlessly connect with various teaching software, support live video, remote teaching, and even collect, mine and analyze big data through artificial intelligence technology, assist teachers in evaluation and real-time feedback (Nkonki & Ntlabathi, 2016), and provide teachers with teaching decision support.

II. THE HISTORICAL DEVELOPMENT AND TECHNOLOGICAL EVOLUTION OF THE SMART BLACKBOARD

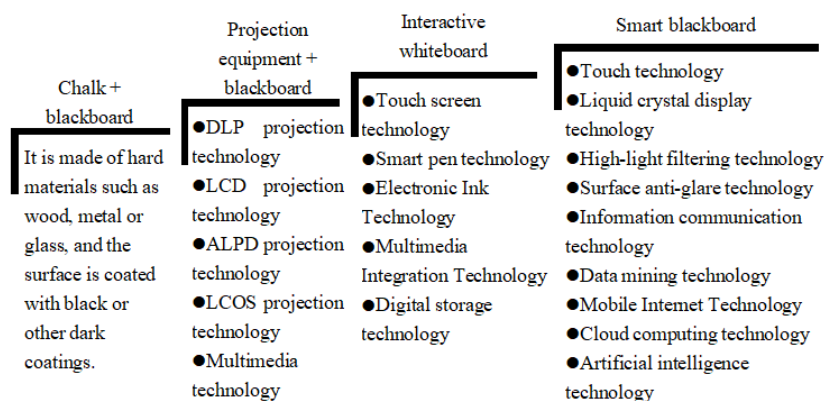


Fig.1 Historical development and technological evolution of smart blackboard

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As shown in Figure 1, the development of blackboard has gone through chalk + blackboard, projection equipment + blackboard, interactive electronic whiteboard, and then to the development stage of smart blackboard. Every key technology innovation has laid the foundation for the development of the blackboard. The chalk + blackboard stage is mainly to make the blackboard's material plus the chalk for writing, which promotes the application of the blackboard in teaching. The breakthrough of projection technology and the application of computers in education and teaching make the combination of projection equipment + blackboard become the main classroom teaching medium. The development of touchscreen technology directly promotes the birth of electronic interactive whiteboards and their wide application in teaching. Smart blackboard is the integrated application of many front-end technologies, such as touch control technology, liquid crystal display technology, big data, cloud computing, Internet of things and so on.

A. Chalk + Blackboard

As the main teaching medium of the classroom learning environment, the traditional blackboard is widely accepted by teachers and students. It is not an indispensable device in the classroom but also shapes the structure and function of the traditional classroom (Minghai & Zeyu, 2017). The traditional blackboard is composed of a smooth wooden board or a special material board, which is written with chalk. Teachers write words, draw graphics, show teaching ideas and key points in real-time, erase corrections, and flexibly control the presentation of teaching content and the organization of teaching activities. The advantages of the traditional blackboard are easy to use, low cost and convenient maintenance, providing students with a more intuitive teaching experience. The disadvantage is that chalk writing may produce dust, affecting the health of teachers and students; the content of blackboard writing cannot be saved and reused, which is not convenient for after-school review and data sharing; the lack of interactive and multimedia display functions limits the expressiveness of teaching content and students' interest in learning (Mahesh & Rao, 2012), and it is difficult to meet the diversified and interactive needs of modern education.

B. Projection Equipment + Blackboard

The technical scheme of projection equipment + blackboard effectively integrates traditional writing surfaces with modern visual display technology. This combination allows teachers to project the content of the computer screen to the screen through the projector while retaining the traditional blackboard writing habits so that digital media and written text can coexist in the same space. This not only enables teachers to display multimedia content such as electronic documents and pictures to students, but also greatly enriches teaching resources and forms (O'Malley, 2006), and also provides a larger visual range, which helps to display complex concepts and information.

Projection equipment + blackboard is not a perfect solution. Compared with traditional blackboard writing, the operation of projection equipment is more complicated, which requires teachers to have certain technical knowledge and pre-preparation time. In an environment with multimedia projection systems as the display platform, the teaching materials are too structured, and the limited thinking of teachers affects the dialogue between teachers and students (Xingfu & Jingdong, 2005). Projection equipment depends on power supply and computer equipment. Any technical failure may lead to teaching interruption and affect the stability of the teaching process. The brightness of the projector is greatly affected by the ambient light, and the bright classroom light will interfere with the display effect.

C. Interactive Electronic Whiteboard

The interactive whiteboard is an input and output device that integrates computer technology, microelectronics technology and communication technology (Chaojun, 2011). It is integrated with a hardware electronic induction Whiteboard and software Whiteboard operating system (ACTIV studio). The core components are an electronic induction Whiteboard, induction pen, computer and projector (Yong, 2010). The interactive electronic whiteboard digitizes the traditional writing interface, allowing teachers to use a stylus or finger to write, draw, and operate (Koçak & Gülcü, 2013). The advantages of the interactive electronic whiteboard are interactivity, storage and multimedia integration. Promote students to participate more actively in classroom activities and improve learning efficiency; the teaching content can be saved in real-time to facilitate students' review and data transmission; it supports multimedia teaching resources such as video, audio and animation, which greatly enriches the teaching methods. Its disadvantage is the high cost of purchase and maintenance; there are some difficulties in teachers' operation, which requires a certain period of training and adaptation. Excessive reliance on electronic whiteboards may reduce the opportunities for face-to-face communication between teachers and students, affecting the effectiveness of teaching interaction.

D. Smart Blackboard

Smart blackboard is intelligent interactive teaching equipment, which is mainly composed of hardware equipment and software systems (Jun, 2023). In 1991, the first smart blackboard came out based on an interactive Whiteboard. " At the beginning of development, due to the slow and unstable speed of the processor and poor graphics processing ability, it has not been widely used. Nowadays, with the advancement of technology and the optimization of software, the smart blackboard has been widely used in the field of education (Xiao & Daguang, 2016). It has become an important part of smart classrooms and smart campuses and plays an important role in smart teaching.

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1. Touch technology innovation and the birth of the smart blackboard

Touch technology was first applied to personal electronic devices. The touch technology adopted by the smart blackboard can realize multi-touch and gesture recognition so that teachers can operate intuitively. This kind of interaction not only simplifies the teaching process but also greatly improves the interactivity and interest of teaching. By applying the handwriting function of the smart blackboard, teachers can write directly on the blackboard and retain traces and can erase and modify the contents of the blackboard at any time (Shuchi, 2022). Using the smart blackboard to display multimedia content, real-time information sharing and communication can be carried out through the Internet. In addition, combined with educational software, the smart blackboard can also support students' interactive learning, online testing and classroom management functions, improving classroom quality and students' classroom experience (Ying et al., 2023).

2. The interconnection between information and communication technology and smart blackboard

Through the built-in computer system and network connection function of the smart blackboard, teachers can easily access and display various digital teaching resources. At the same time, access to the Internet makes the smart blackboard a platform for information acquisition and sharing. Teachers and students access online resources and collaboration tools (Singh et al., 2015), and can also share classroom content to the cloud in real-time, which is convenient for after-school review and remote teaching. Teachers can flexibly choose the most suitable interaction mode according to their teaching needs, so that teachers can teach more naturally (Amruthavarshini et al., 2022), and students can also participate in classroom activities more intuitively through the smart blackboard. By integrating multimedia and Internet technology, the smart blackboard not only changes the traditional teaching methods but also creates a personalized learning environment for students.

3. The Internet of Things and cloud computing intelligence expand the function of the smart blackboard

The Internet of Things and cloud computing technology has brought revolutionary changes to the function and scope expansion of the smart blackboard. Combined with the Internet of Things technology, the smart blackboard has been able to interconnect with other smart devices, which can not only interact in real-time, improve the dynamics and participation of teaching, but also optimize the teaching process through intelligent identification technology. The application of cloud computing has greatly enhanced the data storage capacity of the smart blackboard and the convenience of resource sharing so that teaching resources can be fully utilized across platforms and regions, which greatly improves the utilization efficiency of educational resources (Yang, 2021). In addition, with the increase in distance teaching demand, the smart blackboard realizes the real-time transmission of teaching activities in different places with the help of a cloud computing platform, which ensures that the teaching quality and interactivity are not affected. By analyzing the large amount of learning data accumulated on the cloud platform, the smart blackboard can provide teachers with timely teaching feedback and provide students with personalized learning suggestions, which greatly improves learning efficiency and teaching accuracy (Yushendri et al., 2015).

III. THE TECHNICAL ADVANTAGES AND TEACHING APPLICATION OF SMART BLACKBOARD

A. Many technology integrations to enhance teacher-student interaction and experience

From the perspective of interactivity, the multi-touch technology adopted by the smart blackboard allows multiple users to operate at the same time, which greatly improves the participation and interactivity of the classroom (Mercier et al., 2012). Through gesture recognition and intelligent brush strokes, teachers can intuitively display their ideas, and students can also interact directly with the content through touch or writing (Kellerman et al., 2018). In addition, with special teaching software, the smart blackboard can realize interactive activities such as instant question and answer, voting and games, and further stimulate students' interest and participation in learning.

In terms of teacher-student experience, the user interface of the smart blackboard is usually designed to be simple and intuitive to reduce learning costs and improve ease of use. The ability of an Internet connection ensures real-time updates and personalized recommendations of teaching content to meet different learning needs. The cloud service enables learning materials and progress to be synchronized across devices, providing great convenience for teachers and students (Memoset et al., 2020).

B. The integration of multimodal resources and tools improves the teaching effect

The smart blackboard can quickly search and dial the vast amount of teaching resources available on the network through the built-in network connection function and the compatible OS. They can directly enter the online teaching platform, the resource library or other real-time updated education information on the smart blackboard to make the class more vivid and engaging. Furthermore, the smart blackboard can also display documents, pictures, videos, etc., which is quite helpful for teachers. The smart blackboard also can effectively work with third-party tools at the same time. Teachers can issue homework and arrange tasks via the smart blackboard platform (Jinsheng, 2024), provide timely assessments of students' academic performance, and conduct differentiated instructions for students to guide students based on their ability.

C. Data analysis and individual attention to develop students' ability to learn independently

The smart blackboard also has a built-in data analysis function that can monitor and store students' Learning behavior, performance and activity on the blackboard Through data mining and analysis, the teacher will have a deeper understanding of the current and

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future learning status and demand of the students (Molenaar et al., 2019). This enables the teachers to develop sound and strategic teaching proposals and hence enhance teaching standards. Furthermore, the smart blackboard can also recommend learning resources and the pathway based on the situation of students' learning condition. The smart blackboard analyzes the learning situation and then recommends the most suitable content and difficulty for students which makes the learning process as being more personalized. Indeed, it is proved that the smart blackboards can not only increase the students' attendance and interaction but also boost the learning motivation and academic performance (Tsayang, et al., 2020).

D. Real-time feedback and accurate assessment foster one-on-one teaching

The smart blackboard also includes a variety of real-time feedback functions through a combination of hardware and software. By using the smart blackboard, teachers can achieve immediate connections including rapid tests, and questions and answers. Students' answers and feedback could be immediately shown on the screen which would enable the teachers to track the learning status of the students and could also use the smart blackboard to guide and evaluate the homework of the students (Baohong, 2021). Moreover, using the data analysis tool, the smart blackboard is also able to provide statistical reports of students' feedback in which teachers can know the overall performance and differences of the class. In the context of the teaching evaluation mechanism, the smart blackboard can record the teaching process as well as student interaction data for teachers to obtain objective teaching evaluation data (Anushya, 2020). With the help of the detailed analysis of such data, it is possible to modify teaching methods and material to provide students with individualized learning.

IV. FUTURE TRENDS

A. Artificial intelligence and the construction of the adaptive learning environment

Due to the application of artificial intelligence technology, the smart blackboard can do more intelligent teaching support, such as homework correction, learning resource recommendation, etc. Secondly, artificial intelligence can also support teachers in implementing personalized teaching, analyzing the learning situation of students, and providing learning strategies and paths for each learner, which not only increases the teaching effectiveness but also improves the student's learning experience and outcomes, enhancing the students' engagement and motivation levels (Kokku et al., 2018).

B. VR / AR technology integration and new dimension teaching experience

Students can touch the content displayed on the smart blackboard in real-time through the use of VR or AR gadgets. Such an environment does not only enhance students' learning enthusiasm but also enhances the understanding and application of knowledge. In fact, using VR and AR teaching environments enhances students learning satisfaction and cognitive learning outcomes as indicated in the study conducted by Li in 2023. In the new dimension of the teaching experience, the smart blackboard will pay more attention to personalized and adaptive learning. Through data analysis and artificial intelligence algorithms, the smart blackboard can automatically adjust the teaching content and difficulty according to students' learning progress, preferences and performance, customize the learning plan for each student, and provide a suitable virtual learning space and experience scene. By combining teaching materials with VR technology, students' interactivity can be improved and experience related to the real living space environment can be provided (Li, 2023). At the same time, teachers can also obtain students' learning data in the virtual teaching scene through the smart blackboard, and conduct teaching feedback and counseling promptly.

C. The impact of 5G technology on the performance and application of smart blackboard

At the performance level, the high bandwidth of 5G technology will allow the smart blackboard to smoothly transmit high-definition video and large amounts of data to achieve a more delicate and rich visual display. This is particularly important for running complex VR / AR teaching applications because these applications usually require high-quality images and real-time responses. In addition, the low latency feature of 5G technology can ensure that the interactive experience on the smart blackboard is more immediate and natural, reduce the waiting time of students in use, and improve the overall use experience (Agiwal et al., 2016). At the application level, the wide coverage and stable connectivity of 5G technology will enable the smart blackboard to better support mobile learning and distance education. 5G technology will make the smart blackboard more intelligent and Internet-based. The smart blackboard will be able to seamlessly integrate cloud services and big data technologies to achieve global sharing and personalized recommendations of resources (Jia et al., 2021).

In addition to the mentioned function of displaying the content of the teaching activity, equipped with the Internet of Things technology, the smart blackboard can become the control center of the smart classroom connected with various sensors and devices for the intelligent control of the environment, the study of the learning behavior and the rational usage of the teaching resources.

D. Enhancement of the edge computing and real-time data processing dimensions

Edge computing decentralizes compute tasks to the edge of the network that is, closer to where data is being generated and hence shortens the time needed to transmit data and enhances response time (Cao et al., 2020). Regarding real-time data processing, the usage of edge computing helps the smart blackboard to analyze the student operation as well as the result of teaching in time, to promptly identify the students' problems or potential interests. Well, additionally this ability of real-time data processing is very

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effective for teachers and helps them to provide solid support so that they are allowed to change the methods of teaching by choosing the way they prefer and they can implement more accurate personalized teachings.

V. CONCLUSIONS

It is undeniable that as a result of the close coupling of information technology and education, the smart blackboard has advanced from the initial single informative media to a smart teaching platform equipped with touch, multimedia, and intelligent connection capabilities, etc. From the perspective of the development process of the smart blackboard, its technological evolution has obvious characteristics of the times.

The traditional blackboard mainly focuses on the basic writing and display functions, and the projection equipment and interactive electronic whiteboard can meet the basic digital teaching needs. With the development of technology, especially the wide application of touch technology and multimedia technology, the smart blackboard has begun to have more abundant interactive functions and teaching resource processing capabilities (Gupta, 2017). Smart blackboard has strong technical advantages in teaching applications such as improving teacher-student interaction, personalized learning, provision of multimodal resources, timely feedback and accurate evaluation, which greatly promotes the reform of education and teaching mode.

With the rapid development of new-generation digital technologies such as artificial intelligence, VR / AR, 5G technology and edge computing, the smart blackboard is gradually developing towards intelligence, networking and platformization. However, challenges such as equipment cost, teachers' professional development and technology acceptance, students' privacy protection and data security, technology dependence and unbalanced educational resources cannot be ignored. Teachers' training should be strengthened (Bıçak, 2019), students' awareness of data security should be enhanced (Asim et al., 2023), and cooperation between government and school enterprises should be strengthened to actively and effectively cope with risk challenges. As a link between teachers, students and teaching resources, the technological evolution of smart blackboard will continue to promote the innovation and development of education and teaching mode. In the future, the smart blackboard will play an important role in building a more open, shared and intelligent education environment, and provide strong support for training high-quality talents to meet the needs of the times.

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