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# Smart Classroom: The Evolution and Application in Teaching and Learning

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**ABSTRACT:** As a high-end form of technology-enriched classrooms, smart classrooms are the inevitable result of information technology and education development, as well as the supporting conditions for effectively promoting changes in teaching methods and enhancing talent cultivation goals. Sorting out the evolution of the smart classroom, analyzing the educational impact brought by the smart classroom, and summarizing the lessons learned from the actual use of the smart classroom are crucial to constructing a new generation of smart classroom teaching environments and realizing the talent cultivation goals of the new era. This paper details the background of the birth of the smart classroom and the stage characteristics of the iterative development, analyses the educational changes brought about by the smart classroom, and, on the basis of analyzing the realities of the situation, puts forward suggestions for the use of the six aspects of the facilities, leadership, teachers, resources, management, and security, with a view to being able to better unleash the potential of the smart classroom in the application of educational teaching and learning, and also to provide practical references for the new stage of the smart classroom's construction, management, and use.

**KEYWORDS:** Smart Classroom, Concept and Characteristics, Background of Proposal, History of Development, Changes in Education, Suggestions for Application

## 1. INTRODUCTION

With the in-depth application of various information technologies in education and teaching, human education is transforming and evolving towards intelligent education (Hu et al., 2019).And the smart classroom is the main scene of smart education, as well as the core and central position of digital transformation of school education (Huang & Yang, 2022). Accompanied by the accelerated development and application of digital technology, the smart classroom is becoming increasingly popular. It has become the main form of classroom change in the era of big data and intelligence (Yang et al., 2017).Therefore, in the current critical stage of educational transformation and evolution, smart classrooms have received more and more attention and become a hotspot for teachers and scholars to study.

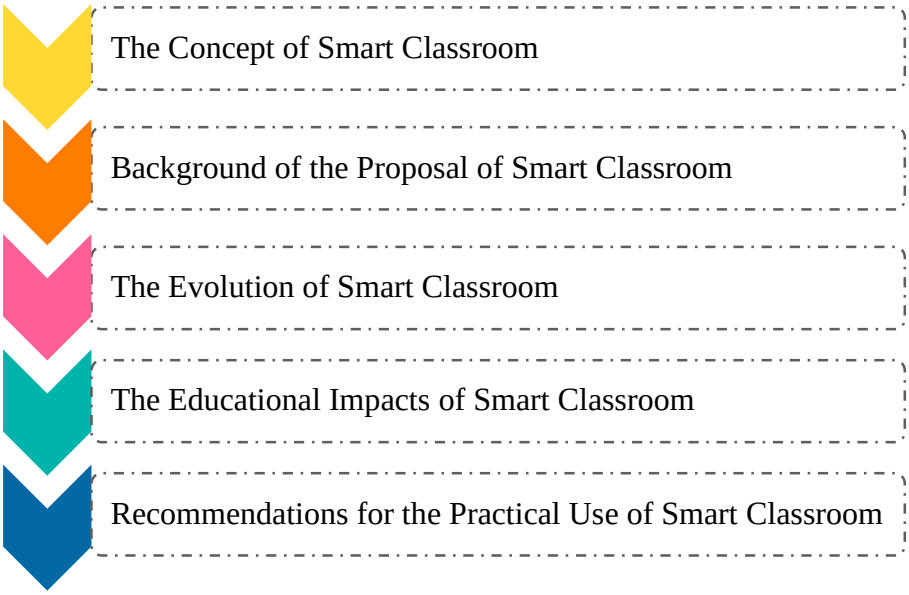


**Fig. 1. The framework structure of this article**

This paper will follow the vein of the smart classroom "birth - development - brought to the educational changes - the recommendations of use " to carry out research, clarify the background of the smart classroom, the development process, the advantages and characteristics, analyze its impacts on current and future education and teaching(as shown in Figure 1). And based on the practical application, it will put forward suggestions in six aspects, namely, facilities, leadership, teachers, resources, management, and safety(as shown in Figure 2), aiming to provide the basis and reference for the real-life application of smart classrooms and the construction of a new generation of smart classroom environments.

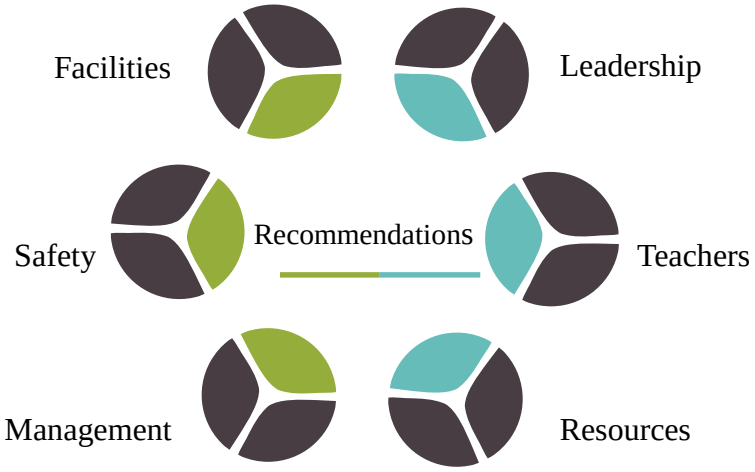


**Fig. 2. Recommendations for the Practical Use of Smart Classroom**

## 2. THE CONCEPT OF SMART CLASSROOM

"Smart classroom" is also known as intelligent classroom, wisdom classroom, active learning classroom, classroom of future, classroom of tomorrow, smart teaching environments, smart learning environments, technology-enriched classrooms and technology-enriched classroom environment.Scholars define the concept of smart classroom from different perspectives.

Skipton et al. (2006) defined a smart classroom as a technology-enhanced classroom. Zhu and He (2012) believes that the smart classroom relies on information technology, learning resources, learning tools, learning activities, etc., comprehensively records and, mines, and analyzes the process data of students' learning, and is able to implement personalized teaching and learning, which is a new type of learning environment for cultivating intelligent talents. Huang, Yang, et al. (2012) define the smart classroom as a

physical manifestation of the smart learning environment, which can be achieved by perceiving the learning context and analyzing learners' characteristics. Perception, analysis of learners' characteristics, provision of appropriate resources and tools, recording of the learning process, evaluation of learning results and visual presentation, etc., which ultimately promotes learners' efficient learning. Zhang et al. (2014) believe that the smart classroom is a smart learning space that promotes student learning, which is constructed on the basis of emerging technologies and integrates physical space and digital space, which is conducive to the interaction between people and people, and between people and technological environments, and is conducive to the development of personalized, open and ubiquitous learning. He (2015) defines a smart classroom as a smart learning environment that can intelligently push personalized learning resources for learners and, simultaneously realize the intelligent evaluation of teaching and learning effects. Zhang et al. (2016) believe that a smart classroom is a typical smart learning environment, which can optimize the presentation of learning content, facilitate the acquisition of learning resources, promote classroom interaction, and have the functions of context perception and environment management. Xi et al. (2017) considered the smart classroom as a learning environment with the participation of technology, which is reflected in the equipment, computer communication technology, and learning resources. Li et al. (2019) considered the smart classroom as a typical media-rich learning environment, specifically referring to technology-enhanced face-to-face classrooms, which combine the active learning process of students with advanced forms of educational technology in order to provide a personalized learning experience.

It can be seen that there are conceptual and theoretical differences between smart classrooms compared with traditional multimedia classrooms and computer rooms. The smart classroom optimizes the teaching environment and process with the help of intelligent technology, empowers personalized learning and evaluation through human-computer collaboration (Liu & Liu, 2021), and highlights the empowerment of wisdom on things and the cultivation of people (Zhu & He, 2012).

Therefore, this paper argues that the smart classroom is a result of the fusion of information technologies and education concepts, in promoting of students' growth and development as the starting point, and with the enhancement of the quality of education as the goal, to achieve rich learning resources, personalized learning process, accurate teaching and learning evaluation, and to create a meaningful learning environment based on the students.

## 3. BACKGROUND OF THE PROPOSAL OF SMART CLASSROOM

Economic and social changes drive changes in talent training modes, and the endogenous development of education needs to be empowered by technology (Liu & Cen, 2022). Technological innovation leads the pace of social development. Information technology in the impact of social development at the same time also led to changes in education, education informatization is gradually popular. Education informatization has emerged in the context of global informatization, and the widespread application of information technology is profoundly changing the concept, model and future development direction of education; the development of international education informatization has promoted the deep-seated change in the education system (Liu, 2012). The integration of information technology and education provides a possibility for the realization of individual learning aspirations, and the promotion of learners' personalized development is one of the basic features of education in the information technology era and an essential means of cultivating innovative talents(Kong et al., 2016).

The concept of "SmartPlanet" was first proposed by IBM CEO Ming Sheng Peng in his speech in November 2008 (Nie et al., 2013; Ren, 2013). With the concept of SmartPlanet and the wide application of smart technologies, smart cities, smart campuses, and smart classrooms have emerged (Lu, 2021). Building smart classrooms creates an ideal smart learning environment for promoting education informatization and deepening teaching reform (He, 2015). Coupled with the promotion of national policies, the popularity of smart classrooms has increased dramatically(Wei & Ma, 2022).

The arrival of the intelligent era has injected new vitality into the development of education informatization and laid a solid technological foundation for the future high-speed development of smart education (Zhang & Xie, 2023). In particular, the convergence of the application of educational big data and the rapid development of artificial intelligence technology have spawned a fundamental transformation of traditional teaching and learning methods, promoting the construction of a new pattern of wisdom education (Xie, 2020). As a core component of smart education, learning environments such as smart classrooms (Hu et al., 2018) have been given high expectations as the key to implementing new smart education concepts, innovating teaching and learning modes, and realizing new talent cultivation goals..

Therefore, the bottom-up demand for education, the top-down policy drive, and the horizontal addition of information technology have led to the birth of the smart classroom and the popularity of its application.

## 4. THE EVOLUTION OF SMART CLASSROOM

The development of smart classrooms is affected by the intertwined influences of changing times, technology diffusion, and educational changes (Wu, Wang, et al., 2022), and it is a gradual evolutionary and progressive process. The development of the smart classroom can be divided into the following stages:

(1) Multimedia classroom stage: This phase focuses on the promotion of the use of computers and multimedia equipment in classrooms (Nie et al., 2013). In this stage, the classroom began to introduce multimedia equipment, such as computers, projectors, audio, etc., which can be used by teachers to conduct multimedia teaching and improve the vividness and interest of teaching.

The concept of "Smart classroom" was first mentioned by Rescigno in his article "Practical Implementation of Educational Technology" in 1988 (Rescigno, 1988). However, the early smart classroom was a multimedia classroom in the era of audiovisual technology, where interactive multimedia connects whiteboards, computers, and projectors. The images displayed by the computers are projected onto the whiteboards through the projectors, constituting a teaching and learning environment with the whiteboards as the interactive endpoints/interfaces (Becta, 2003).In 1991, the Smart Board Company of Canada produced the first piece of truly interactive whiteboard (Betcher & Lee, 2009), which provides teaching resources and tools such as slides, pictures, videos, etc., and intuitively presents the originally abstract knowledge in a visual form. However, classroom teaching at this time is still based on knowledge instillation, emphasizing the memorization, understanding, and application of knowledge, which is not fundamentally different from traditional classrooms.

(2) Networked Classroom Stage: The focus of this phase is on classroom access to the campus network and easy access to the Internet (Nie et al., 2013). In this stage, the emergence of various digital devices, such as projectors, slide presenters, and digital whiteboards, has brought significant changes to teaching. Classrooms are connected through the Internet to achieve the sharing of teaching resources and distance learning. Teachers can present educational content more intuitively and vividly, and can use network resources for teaching, and students can conduct independent online learning through the Internet.

Shi et al. (2003) conducted an early application of smart classrooms in distance education. After that, it was gradually improved. In 2005, Gu et al. (2005) proposed a lightweight active spatial service model ASMod based on new techniques such as combined spatial index; In 2006, Qin et al. (2006) proposed an agent-based middleware called CAMPS to provide intelligent spatial context-aware services; In 2008, Suo and Shi (2008) constructed a hybrid learning environment through pervasive computing technology, integrating the advantages of traditional learning and e-learning to create a powerful smart space; In 2009, Suo et al. (2009) built Open Smart Classroom, a prototype application based on the multi-intelligence system architecture in smart space and web service technology, to address the scalability challenges of the education system at that time; In 2010, Shi et al. (2010) applied pervasive computing technology to distance learning through the smart classroom project, which combines distance education with traditional classroom education to provide a real-time interactive distance learning experience.

According to the classification of "teaching space" and "learning space" in the classroom teaching environment, the smart classrooms in the first two phases belong to the "teaching space" in the classroom teaching environment, and are characterized by the following features It has the typical mark of the industrial era, focuses too much on the transmission of knowledge and skills, and lacks due life care (Qi, 2014).

(3) Smart Classroom Stage: In this stage, the classroom introduces advanced technologies such as artificial intelligence, mobile networks, big data, etc.. It empowers the intelligent attributes of the "classroom" with the cloud-based intelligent learning platform and intelligent technology (F. Q. Li et al., 2021), integrating data, resources, and activities to support precise teaching and personalized learning (Li et al., 2020), and realizes intelligent teaching monitoring and management, such as automatic recording of the learning process, real-time teaching feedback, etc., which is the materialization of the smart learning environment, and is a typical "learning space", which is characterized by shifting from an emphasis on order to experience, and focusing on dialogue, collaboration, and interaction (Chang & Ou Yang, 2022).

After 2010, devices and technologies such as mobile Internet, portable terminals, and the Internet of Things (IoT) have gradually integrated into the classroom, promoting classroom teaching from offline physical space to online cyberspace, and gradually forming

a new type of teaching environment with ubiquitous connectivity, terminal interaction, intelligent perception, and human-computer collaboration (Wu, Wang, et al., 2022), which has become a smart classroom in the true sense of the word.

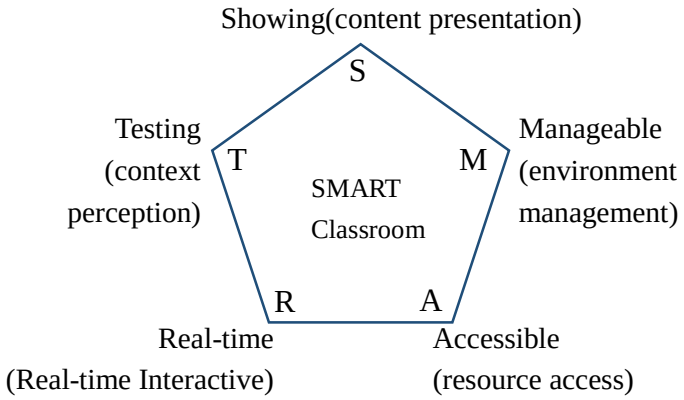


**Fig. 3. "SMART" model**

In 2012, Huang et al. summarised the stage-by-stage development of the smart classroom, and proposed the "SMART" conceptual model from the five aspects of content presentation, environment management, resource access, Real-time Interactive, and context perception(as shown in Figure 3) (Huang, Hu, et al., 2012).

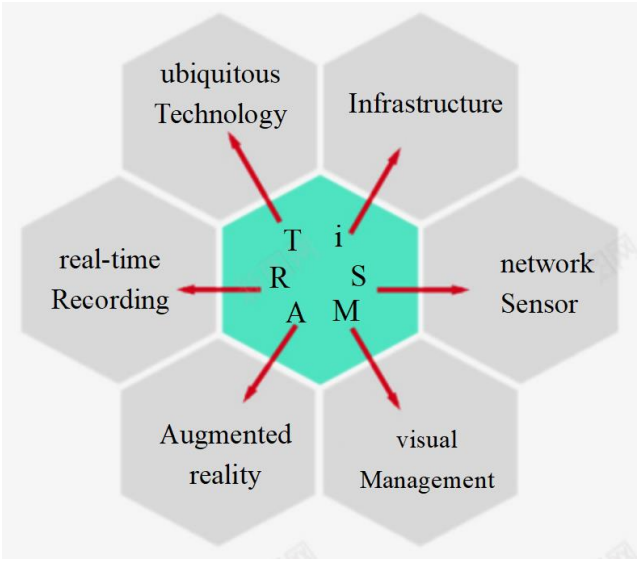


**Fig. 4. "iSMART" model**

The "SMART" conceptual model focuses on presenting the "smart" characteristics of the smart classroom. In order to provide a more operational construction reference, Nie et al. (2013) constructed the "iSMART" model of the smart classroom from the point of view of the system components, which consists of six major systems (as shown in Figure 4). In 2019, Palau et al. proposed three dimensions that must coexist in a smart classroom: the environment, the technology, and the implementation process, each containing different sub-characteristics (Palau & Mogas, 2019).

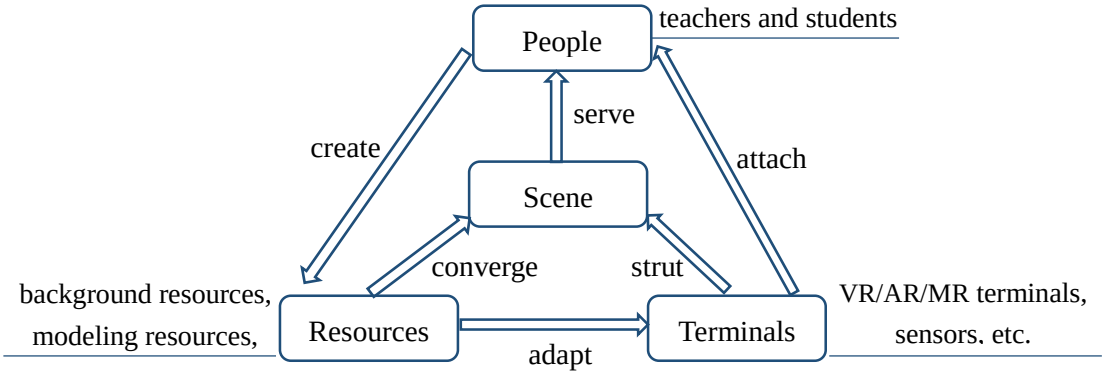


**Fig. 5. The four elements and relationships of next-generation smart classrooms**

Driven by scientific and technological progress, the smart classroom gradually expands its functions and forms and further moves towards intelligence and mobility. In 2022, Wu et al. constructed a new type of smart classroom by combining the four elements of the scene, people, resources, and terminals(as shown in Figure 5)(Wu, Wang, et al., 2022).

The development of smart classrooms, from assisting teaching improvement and empowering teaching innovation, is moving towards digital transformation, evolving from simple computer-assisted teaching to a more complex and enriched model of educational innovation. In the future, with the further development of digital twin, meta-universe, AR/VR/MR, Internet of Things (IoT), artificial intelligence, and other technologies, which will provide a stronger technological drive for the smart classroom, the smart classroom will be more three-dimensional, diversified, IoT-connected, and intelligent. It can realize a higher level of human-computer collaboration, intelligent interaction, and a high degree of immersion.

In conclusion, the development history of the smart classroom reflects the continuous progress of educational technology and changes in the concept of education and teaching. It provides strong support for realizing teaching reform.

## 5. THE EDUCATIONAL IMPACTS OF SMART CLASSROOM

### 5.1 Teaching Innovation

The smart classroom relies on emerging technologies such as artificial intelligence and smart terminals to build an intelligent learning environment, which facilitates teachers' teaching innovation (Korozi et al., 2017) and is a powerful driver for changes in the teaching mode (Chen et al., 2020).

The digital technology in the smart classroom helps to change the traditional centralized, one-size-fits-all knowledge-promoting model and promotes the establishment of a more personalized, dynamic knowledge-pulling model (Gros, 2016); it helps to break the past situation of a single teaching method, limited means of teaching, and limited access to resources, and to build a diversified, intelligent and efficient teaching model (Cheng et al., 2018).Intelligent learning behavior data collection and analysis systems, such as those in smart classrooms, support the mutual integration of online and classroom learning and the collection and analysis of learning activity data, which facilitates teachers' precise teaching and the development of individualized learning programs (Zhang et al., 2019), and provide a more desirable technological means for tailoring teaching to the needs of the students, implementing the individualization of teaching and highlighting the students' subjective position (Bai & Zheng, 2020).

In short, smart classrooms enhance the technological support and resource supply for teaching and learning, making classroom teaching shift from menu-based presetting to generative construction, and making individual-oriented personalized learning and teaching activities to cultivate higher-order cognition feasible (Wu, Wang, et al., 2022).

### 5.2 Promoting Pedagogical Interaction

Pedagogical interaction is the most active factor in classroom teaching activities, and it is an essential factor that affects the quality and effectiveness of teaching and learning (Li et al., 2014). The powerful interactive features of the smart classroom enable information to flow in the classroom (Alfoudari et al., 2021), providing convenient conditions for teaching and learning interactions (Zhu, 2014). Teachers in the smart classroom environment can guide students to learn independently by using a variety of classroom interactive tools, give students timely feedback, stimulate students to actively participate in teaching and learning activities, and realize efficient and in-depth interactions between teachers and students (Al-Qirim, 2016; Yang, 2016). Teacher-student interaction

in the smart classroom environment is more flexible and diverse. In addition to instant interaction in the classroom, teachers and students can also use the cloud platform for extracurricular exchanges, etc.(Liu, 2016), to strengthen teaching interaction. The smart classroom provides effective technical support for classroom interaction, which can achieve multi-dimensional interaction between people and, technology, equipment, and resources (Cheng, 2015).

At the same time, the space design of the smart classroom is flexible and diversified. The desks and chairs in the classroom can be freely combined and spliced according to the needs of teaching and learning activities, which increases the extensibility of the time and space for exchanges and discussions between teachers and students and supports a variety of collaborative learning activities in small groups, which provides powerful environmental support to enhance students' interest in learning, motivation to learn and teacher-student interactions (Zhang et al., 2019).

### 5.3 Classroom Effectiveness and Learning Quality

Smart classroom, with its unique advantages of interactivity, efficient information output, and diverse presentation methods, has brought profound changes to the traditional teaching mode, which can significantly improve the actual effect of classroom teaching in high schools (Bai & Zheng, 2020). Specifically embodied in:

**i. The enhancement of students' deep learning ability**

"Deep learning" is a concept opposite to "Surface Learning". Deep learning consists of two interrelated and mutually influencing progressive stages of knowledge understanding and mastery, knowledge synthesis, and innovation (Lv & Gong, 2018). It requires both a depth of learning methods, emphasizing complex problem solving, and a depth of learning outcomes, emphasizing students' higher-order abilities in cognitive, self, and interpersonal aspects (Zhu & Peng, 2017). Therefore, deep learning is both a learning mode and a learning outcome. As a learning mode, deep learning emphasizes learners' active, positive, and deep knowledge processing and cognitive construction; as a learning outcome, deep learning emphasizes positive affective experiences such as deep motivation, higher interest and engagement in learning, and the cultivation of higher-order competencies such as problem-solving ability, cooperation and communication, metacognitive ability, and innovation ability (Chen, 2018).

The smart teaching mode has a positive effect on students' deep learning (Bai, 2022; Li, 2021). The smart classroom promotes students' active learning and collaborative learning, changing passive learning into active knowledge-seeking, and genuinely realizing meaningful learning constructs (Zhang & Yang, 2018). Teaching in smart classrooms can significantly improve students' deep learning level, including the overall level of deep learning and the level of each sub-dimension (B. L. Chen et al., 2019).

**ii. The enhancement of students' engagement in learning**

The main external factors for students' low classroom learning engagement are the teaching method and learning environment at two levels: the traditional classroom teaching mode is dull, with less teacher-student interaction and communication; the learning environment cannot effectively support teaching, and learning will lead to the phenomenon of students' lack of classroom learning concentration and low engagement (Wang & Huang, 2015). However, in the smart classroom environment with rich technical support, teachers are able to independently choose a variety of teaching methods such as group collaboration, lecture method, inquiry learning method, task-driven method, etc., maximize the utilization of resources and tools to build teacher-student interaction links, carry out a diversified assessment, and take students as the principal part of learning, which can maximally activate students' motivation and participation in learning. Studies have shown that the students' learning engagement in the smart classroom environment is better, and students show higher behavioral and emotional engagement (Gu et al., 2017; Zhang et al., 2019).

### 5.4 Teaching and Learning Assessment

Teaching evaluation has an important value judgment function, which can diagnose, provide feedback and guide teaching activities' design, organization, and implementation (Wu, Wang, et al., 2022). Smart classrooms can provide technical support for data mining and learning analytics to help teachers effectively conduct intelligent teaching and assessment (He, 2015).

"Speaking by data" is an important guiding principle of classroom teaching in a smart classroom environment, and data-based teaching decision-making and evaluation is one of the important features of classroom teaching in a smart classroom environment (Wang & Yang, 2022). The smart classroom uses artificial intelligence technology to efficiently integrate and correlate multimodal learning behavior data such as text, voice, video, image, etc., generated in the teaching situation (Liu et al., 2022), and its storage and management system can automate the collection, encoding and analysis of the learning process data and the learning environment data (Pirahandeh & Kim, 2017), which allows teaching evaluation to be built on the basis of educational big data

analysis, and enables more objective and precise analysis of learning conditions, learning diagnosis and evaluation of teaching quality (Bai & Zheng, 2020; Sun et al., 2019). It helps teachers to analyze students' classroom status, knowledge mastery, and teaching implementation effect in real time and accurately, improves the objectivity and accuracy of classroom assessment and analysis, and helps teachers to find teaching problems and adjust teaching strategies in time.

All in all, smart classrooms can enhance the quality and boost the efficiency of student learning, ignite students' enthusiasm and initiative in learning, greatly enrich the form of classroom teaching, and promote the transformation and innovation in classroom instruction (Zhang et al., 2019).

## 6. RECOMMENDATIONS FOR THE PRACTICAL USE OF SMART CLASSROOM

In the era of intelligence, the integration of big data, artificial intelligence technology, and teaching has been strengthened, the technical means and resources of the smart classroom have become increasingly rich, and the application of subject teaching has become more and more in-depth. However, in specific teaching practices, schools and teachers still face many new problems (Liu, 2019). The following will make suggestions on the realistic use and improvement of smart classrooms from six aspects.

### 6.1 Optimizing the Educational Technology Infrastructure

Infrastructure construction is a guarantee for the deep development of education informatization (Wang, 2019). In the context of the intelligent era, the use of intelligent information technology to build intelligent and efficient smart classrooms and explore the upgrading and development of smart classrooms is necessary to promote the change of talent training mode and promote the deepening development of education informatization (Liu, 2019). Firstly, the design and construction of smart classrooms should be orientated towards teaching needs. The partnership between schools and the education technology industry should be strengthened to ensure that enterprises develop technology products that meet the actual needs of education and teaching (Wang, 2019). Secondly, it is necessary to ensure the stability and safety of smart classroom technology. This is because various technical failures in the teaching process may affect the teaching progress and teaching effect.

Thirdly, the construction and optimization of smart classrooms should align with the school's reality and should not unilaterally pursue the latest, the best, and the coolest. The use of technology is affected by a variety of people, processes, and other factors both inside and outside the school (Selwyn, 2019). Therefore, it is important to fully consider the specific circumstances of the school and develop reasonable goals and promotion strategies for the construction of smart classrooms. Careful consideration should be given to the localized application of the technology in the school, which can be pre-tested on a small scale before the introduction (Selwyn, 2019).

### 6.2 School Management and Leadership

Educational leaders are the "helmsmen" and "top designers" of educational reform and development in a region and school. In the information age, technological change in schools cannot be separated from the information literacy of educational leaders themselves (Wang, 2019). Based on the social demand for talents and the needs of students' personal lifelong development, educational leaders should determine the strategic direction and value proposition from the school level, set priorities for development (Cheng et al., 2022), propose appropriate reform programs, and establish a supporting budget and resource allocation mechanism, management system, etc. (Xiao & Wang, 2022). Therefore, the integration of educational resources and the updating of teaching technology in the smart classroom not only requires a large amount of human and material input but also the information wisdom, insight, and foresight of educational leaders.

Therefore, education management and school leaders should focus on improving their information literacy, enhancing digital concept cognition, developing digital technology application capabilities, and advancing the implementation, decision-making, and governance capabilities of digital initiatives, etc. (Xiao & Wang, 2022), in order to adapt to education teaching and talent cultivation, school development, and management and governance in the digital environment (Xu & Zhang, 2022).

### 6.3 Enhancing Teachers' Digital Skills and Motivation

New technologies in smart classrooms undoubtedly require more thought and effort from teachers (Selwyn, 2019), and educational leaders must be fully aware of the challenges teachers may face in embracing new technologies. Zhang and Xu (2018) found that school policies, technical support, and collegial support significantly impact teacher acceptance. Chen et al. (2020) drew

on the Unified Theory of Acceptance and Use of Technology to construct a smart classroom acceptance model and conduct an empirical study. And found that a sound smart teaching policy, an excellent smart teaching atmosphere, smart teaching demonstration effects, and performance expectations would strengthen teachers' willingness to use smart classrooms. Therefore, schools and education departments should take into account the actual situation, starting from administrative management, teaching management, personnel management, teacher performance appraisal, etc., improve the incentive mechanism, create a good atmosphere, mobilize teachers' motivation, and promote teachers' in-depth participation (Li, 2020).

Secondly, training and guidance for teachers should be strengthened. Teachers need to have the professionalism and teaching ability to adapt to the needs of education in the information age in order to make better use of smart classrooms for teaching and to enhance the quality of education and teaching effectiveness. Therefore, it's crucial to enhance teachers' ability and confidence in technology application (Jiang, 2022). According to the different levels of teachers' mastery of information technology, training courses, and contents are carefully designed to help teachers learn to take advantage of digital technology, and carry out teaching work creatively.

### 6.4 Improving the Quality of Educational and Teaching Resources

Digital teaching resources such as multimedia materials, online courses, electronic teaching materials, and teaching software (Liu et al., 2023b) are important "soft power" in the smart classroom and play a prominent role. As an important source of content for teaching and learning activities, the digitization of learning resources is not just a digital backup of the platform for teaching videos, teaching documents, etc., but should also establish the association of resources, the path of resource utilization, etc., so as to facilitate the personalized utilization of students (Xiao & Wang, 2022). Meanwhile, so as to meet the different needs of teachers and students, the smart classroom should, under the guidance of educational concepts, comprehensively apply all kinds of teaching and learning systems, realize the functions of resource construction and sharing, teaching and learning support, etc. (M. Y. Chen et al., 2019; H. X. Li et al., 2021), and present dynamic, open, unstructured and diversified modes (Cheng et al., 2022), provide the data and resource support for the whole process of pre-class, in-class, post-class, and construct a multi-dimensional new ecology of teaching and learning that is "on-line and off-line, in and out of the classroom, and in the form of virtual and reality" (Liu, 2023).

To highlight the production, distribution, and application of top-notch educational digital materials with the core of popularisation, development, and enhancement of AI capabilities, to promote the large-scale supply of excellent resources and the improvement of the level of personalized services (S. N. Y. Liu, 2022a), to realize the formalized description, automated generation and precise scheduling of different teaching resources, and to create a comprehensive and intelligent three-dimensional teaching scenario through the automated convergence of resources and the intelligent scheduling of resources (Wu, Wang, et al., 2022). Thus, the seamless connection of multi-space and all-scene teaching resources and data elements can be realized to better support teachers in carrying out multi-mode teaching innovation (S. N. Y. Liu, 2022b).

### 6.5 The Operation and Maintenance of Smart Classroom

At present, the smart classroom in the operation and maintenance of equipment and other management, there is still a degree of intelligence that is not high and not standardized enough.Lack of foresight in equipment updating, the maintenance of smart classroom equipment mainly relies on manual inspection or teachers to report repairs. The operation and maintenance mode is passive and inefficient, affecting teachers' use (Wei & Hua, 2021).

Schools should formulate a reasonable management system for "artificial intelligence + education" (H. X. Li et al., 2021), and improve smart classrooms' management and maintenance mechanisms. Establish a monitoring mechanism for smart classrooms to identify and address issues promptly. Improve the smart classroom evaluation indexes and methods, and regularly evaluate the effectiveness of the use of smart classrooms. Cultivate and select excellent IT talents to be responsible for maintaining and managing the school's smart classroom equipment to ensure the smooth application of the smart classroom.

At the same time, the timely updating and optimization of the Smart Classroom Service System have to be consistently done. The service system is the business support platform of the smart classroom, the intermediary that carries the interrelationship between people and the environment, provides convenient teaching tools, resources, data and evaluation, and other teaching support services for the development of smart classroom teaching and learning activities, and is the important technical support for the orderly operation of smart classroom teaching (B. Q. Liu, 2022). Schools should update and upgrade the hardware equipment and software environment of the smart classroom in a timely manner based on systematic research on classroom teaching needs and

strive to improve the usability and stability of the entire smart classroom system, and facilitate the sustainable progress of the smart classroom.

### 6.6 Privacy and Security

The openness of the information age poses a threat to network information security (Wang, 2019). How to solve the issues of ethics and morality caused by digital technology and form relevant ethical norms has garnered attention from nations worldwide (Wu, Li, et al., 2022). The smart classroom relies on network systems and digital technology. It generates a large amount of data in the process of using it, such as users' personal information, learning behavior information, learning social information, environmental information, and even physiological information, psychological information, behavioral trajectory information, and so on (Liu et al., 2023b). The use of Artificial Intelligence has reached a new historical level of knowledge about the bodies and minds of teachers and students, and if this information is used properly, it will bring great benefits to classroom teaching; if it is not regulated and regulated, it will bring about a lot of serious social problems, such as privacy, morality, socialization, values, and mental health problems, and so on (H. X. Li et al., 2021).

Therefore, in the process of pedagogical reform and innovation using smart classrooms, it is important to think cautiously about issues related to data ethics and technology ethics (Liu et al., 2023a). Fully understanding and recognizing the possible risks and appropriately mitigating them through various means to build a safer digital education ecosystem is crucial to the use of smart classrooms to advance the development process of education informatization (Jiang, 2022).

## 7. CONCLUSION

Empowered by technology, smart classrooms help teachers and students carry out colorful teaching activities through visual information expression, convenient information transmission, rich, intelligent applications, and other functions, and promote changes in teaching methods (Jiang et al., 2018). The aim is to achieve intelligent and efficient classrooms, leading to a humanistic, diversified, collaborative, and dynamic smart classroom teaching ecology (B. Q. Liu, 2022), enhance the efficiency of in-class instruction and ultimately foster the progress of students' comprehensive quality and core literacy.

However, the scholarly and practical investigation of the smart classroom is a dynamic process that iterates with the innovative application of new technologies, the genuine requirements of current instruction, and the future development trend of education (Chai et al., 2022). In the process of teaching practice, educators should grasp the new needs, combine with the new scene, research and explore deeply to more effectively fulfill the role of the smart classroom, to promote the comprehensive integration of the smart classroom and education and teaching, and to achieve a new breakthrough in the development of smart education in schools.

## REFERENCES


1) Al-Qirim, N. (2016). Smart board technology success in tertiary institutions: The case of the UAE University. *Education and Information Technologies*, *21*(2).
2) Alfoudari, A. M., Durugbo, C. M., & Aldhmour, F. M. (2021). Understanding socio-technological challenges of smart classrooms using a systematic review [Review]. *Computers & Education*, *173*, 20, Article 104282. https://doi.org/10.1016/j.compedu.2021.104282
3) Bai, S. (2022). *Research on the Design and Application of Smart Classroom Teaching Mode to Promote Deep Learning* [Master, Northeast Petroleum University].
4) Bai, X. M., & Zheng, H. (2020). University Information Teaching Mode under New Information Technology Environment. *Information Science*, *38*(08), 74-78.
5) Becta, A. (2003). *What research says about interactive whiteboards*. MirandaNet. https://mirandanet.ac.uk/wp-content/uploads/2019/06/wtrs_whiteboards.pdf
6) Betcher, C., & Lee, M. (2009). *The Interactive Whiteboard Revolution: Teaching with IWBs*. ACER.
7) Chai, H. F., Yang, Y. H., Dong, R., Zhang, Z. W., Li, M., & Shen, L. Y. (2022). Exploration of Smart Classroom Construction and Blended Teaching Application ——Taking the “Smart Cloud Classroom” of Zhejiang University as an Example. *Modern Educational Technology*, *32*(05), 110-118.

8) Chang, S., & Ou Yang, G. M. (2022). From Teaching to Learning:The Educational Implications of Learning Space and Its Construction Path. *Education Science*, *38*(03), 60-66.
9) Chen, B. L. (2018). *Investigating the Influences of Instructional Interaction on Deeper Learning in Smart Classroom* [Doctoral, Central China Normal University].
10) Chen, B. L., Zhang, Y., Yang, B., Xiong, J., & Lin, L. (2019). Study on Effects of Instructional Interaction on Deep Learning in Smart Classroom. *e-Education Research*, *40*(03), 90-97.
11) Chen, C., Ye, Y. M., Sun, W. H., & Li, X. T. (2020). Research on Influencing Factors of Primary and Secondary School Teacher's Acceptance of Smart Classroom. *Modern Educational Technology*, *30*(04), 101-106.
12) Chen, M. Y., Yang, Y. P., Chen, M., & Chen, Z. H. (2019). Research on the Construction and Practice of Blended Learning Space in the View of Smart Education. *Distance Education in China*(11), 79-85.
13) Cheng, J. G., Cui, Y. R., Li, M., & Han, X. B. (2022). Analysis on the Core Elements of Digital Transformation in Higher Education Teaching and Learning. *China Educational Technology*(07), 31-36.
14) Cheng, L. D., Wang, J. B., Sun, T., & Tang, L. (2018). Research on Multiple Interactive Teaching Models in Colleges and Universities under the New Information Environment. *The Chinese Journal of ICT in Education*(15), 74-76.
15) Cheng, M. (2015). Design and Construction of Smart Classrooms. *Research and Exploration in Laboratory*, *34*(06), 248-252.
16) Gros, B. (2016). The design of smart educational environments. *Smart learning environments*, *3*, 1-11.
17) Gu, H. L., Shi, Y. C., Xu, G. Y., & Chen, Y. (2005). A core model supporting location-aware computing in smart classroom. In R. W. H. Lau, Q. Li, R. Cheung, & W. Liu (Eds.), *Advances in Web-Based Learning - Icwl 2005* (Vol. 3583, pp. 1-13). Springer-Verlag Berlin. <Go to ISI>://WOS:000231036300001
18) Gu, X. Q., Wang, C. L., & Wang, F. (2017). Historical Mission and Roles of ICT in Educational Reform in the Past 20 Years. *e-Education Research*, *38*(06), 9-19.
19) He, K. K. (2015). Wisdom Classroom + Classroom Teaching Structure Reform——The Fundamental Methods of Realizing Educational Informationization. *Educational Research*, *36*(11), 76-81+90.
20) Hu, P. R., Shen, H. X., Wang, Z. X., & Yin, N. (2018). An Empirical Study on the Whole Process Control Management Model Based on Smart Classroom. *An Empirical Study on the Whole Process Control Management Model Based on Smart Classroom*, *37*(10), 283-286.
21) Hu, Q. T., Liu, L. Q., & Zheng, K. (2019). The New Structure of Smart Education under the Background of the Fourth Industrial Revolution. *China Educational Technology*(03), 1-8.
22) Huang, R. H., Hu, Y. B., Yang, J. F., & Xiao, G. D. (2012). The Functions of Smart Classroom in Smart Learning Age. *Open Education Research*, *18*(02), 22-27.
23) Huang, R. H., & Yang, J. F. (2022, 2022/4/6). Connotation and Implementation Path of Digital Transformation in Education. *China Education News*.
24) Huang, R. H., Yang, J. F., & Hu, Y. B. (2012). From Digital to Smart :The Evolut ion and Trends of Learning Environment. *Open Education Research*, *18*(01), 75-84.
25) Jiang, L. B., Mao, Q. M., Wan, Z., & Shen, H. (2018). Research on the Performance of Classroom Teaching Reform in the Smart Classroom —An Analysis Based on Classroom Reaching Behaviors. *China Educational Technology*(06), 52-58.
26) Jiang, Y. (2022). Strategic Initiatives for the Use of Technology in Education in the UK: Origins, Pathways and Implications--Interpretation of the "Realising the Potential of Technology in Education". *Education & Equipment Research*, *38*(02), 92-96.
27) Kong, J., Guo, Y. C., & Guo, G. W. (2016). Technology Enhanced Personalized Learning: The New Trend to Promote Students' Development. *China Educational Technology*(04), 88-94.
28) Korozi, M., Leonidis, A., Antona, M., & Stephanidis, C. (2017). LECTOR: Towards Reengaging Students in the Educational Process Inside Smart Classrooms. In P. Horain, C. Achard, & M. Mallem, *Intelligent Human Computer Interaction* International Conference on Intelligent Human Computer Interaction, Cham.

29) Li, F. Q., Wang, Z., & Yin, M. (2021). The Evolution and Trend of Smart Classroom. *Modern Educational Technology*, *31*(09), 13-19.
30) Li, F. Q., Yin, M., & Shi, J. (2020). The Construction of Smart Classroom Ecosystem. *China Educational Technology*(06), 58-64.
31) Li, H. X., Jiang, W. X., & Ding, Y. P. (2021). The Possibility and Realization of Classroom Teaching Fairness in the Context of Artificial Intelligence. *Journal of Tianjin Normal University(Social Sciences)*(02), 48-53.
32) Li, J., Zhang, Q., Miao, Z. G., Li, X., & Zhou, Y. (2014). A Study of Teaching Interaction Behaviour in Secondary School Informatics Classrooms - A Perspective Based on Qualitative Analysis. *China Educational Technology*(02), 101-107.
33) Li, S. S. (2021). *Research on the Design and Application of Smart Classroom Teaching Mode to Promote Deep Learning of College Students* [Master, Chongqing Normal University].
34) Li, Y., Yang, H. H., & MacLeod, J. (2019). Preferences toward the constructivist smart classroom learning environment: examining pre-service teachers' connectedness. *Interactive Learning Environments*, *27*(3).
35) Li, Y. M. (2020). A Study on Optimising Strategies for Improving Teachers' Information Technology Application Skills in Primary and Secondary Schools. *Modern Distance Education*(05), 68-73.
36) Liu, B. C., & Cen, Y. (2022). The Global Digital Transformation of Education: Dynamics, Tendency and Implications. *Modern Distance Education Research*, *34*(06), 12-23.
37) Liu, B. Q. (2016). Research on Design and Implementation Strategy of Smart Class Teaching in the Ara of "Internet +". *China Educational Technology*(10), 51-56+73.
38) Liu, B. Q. (2019). Development, Platform Architecture and Application Design of Smart Class ——From Smart Class 1.0 to Smart Class 3.0. *Modern Educational Technology*, *29*(03), 18-24.
39) Liu, B. Q. (2022). Ecological Development of Smart Classroom: Concept, System Composition and Practical Paradigm
40) —Ten-year Exploration of Smart Classroom Theory and Practice Based on Technology Empowerment. *China Educational Technology*(10), 72-78.
41) Liu, B. Q. (2023). Smart Classroom Leading Digital Transformation of Teaching: Trends, Characteristics and Practical Strategies. *e-Education Research*(08), 71-79.
42) Liu, B. Q., Yu, Y. K., & Yuan, T. T. (2022). Process Evaluation Empowered by Intelligent Technology: Goals, Paths and Typical Scenarios. *Modern Educational Technology*, *32*(05), 14-23.
43) Liu, G. P., & Liu, X. (2021). A Conceptual Model of Smart Education from Perspective of Interdisciplinary Comparison. *e-Education Research*, *42*(03), 5-11.
44) Liu, S. N. Y. (2022a). Innovation of Talent Training Mode and Reconstruction of the Supporting System by Bidirectional Empowerment of Artificial Intelligence and Education. *Journal of Science, Technology and Education Studies*, *2*(02), 42-56.
45) Liu, S. N. Y. (2022b). The Road to Convergence of Artificial Intelligence + Education. *Journal of National Academy of Education Administration*(10), 7-10.
46) Liu, S. N. Y., Hao, X. H., & Li, Q. (2023a). The Chinese Approach of Education Digital Transformation. *China Educational Technology*(01), 52-61.
47) Liu, S. N. Y., Hao, X. H., & Li, Q. (2023b). On the Computability of Education. *e-Education Research*, *44*(03), 5-12.
48) Liu, Y. D. (2012). *Grasp the opportunity to accelerate Create a new situation for education informatization work*. Ministry of Education of China. http://www.moe.gov.cn/srcsite/A16/s3342/201211/t20121102_144240.html
49) Lu, G. Q. (2021). *Research on the Effects of Situational Perception on Student Engagement in Smart Classroom* [Doctoral, Central China Normal University].
50) Lv, L. H., & Gong, F. (2018). A Comparative Research on Undergraduates' Deep Learning and Its Influence Mechanism between the Research Universities in China and USA ——Based on the SERU Data Analysis for the Eight Universities in China and USA. *Educational Research*, *39*(04), 111-120.
51) Nie, F. H., Zhong, X. L., & Song, S. Q. (2013). How to Build a Smart Classroom: from Concept to Implementation. *Modern Educational Technology*, *23*(07), 5-8.

52) Palau, R., & Mogas, J. (2019). Systematic literature review for a characterization of the smart learning environments. *Propuestas multidisciplinares de innovación e intervención educativa*, 55-71.
53) Pirahandeh, M., & Kim, D. H. (2017). Energy-aware and intelligent storage features for multimedia devices in smart classroom [Article]. *Multimedia Tools and Applications*, *76*(1), 1139-1157.
54) Qi, J. (2014). The Connotation，Influencing Factor and Status Reflection of Teaching Space. *Journal of Tianjin Normal University(Elementary Education Edition)*, *15*(01), 12-15.
55) Qin, W. J., Suo, Y., & Shi, Y. C. (2006). CAMPS: A middleware for providing context-aware services for Smart Space. In Y. C. Chung & J. E. Moreira (Eds.), *Advances in Grid and Pervasive Computing, Proceedings* (Vol. 3947, pp. 644-653). Springer-Verlag Berlin. <Go to ISI>://WOS:000237540300063
56) Ren, Y. Q. (2013). Smart Campus: The Turning Points and Challenges of Information Technology in College Management. *The Chinese Journal of ICT in Education*(19), 20-21.
57) Rescigno, R. C. (1988). *Practical Implementation of Educational Technology. The GTE/GTEL Smart-Classroom. The Hueneme School District Experience.* Education Resources Information Center(ERIC). https://eric.ed.gov/?id=ED313007
58) Selwyn, N. (2019). *Teachers And Technology: Time To Get Serious*. https://my.chartered.college/impact_article/teachers-and-technology-time-to-get-serious/?_gl=1*bbsdeb*_up*MQ..*_ga*NDE0MjY0OTk1LjE2OTUwMDUyOTc.*_ga_RNHLD18NVN*MTY5NTAwNTI5Ni4xLjAuMTY5NTAwNTI5Ni4wLjAuMA..
59) Shi, Y. C., Qin, W. J., Suo, Y., & Xiao, X. (2010). *Smart Classroom: Bringing Pervasive Computing into Distance Learning*. Springer. https://doi.org/10.1007/978-0-387-93808-0_33
60) Shi, Y. C., Xie, W. K., Xu, G. Y., Shi, R., Chen, E., Mao, Y. H., & Liu, F. (2003). The smart classroom: Merging technologies for seamless tele-education [Article]. *Ieee Pervasive Computing*, *2*(2), 47-55.
61) Skipton, C., Matulich, E., Papp, R., & Stepro, J. (2006). Moving From Dumb To Smart Classrooms: Technology Options And Implementation Issues. *Journal of College Teaching & Learning*, *3*(6), 19-27.
62) Sun, J. K., Zhang, X. P., & Zhao, J. (2019). Thinking about Smart Classroom Construction and Application. *University Education*(04), 25-27.
63) Suo, Y., Miyata, N., Morikawa, H., Ishida, T., & Shi, Y. C. (2009). Open Smart Classroom: Extensible and Scalable Learning System in Smart Space Using Web Service Technology [Article; Proceedings Paper]. *Ieee Transactions on Knowledge and Data Engineering*, *21*(6), 814-828.
64) Suo, Y., & Shi, Y. C. (2008, Aug 13-15). Towards blended learning environment based on pervasive computing technologies.*Lecture Notes in Computer Science* [Hybrid learning and education, proceedings]. 1st International Conference on Hybrid Learning and Education, Hong Kong, PEOPLES R CHINA.
65) Wang, L. Q., & Yang, P. (2022). Problems and Countermeasures Facing the Construction and Application of Intelligent Teaching Environment in Colleges and Universities--Taking University H as an Example. *China Information Technology Education*(14), 106-109.
66) Wang, M. (2019). Exploring the UK's"Education Technology Strategy：Realising the Potential of Technology in Education". *Journal of World Education*, *32*(17), 21-27.
67) Wang, Y. X., & Huang, Z. D. (2015). The Participatory Teaching: An Effective Way of Improving the Students' Learning Enthusiasm. *Education and Teaching Research*, *29*(09), 70-73.
68) Wei, J. X., & Ma, L. (2022). A Review of Domestic Smart Classroom Research Based on Content Analysis Approach. *China Educational Technology & Equipment*, 1-5.
69) Wei, L., & Hua, K. M. (2021). Research on the Application of Operation and Maintenance Control Mode of Digital Classroom in Colleges and Universities Based on Data Analysis. *The Chinese Journal of ICT in Education*(23), 68-71.
70) Wu, D., Li, H., & Yu, X. R. (2022). Digital transformation of education: international perspective, development needs and implementation strateg. *Distance Education in China*(07), 21-27+58+79.
71) Wu, D., Wang, J., Wang, M. Q., Zhong, Z., & Xu, J. (2022). The Evolution and Trend of Classroom TeachingEnvironment from the Perspective of Technological Development. *Open Education Research*, *28*(05), 49-55.

72) Xi, H. X., Liao, H. J., & Huang, C. G. (2017). Study on Framework Design and Implementation Strategies of Smart Learning Environment. *e-Education Research*, *38*(04), 72-76.
73) Xiao, G. D., & Wang, Z. H. (2022). Digital Transformation in Higher Education: Key Areas, Content Structure and Practice Paths. *China Higher Education Research*(11), 45-52.
74) Xie, J. (2020). *Research on Construction of Teacher's Precision Teaching Ability Model* [Doctoral, Northeast Normal University].
75) Xu, X. F., & Zhang, C. (2022). The Essentials and Approaches of Higher Education Digitalization Reformation in China. *China Higher Education Research*(07), 31-35.
76) Yang, J. F. (2016). Evaluation and Optimization of Technology-enhanced Classroom Environment. *e-Education Research*, *37*(12), 99-105.
77) Yang, X. M., Luo, J. J., Liu, Y. X., & Chen, S. C. (2017). Data-driven Instruction: A New Trend of Teaching Paradigm in Big Data Era. *e-Education Research*, *38*(12), 13-20.
78) Zhang, C., & Xie, Y. S. (2023). An Overview of Research on Smart Education in China - A Visual Analysis Based on CiteSpace. *Primary and Middle School Educational Technology*(04), 3-8.
79) Zhang, K., & Yang, Z. M. (2018). Research on the Construction and Application of Wisdom Classroom ——Taking China University of Mining and Technology as an example. *Modern Educational Technology*, *28*(10), 81-86.
80) Zhang, Y., Hao, Q., Chen, B. L., Yu, H. E., Fan, F. L., & Chen, Z. (2019). Research on College Students' Classroom Engagement and Its Influencing Factors in Smart Classroom Environment—Using Educational Technology Research Method Course as an Example. *China Educational Technology*(01), 106-115.
81) Zhang, Y., & Xu, Z. J. (2018). Research on the Acceptance of College English Teachers'Flipped Classroom. *Theory and Practice of Education*, *38*(36), 53-55.
82) Zhang, Y., Zhu, Y., Bai, Q. Y., Li, X. Y., & Zhu, Y. H. (2016). Research of the Teaching Interaction Behavior Characteristics of Primary Mathematics in the Smart Classroom. *China Educational Technology*(06), 43-48+64.
83) Zhang, Y. Z., Zhang, B. H., & Han, Y. X. (2014). Meta－analysis of Research on Intelligent Classrooms Worldwide. *Open Education Research*, *20*(01), 81-91.
84) Zhu, Z. T. (2014). Leading the Innovative Development of Education Informatisation with Smart Education. *The Chinese Journal of ICT in Education*(09), 4-8.
85) Zhu, Z. T., & He, B. (2012). Wisdom Education: The New Realm of Education Informatisation. *e-Education Research*, *33*(12), 5-13.
86) Zhu, Z. T., & Peng, H. C. (2017). Deep Learning: A Core Pillar of Smart Education. *Journal of the Chinese Society of Education*(05), 36-45