

# Analysis of Key Technologies and Application Scenarios of Smart Schools Construction

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## Abstract

The “Education Informatization Action Plan 2.0” of the Ministry of Education summarizes smart schools as “based on emerging technologies such as artificial intelligence, big data, and Internet of Things, relying on various smart devices and networks, actively carrying out innovative research and demonstration of smart education, and promoting the transformation of education mode and ecological reconstruction supported by new technologies.” Through the analysis of key technologies and application scenarios of smart schools, this paper points out that the construction of smart schools needs to be people-oriented, intelligent and collaborative, and realize the deep integration of physical schools and smart schools. On this basis, combined with the construction cases of smart schools, in order to provide reference for the technical landing and application promotion of smart schools.

**Keywords:** education informatization, smart schools, artificial intelligence, Internet of Things

## 1. Introduction

In 2010, Zhejiang University proposed the prototype of “smart schools” for the first time: ubiquitous online learning, integrated and innovative network scientific research, transparent and efficient school governance, rich and colorful schools culture, and convenient and thoughtful schools life. That is, “a safe, stable, environmentally friendly and energy-efficient schools.” “From the perspective of communication, smart schools is a new schools environment based on communication technologies such as the Internet of Things. From the perspective of education informatization, smart schools is a new teaching

environment built based on network technology that can realize resource sharing, intelligent teaching, and topic interaction. This paper elaborates the connotation of smart schools from three aspects: key technologies, application scenarios and main features, and hopes to provide more ideas and inspiration for the construction of smart schools in the future.

## 2. Key Technology

### 2.1 Artificial Intelligence Technology

Artificial intelligence technology represented by ChatGPT is profoundly changing all aspects of human social life, and the “New Generation of Artificial Intelligence Development Plan” clearly requires “the use of intelligent technology to

accelerate the reform of talent training models and teaching methods, and build a new education system including intelligent learning and interactive learning”, artificial intelligence has become a topic that needs special attention in the field of education at the national level. In the process of smart schools construction and application, artificial intelligence technology can be used to design and develop “intelligent tutor system”, “automated evaluation system” and “educational robot”, etc., to promote personalized development of education. even if students use the same application, artificial intelligence will collect different learning data of students in all aspects of education, combined with students’ learning situation to guide them, prescribe the right medicine, and realize data-based personalized education.

### 2.2 Big Data and Data Mining

Big data and data mining technologies can quickly process, analyze, and obtain meaningful and valuable information from many types of databases and massive amounts of complex data. In the process of construction and application of smart schools, big data and data mining can be used to process and analyze schools data, especially unstructured data, and provide more scientific and accurate data support for school teaching, scientific research, and management.

Taking the big data of environmental perception collected by the user’s smart device as an example, the users obtain data from three dimensions of environmental data, terminal data, and behavior data through intelligent terminals, and then analyze user behavior to get the current students’ learning environment, learning progress and learning suggestions through data mining, as shown in Table 1.

**Table 1.** Context perception data and content

Environmental data	Learning content, learning duration, learning time, etc.
Terminal data	Network conditions, location information, terminal device models, etc.
Sensor data	Acceleration, light sensing, gravity, heart rate, etc.

### 2.3 Internet of Things Technology and Environmental Perception Technology

The Internet of Things is the basic technology of

smart schools construction, it has been fully applied in teaching, scientific research, management, life and other aspects, through the deployment of sensors that can sense human body temperature, sound and movement, the Internet of Things can realize the interconnection of various objects in schools, comprehensively obtain and summarize the latest data information, timely identify problems that may arise in schools for students, and handle problems accordingly to build a perceptual school environment.

### 2.4 Virtual and Augmented Reality

Virtual reality (VR) and augmented reality (AR) are cutting-edge technologies for smart schools construction. The three-dimensional virtual situation close to the real world is constructed by virtual reality technology, and the interactive behavior of learning occurs in the virtual situation, which improves students’ immersion and enthusiasm to participate in teaching.

Augmented reality seamlessly connects virtual situations with real life. In the construction of smart schools, the organic integration of smart schools and physical schools can be realized with the help of virtual reality and augmented reality, and there are very broad prospects in scientific research observation, vocational skills practice, micro-world observation, and astronomical knowledge learning.

Virtual reality and augmented reality are already used in many scenarios, for example, The German Academic Exchange Service (DAAD) set up a VR virtual experience area at the China International Education Exhibition 2023, where students can remotely observe the training of students in the taekwondo club of Brandenburg University of Technology while wearing VR glasses, and visit the recycling laboratory of Trier University of Applied Sciences and the technological recycling site, which greatly improves students’ interest in learning boring knowledge points.

## 3. Application Scenarios

### 3.1 Safe Schools

#### 3.1.1 Attendance Management

Schools attendance have always been safety issues of concern to schools and society, but traditional doorman management and video surveillance cannot detect problems such as students leaving school without authorization or not arriving on time.

Combined with face recognition and cloud computing technology, the school enters the student's face information in advance, deploys a camera in the entrance passage of the school gate, automatically captures photos of students when they pass through the school gate, then compares the photos with the data in the cloud server. If matches successfully, the system automatically generates the student's attendance record, which find out the situation of not arriving on time for the school.

### 3.1.2 Video Surveillance

Video surveillance combining edge computing and AI technology can turn passive monitoring into active analysis, avoiding the problem of manual processing of massive data in traditional video surveillance. Edge computing reduces the demand for traditional cloud computing, storage, and network bandwidth to improve video analysis efficiency by preprocessing video data, removing redundant information, and migrating some data analysis to the edge computing.

For example, by analyzing the situational information, the dynamic detection algorithm is used to determine whether the student's mobile behavior is abnormal, and whether the behavior of the school personnel have potential safety hazards. Through big data analysis and statistics of crowded areas at different times, schools can organize students to travel at different times; Combined with LBS positioning technology, schools can monitor abnormal areas of personnel at any time, if they found that the number of people in some areas suddenly increases or decreases, school administrators can receive timely warning to avoid possible safety hazards.

### 3.1.3 Intelligent Temperature Measurement

During the COVID-19 epidemic, the intelligent temperature measurement function become the standard configurations of the smart schools, students automatically carried out body temperature detection when entering the schools, and timely synchronized the abnormal body temperature to the schools administrators, eliminating the process of manual paper recording. Intelligent temperature measurement can satisfy the needs of the schools for rapid non-sensing temperature measurement, and improve the scientific and pertinent nature of prevention and control.

The intelligent temperature measurement

system during the epidemic can also integrate face recognition, body temperature monitoring, identity verification, blacklist early warning and other functions, equipped with infrared thermal imaging body temperature detection module, which can detect up to 0.1 degrees. The detection error is less than  $\pm 0.3$  degrees, which provides regular support for temperature measurement during the epidemic.

### 3.1.4 Intelligent Security

The schools can install intelligent monitoring equipment such as smoke detectors and alarms in key security areas through the strong current monitoring system, fire monitoring system, lighting system, and connect the alarm trigger with the monitoring center through the network connection.

Once an abnormal situation occurs, the monitoring center can get alarm information in time, view the image of the incident through the monitoring system, and alarm the fire department, power department and other departments to achieve effective perception.

## 3.2 Intelligent Teaching

### 3.2.1 Smart Class Card

The smart class card is generally installed at the door of the classroom, providing a unified management and release information platform, which is used to display class information, class culture, schools culture, moral education evaluation and student attendance, it can also supports text, pictures, audio and video and other forms of display and registration, so as to achieve benign interaction between students, parents and schools, which creates a blend of class culture and schools culture.

### 3.2.2 Smart Student ID

As an upgrade of the traditional student ID card, through the integration of the Internet of Things and wireless communication technology, the smart student ID card can be used as a communication portal to collect the daily status of students (attendance, location, trajectory, alarm information, etc.), and upload these data to the cloud server for real-time analysis and calculation, meeting the needs of schools and parents for schools safety and home-school communication. It mainly includes the following functions.

#### 1) Insensitive attendance

Using advanced long-range sensing technology,

smart student ID can avoid the time-consuming, congestion and unreliability of traditional access control management systems. When students enter or leave the school gate, parents will receive a synchronized text message on their mobile phone.

2) Interactive classroom

Teachers can select courseware or assessment questions through the resource platform, and students interact through intelligent student ID cards to answer questions.

3) Intelligent positioning

The student ID card adopts GPS, wireless base stations, WiFi positioning mechanism to synchronize the student's location, and send the location information to the guardian's mobile phone in the form of text message. Reservoirs, Internet cafes and other areas can be set as dangerous areas, and parents will receive a message alert as soon as children approach entering dangerous areas.

4) Family calls

The child can press the family call button on the smart student ID to call the parents, in case of emergency, the children can hold the SOS key to make an emergency call.

5) Schools consumption

In other consumption scenarios such as supermarkets inside or outside the school, the children can show the payment code to complete the transaction quickly, this feature support limited online recharge of pocket money.

3.2.3 Distance Learning

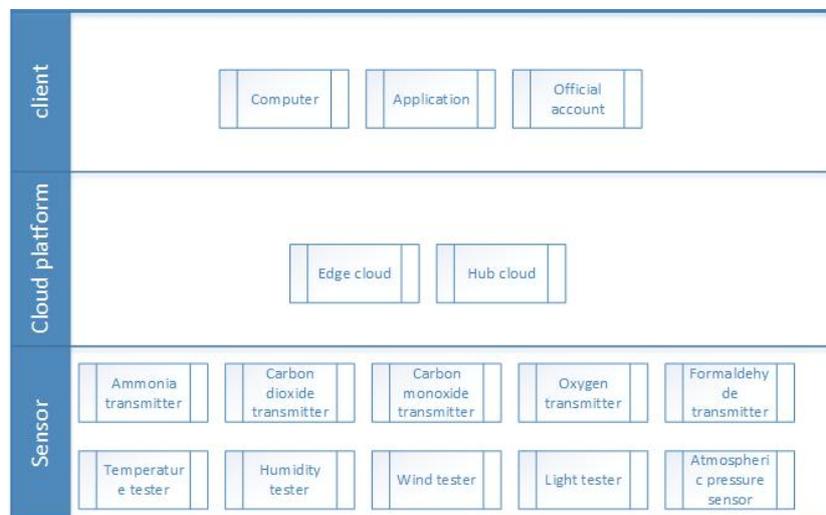
By integrating multimedia equipment such as computers, projectors, projection screens in the classroom, the equipment in classroom can be safely shut down and remotely supervised, teachers carry out teaching in the main classroom, and the their teaching video can be synchronized on each connected classroom electronic screen in real time, so as to achieve a substantial increase of the teaching range, it can also effectively overcome the shortcomings of complex integration, difficult management and single function of traditional multimedia equipment.

In 2023, Hefei Normal Primary School presented a second-grade Chinese audio literacy class to the world at the World Digital Education Conference, and schools in remote areas such as Shangxi Central Primary School in Guangxi Zhuang Autonomous Region participated remotely in the classroom. Through distance teaching, high-quality educational resources are radiated to relatively remote areas to achieve the co-construction and sharing of high-quality courses.

3.3 Green Schools

3.3.1 Environmental Monitoring

The environmental monitoring function can detect the environmental parameters closely related to human health in the indoor environment (such as air temperature and humidity, air TVOC content, CO2 content, PM2.5, indoor illuminance, etc.), and handle abnormal information timely to ensure the health and safety, as shown in Figure1.



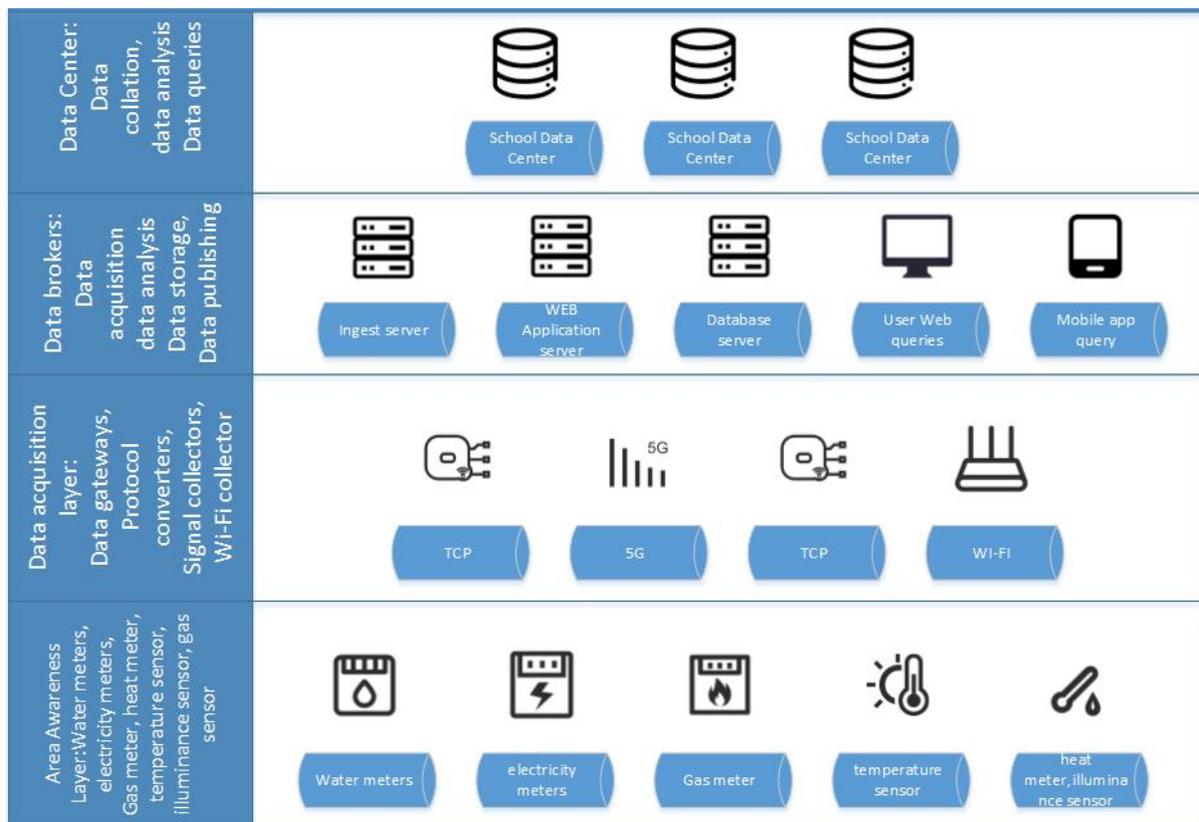
**Figure 1.** Environmental monitoring architecture diagram

Relying on the monitoring platform, the school uses real-time monitoring equipment such as environmental monitoring sensors and wind direction anemometers to detect dozens of air pollutants including NO, NO<sub>2</sub>, SO<sub>2</sub>, CO, allergic pollen, PM<sub>2.5</sub>, PM<sub>10</sub> and their possible diffusion directions, so as to realize alarm to ensure the health of teachers and students.

### 3.3.2 Energy Consumption Monitoring

By installing and arranging smart circuit breakers, smart sockets, smart meters, smart water meters and other equipment in the smart

schools, accurate control of electricity consumption is realized, data information of each power port is accurately obtained, and remote power transmission/power off control can be realized too; By installing a smart water meter, the water port situation in the school can be known in real time and the remote switch control can be obtained, the relevant historical information can be accurately obtained through the system, which can be used as a data basis for the school's energy decision-making, as shown in Figure 2.



**Figure 2.** Smart schools energy consumption monitoring system

Through big data analysis, schools can continuously optimize energy-saving strategies, automatically analyze and count energy measurement in each classroom or specific area, and provide energy-saving optimization strategies and suggestions.

### 3.3.3 Lighting Management

The lighting management system can adjust the color temperature of light according to the indoor lighting situation, maintain healthy light, and make the indoor average illumination constant and uniform, which is conducive to protecting the eyesight of teachers and students

and providing them with a healthy and comfortable learning environment. For different teaching situations, a variety of different lighting modes can be set (such as reading and writing, video playback, recess, etc.).

### 3.3.4 Water Monitoring

The water monitoring system can realize data collection and transmission through the Internet of Things, cloud platform, sensing equipment, wireless communication and other technologies, obtain target data such as turbidity, PH, hardness, heavy metals, chloride, oxygen consumption and other target data, and actively

report to the cloud platform through the wireless network. Relevant personnel can monitor the water body online in real time to realize remote monitoring and management of the schools water body.

#### 4. Main Features

The characteristics of smart schools mainly include the following four aspects:

##### 4.1 Comprehensive Perception of the Environment

Comprehensive perception of the school environment includes two aspects, one is that the sensor can sense, obtain and transmit relevant information of users, terminals, and resources, and the other is the perception, acquisition and transmission of students' individual characteristics, learning preferences, cognitive characteristics, learning states and learning scenarios (learning time, learning environment, learning behavior, etc.).

##### 4.2 Massive Data Support

Based on the massive information obtained by sensors, the smart schools can establish data models and prediction methods through big data analysis, conduct trend analysis, prospect and prediction of the collected information, and make rapid and proactive responses to the behavior of users, terminals and resources, so as to realize active management of users, terminals and resources.

##### 4.3 Open Learning Environment

The smart schools supports user behavior in an open learning environment, and expands the resource environment to expand teaching behavior from textbooks to outside the classroom. By expanding the learning time environment, the teaching behavior is expanded from in-class to after-school; By expanding the spatial environment, teaching behavior can be carried out in both real and virtual environments.

##### 4.4 Personalized Services for Teachers and Students

The smart schools support personalized services for teachers and students, meet the personalized needs of teachers and students in schools life and learning through key technologies such as artificial intelligence and big data, provide personalized educational resource services for teachers and students, and solves the problem of stereotyped traditional education.

#### 5. Epilogue

As the supporting force for the development of

smart schools, smart technology and application scenarios can systematically improve the school's teaching level and information management level by combining the specific needs of parents, students and schools, so that the safe schools, intelligent teaching, and green schools scenarios can meet the needs of teachers and students in an all-round way. On this basis, it is necessary to pay more attention to the application and services of key technologies in smart schools, meet the personalized needs of different user groups, realize customized access to functional services, improve the level of traditional schools information management, and realize one-stop services on smart schools.

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