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Smart Campus and Internet of Things Technology

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Abstract

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Abstract

The purpose of this thesis is to investigate application of the Internet of Things technology in the construction of a smart campus and to analyze its impact on various aspects of school management and learning. Advances in this technology can promote educational progress and help its widespread adoption.

This thesis employs a literature review, a theoretical analysis, and a case study to gather pertinent information regarding the concept, key technologies, and application examples of IoT and smart campus.

The key findings of this thesis include a detailed elaboration of the application of the Internet of Things technology in the construction of a smart campus. Analysis of the impact of the technology on school management capabilities, campus security, and teaching, learning and life of teachers and students is presented. The affiliated Beicai Middle School is shown as a real-life example of a smart campus. In addition, benefits, challenges, and future trends of smart campuses using Internet of Things technology are discussed.

Keywords
Internet of things；Smart campus；5G

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1 INTRODUCTION

1.1 Background of topic selection

The Internet of Things is a novel technology, following computers, the Internet, and mobile communication networks, due to the rapid development of information technology in the modern era，it is a new paradigm that is acquiring rapid traction in wireless communications today (Atzori, Iera & Morabito, 2010).

It is the third phase of the global information industry, coming after computers, the Internet, and mobile communication networks. It is cutting-edge technology. The Internet of Things has received a great deal of focus from nations and regions around the globe. South Korea, Japan, the United States, and the European Union have viewed Internet of Things technology as the core strategy for national development, and the Internet of Things as a key development area, with a focus on communications, people's livelihoods, and national information security networks. Applications, including the Internet of Things-based "U Society" strategy in Japan and South Korea, the "Internet of Things Action Plan" in Europe, and the "Smart Grid" and "Smart Earth" programs in the United States, have been implemented successively (China Investment Consulting Network 2010).

The increasing adoption of technologies like radio frequency identification, cloud computing, two-dimensional codes, and sensors has increased the potential for growth in the Internet of Things and helped propel the global information technology sector forward. Without a doubt, increasingly, the Internet of Things (IoT) is revolutionizing the way we live and connect objects in our daily lives by providing connectivity between them (Deanna Kennedy,Ziye (Randy) Wang,2018,1331).

Internet of Things technology also plays an essential role in the development of the smart campus system. Smart residences, campuses, structures, and cities have been created using IoT technology extensively (Marti Widya Sari, Prahenusa Wahyu Ciptadi & R. Hafid Hardyanto,2017,1). The Internet of Things is based on the Internet, with RFID, GPS, GIS, JIT, EDI, and other information sensing and identification equipment and information processing equipment combined with the Internet to form a vast network (Marti et al 2017, 1) provides a comprehensive information service platform for teachers and students, helps to improve school management capabilities and campus security, brings many conveniences to the study and life of teachers and students, and promotes education. Slowly, schools are beginning to comprehend the significance and utility of IoT. The use of the Internet of Things in daily instruction can radically alter the teaching method (Sengupta Shantashree, 2019,24), and the advancement of informatization will alter the teaching method and promote the growth of instruction.

Internet serves as the basis for the Internet of Things. Information exchange and mobile phones can be accomplished by combining information perception and information processing apparatus with the Internet to form a network. (Fan & Zhou, 2011,532).

The construction of a smart campus can also utilize Internet of Things technology, which can not only accelerate the process of building a digital campus, but also improve the management level of

the school and the security of the campus, provide greater convenience for the study and life of teachers and students, and advance the development of teaching. Using the Internet of Things, schools can also invest in management information to enhance school resource utilization and shared space. (Bart, Monique, Arkesteijn, Alexander & Alexandra,2021,1).

1.1.1 Significance of topic selection

First of all, the author consulted a lot of information, briefly expounded the concept of Internet of Things and smart campus, and the relationship between them, analyzed the key technology of Internet of Things in the construction of smart campus, and expounded the technology of Internet of Things and Internet of Things. The application advantages, challenges and future trends of IoT technology in the development of smart campus system are summarized on the basis of research investigation. On this basis, strengthen the theoretical basis for integrating the Internet of Things technology into the construction of smart campuses, provide theoretical reference for individuals to explore the innovative development of smart campuses, and also provide exchanges for professionals interested in the construction of smart campuses.

Secondly, the topic was chosen for pragmatic purposes. Due to the rapid advancement of communication and digital technologies in the modern world, the modern education system reform has also imposed stricter requirements on campus construction. How to utilize information technology to promote the intelligent development of school instruction, scientific research, and management, etc. Promoting the sharing and equitable distribution of resources at all levels of the campus is a challenge that the management staff of each school must address. Presently, the Internet of Things has been widely adopted across all industries and has produced a number of outcomes. The technology of the Internet of Things can also be used to create intelligent campuses. The convergence of the Internet of Things and education is an inevitable trend in the development of technology. The implementation of Internet of Things technology cannot only facilitate the interconnection of people and objects, objects and objects on campus, but it can also enhance the intelligence of instructors and students. Moreover, it can create a high-quality environment for students' study, teachers' instruction, and scientific research, and provide a firm foundation for updating teaching methods to enhance teaching quality and efficiency. Consequently, it is necessary to investigate the implementation of Internet of Things technology and the creation of smart campuses. This thesis analyzes the significance of the Internet of Things for the construction of smart campuses and combines the design of the overall architecture model and the application of key Internet of Things technologies in the construction of smart campuses to examine the specific application strategies, benefits, and future trends of Internet of Things technology in the construction of smart campuses. The author also hopes that the relevant management leaders and technical staff of each school will pay attention, seize the development opportunities of the times, and maximize the benefits of Internet of Things technology when constructing smart campuses, so that the construction of smart campuses will be more scientific and reasonable, and better suited to the wants and needs of teachers and students in the school.

Teachers, students, and administrators can perceive teaching resources on different levels, resulting in an interactive and collaborative living and learning environment. A smart campus is a new paradigm for campus development that is characterized by intelligent technology, intelligent management, intelligent instruction, and intelligent living. Many campuses can develop intelligent campuses based on their particular needs.Once the digital infrastructure for service delivery on campus is established and the creation of smart campuses is complete, campus activities can advance in a manner that offers numerous benefits to the locals (Marti, Widya & Sari, 2017).

The Internet of Things integration will ultimately have the greatest and most potent impact on the joint force as a whole. It can be said that the Internet of Things will facilitate the development of smart campuses with bright futures in the future. This thesis analyzes the significance of the Internet of Things technology for the construction of a smart campus, and combines the design of the overall architecture model and the application of typical technologies in the process of building a smart campus to analyze the scientific path of smart campus construction in the context of the Internet of Things technology, thereby making the construction of smart campuses more scientific and rational.

1.2 Main research content and research methods

1.2.1 Main research content

For the writing and research of this thesis, a large number of literature on Internet of Things technology and smart campus were consulted, as well as some domestic and foreign literature and cases of smart campus construction in universities. The specific investigation is divided into the following chapter:

The introduction explains the background of the selected topic, the significance of the research, the key research concepts, and the specific research methods.

The second chapter provides an overview of the technology behind the Internet of Things. First, the concept of the Internet of Things is defined, followed by a discussion of the concept and specific application value of the main technologies of the Internet of things.

The third chapter explains the concept of a smart campus, presents the overall architecture model of a smart campus system based on the construction of Internet of Things technology, and then analyzes the specific application strategy of Internet of Things technology in the construction of a smart campus.

The fourth chapter investigates the author's high school alma mater, Beicai High School Affiliated to Shanghai Maritime University, and analyzes the application significance of Internet of Things technology in the construction of a smart campus using the alma mater as an example.

Fifthly, the author summarizes the application advantages of the Internet of Things technology in the construction of smart campus systems, as well as the challenges and development trends, in order to facilitate the exchange of ideas among pertinent professionals.

The sixth chapter is the overview and prognosis. It reflects on the dearth of research on Internet of Things technology and smart campuses and makes recommendations for future researchers. It is anticipated that the construction of Internet of Things-based intelligent classrooms will improve. As a result of this content's research, it is anticipated that pertinent professionals will be provided with suggestions for improving the application level of Internet of Things technology in smart campus construction.

1.2.2 Main research methods

(1) Literature-based research methodology. The research on Internet of Things technology and smart campus must consult a large body of literature, conduct specific analysis on existing academic thesiss, magazines, and Internet-related content pertaining to Internet of Things technology and smart classrooms, and compile a large number of relevant theories.

(2) Law governing investigative practices. Since 2018, Beicai High School Affiliated to Shanghai Maritime University has been investigating and attempting to construct a smart campus. In 2020, it became a school for the Smart Campus project in Pudong New District, Shanghai, and from 2021, it has served as a benchmarking school for the application of educational informatization in Shanghai. The author took advantage of the invaluable opportunity of an internship, during which he frequently conducted interviews with relevant teachers to obtain valuable practical information, combined with the vast amount of literature he read to internalize the information, and used his alma mater as a specific example to more thoroughly comprehend the application of Internet of Things technology in the construction of smart campus applications.

(3) Methods based on inductive reasoning and speculation. In order to examine the application of Internet of Things in the development of smart campuses, this thesis introduces a large number of fundamental concepts and related technical definitions from the fields of Internet of Things and smart campus. Simultaneously, it is necessary to analyze the applicability advantages of Internet of Things technology in the development of smart campus systems, as well as the development challenges and challenges. Consequently, the author employs inductive reasoning and speculative methods in the inductive method, draws on the experience and perspectives of the predecessors, and derives his own point of view through speculative analysis for pertinent professionals to exchange, consider, and discuss.

2 INTERNET OF THINGS AND SMART CAMPUS RELATED TECHNOLOGIES

2.1 Artificial intelligence

Artificial intelligence was first defined in the 1950s (Crevier & Daniel, 1993). Artificial intelligence is a branch of computer science, which is researched and developed to expand and imitate the methods, techniques and theoretical application systems of the human brain.

The aim of artificial intelligence development is to make machines have certain human intelligence. The development of artificial intelligence aims to give machines a certain level of human intelligence. Through a sequence of system learning techniques (machine learning, image recognition), and later with the aid of cloud storage and other technologies, such that the machine gains abilities akin to those of the human brain, such as specific judgment capacity and learning ability (He Hongwei, Li Chenguang & Guo Lei 2022,80.).

Popularization has resulted in the successful incorporation of artificial intelligence into a variety of disciplines in order to aid humans in navigating a variety of complex applications (Clark, Jack ,2015). Artificial intelligence plays an extremely important role in school education informatization construction, and artificial intelligence has a wide range of applications in education informatization construction.

Artificial intelligence technology can be applied to many aspects, such as school teacher and student management, safety precaution management, energy management, education mode, etc., through information integration and reasoning at any time, the implementation of reasonable operation, can maximize the satisfaction of teachers and students' services. In terms of campus construction, artificial intelligence technology can be used in combination with education informatization to improve comfort satisfaction and provide better intelligent services, so as to optimize campus construction (Hu Xianzhi et al. 2021, 61.).

Artificial intelligence can also play a role in students' learning. Teachers' teaching experience and resources in schools are undoubtedly important. Traditional information construction is scarce for the utilization of teaching experience, and there is no way to achieve the complete use of teaching resources. However, artificial intelligence technology can solve the cognitive problems of computers on teaching data (Liu Xiaoning 2020, 116). Intelligent learning management system in artificial intelligence can individualize learning content for specific students. Taking linguistics as an example, Mandarin is a compulsory course in Chinese universities, and there is also a demand for specific work after graduation, due to the popularity of different students in various regions of Mandarin level is also different. Using data mining and machine learning techniques, artificial intelligence can provide students with personalized learning content and learning path home, thereby improving students' learning efficiency and learning results. Numerous studies assert that artificial intelligence can alleviate human labor and improve educational knowledge and skills. (Irhadtanto, Puspitaningsih & Dian, 2022, 642)

2.2 Internet of things

The Internet of Things is essentially an interconnected network that connects physical devices and items to the Internet, enabling interaction and data transmission between devices. According to the agreed standard protocol, sensor, wireless communication, infrared sensor, RFID and other sensing equipment can be used to realize an automatic intelligent application, so as to realize the interconnection of people, objects and machines at any time and place (Costa, Genovesi, Borgese, Michel, Dicandia & Manara, 2021).

Four different hierarchies are built into the Internet of Things: the sensing layer, the network layer, the platform layer, and the application layer. The sensing layer includes various sensors, actuators, controllers and other devices, which are used to collect various data in the physical world and perform various control operations. The main function of the sensing layer is to identify specific objects using sensors as well as RFID techniques (He Ping 2021,208.). The devices in network layer generally include various network devices, such as router, switch, etc. The network layer is used to connect the devices in perception layer together and form a communication network, which can acquire and transmit information data. The platform layer can process the data information deeply, transmit the data from the perception layer to the application layer, and then process, analyze, store, manage and further play a role in the data information. The application layer is used to apply the data collected in the Internet of Things to specific scenarios and plays a role in integrating the network system process. The physical network management mode is composed of these four hierarchical structures (Jian Ren &Tongtong Li, 2009)

The intelligent campus platform based on Internet of Things greatly improves the satisfaction of teachers and students, brings great convenience to school teachers and students, saves the funds of construction site, and also plays a great role in promoting the construction of school learning practice (Wang Xueqiang 2019,48).

2.3 Big Data

Big data technology uses advanced computer technology and algorithms to process, store and analyze a large amount of data. These data come from different sources, social media, sensors, the Internet, mobile devices, the Internet of Things. Big data technology can help people discover laws and trends from these massive data and provide data support and guidance for decision making (Marina Da Bormida, 2021).

At present, more and more campuses recognize the practicability of big data technology, and big data technology is widely used in smart campuses (ZHANG Bing 2023, 368.). The widespread use of big data technology has improved the school's administration of students, teachers, and campus security, and can also rationally allocate resources based on data collection and resource utilization. The application of big data technology significantly improves the teaching quality of colleges and universities, reflects the informatization transition of school education, human resources optimization methods, promote the construction of smart campus is essential, and one of the core technologies to promote the construction of smart campus is big data technology. (Deng Rui 2022,

119). Big data technology is the core, which can help users find laws and trends from massive data, and provide data support and guidance for decision-making, and then provide a more intelligent and efficient learning and education environment for students and teachers.

In short, big data technology can provide data support and guidance for all aspects of smart campus, thereby improving the operation efficiency and management level of campus.

2.4 5G

5G technology makes the world of the future so thrilling. No matter the industry, 5G has permeated people's lives, including education, purchasing, medical care, and navigation. With the advent of 5G, it has become incredibly convenient to use a variety of terminal devices. The digital age is no longer distant. With the introduction of 5G, the Internet of Things has entered a new era. 5G refers to the fifth iteration of mobile cellular communication technology. It is a wireless communication technology with faster speeds, greater stability, shorter delays, and lower costs than 4G. 5G will bring more intelligent applications and services to smart campuses as a result of its characteristics of high transmission rate and broad coverage (T-Mobile for Business, 2021).

Millimeter-wave communication technology: 5G networks employ millimeter-wave communication technology, which enables faster transmission rates and shorter delays. In addition to higher frequency and reduced transmission distance, millimeter wave communication technology requires more base stations and antennas for coverage (Z. N. Chen and X. Qing).

5G networks utilize large-scale antenna array technology, which can increase network capacity, network speed, and network coverage. Large-scale antenna array technology can also implement beamforming and adaptive beam tracking, thereby enhancing network coverage quality and stability. High-frequency millimeter wave communication technology, compared with the traditional transmission frequency band that can only reach less than 3Ghz, 5G technology has higher frequency and shorter transmission distance, and can theoretically reach 284.6GHz band frame, which solves the problem associated with the traditional transmission frequency band. Insufficient area. (Yang, Shi & Zhuang ,2021,4)

5G networks utilize software-defined network technology to facilitate rapid network deployment and management. Furthermore, software-defined network technology enables the automatic allocation and optimization of network resources, thereby enhancing network performance and stability (Rohini Sharma, 2021).

Technology for network slicing: 5G networks use network slicing technology to partition and deploy network resources. Using network slicing technology, different network services can be provided for various application scenarios to satisfy the requirements of various applications (S. Zhang, 2019).

Edge computing technology: 5G networks employ edge computing technology, which can deploy resources such as computing and storage at the network's edge, thereby decreasing data

transmission delays and network congestion. Edge computing technology enables real-time data processing and analysis, thereby enhancing the responsiveness and effectiveness of applications (Pérez, J., Díaz, J., Berrocal, J. et al, 2022).

5G plays a crucial role in the development of information infrastructure, and it can play a greater role in collaborating with diverse IoT technologies. Through data analysis, artificial intelligence can predict and alter network performance, thereby enhancing 5G performance. Moreover, 5G technology has high-speed transmission characteristics, so it can provide a speedier information dissemination environment for big data technology at the big data level. ((Lili ,Xiongfei ,Chen & Tiemai ,2022, 193)

3 OVERVIEW OF SMART CAMPUS

3.1 Current Status of Smart Campus Construction

Since the start of the 21st century, many countries have put a lot of value on how new technologies like artificial intelligence, the Internet of Things, and cloud computing are used on college campuses. Smart schools have been built in a number of countries, which has made the learning environment, living environment, and teaching environment all much better. (Li-fang Zhang, 2020). Through the construction of smart campuses, universities in Japan have developed intelligent attendance equipment. Through the intelligent system, attendance can be monitored in real time, and information resources can be shared, thereby effectively promoting the expansion of higher education. (He Hongwei et al ,2022). Cambridge University has built a campus cloud storage platform for campus services. The cloud storage platform offers instructors and students personalized services such as data storage, sharing, collaboration and sharing, and backup (Doug Bonderud, 2021).

Nanyang Technological University's smart classrooms incorporate technologies such as the Internet of Things, VR, and intelligent management and control to create remote live broadcast classrooms, interactive seminar classrooms, and virtual laboratories that can support flipped classrooms, hybrid teaching, and interactive teaching. The instruction mode drastically reduces teaching expenses (Xu Qingshan, Zhang Jianhua & Yang Lihua,113). Top-tier design and practical application of smart campus construction in colleges and universities: Using "Smart Beihang University" as an example. Using new information technologies such as the Internet of Things, building information models, geographic information systems, and mixed reality, Nanyang Technological University has developed a visual management platform that effectively avoids the difficulty of later construction, renovation, and maintenance, and reduces the cost of operation and maintenance management (Li Youzeng, Zhou Quan& Zhao Xiaobo, 2018, 114). Under the influence of strategic plans such as "China Smart 2025", numerous colleges and universities in China have begun to prioritize the construction of smart campuses. The Dalian Maritime University Smart Campus Research Center has developed smart services such as smart everyone, classrooms, facilities, and services, integrating teacher instruction, student learning, and life services (Tang Kun, Ma Yaying, Nie Baohua& Tang Jingwu, 2021,202-205).

3.2 Overall Architecture Model of Smart Campus Construction

The wide application of big data technology has strengthened the school's management of students, teachers and campus safety, and at the same time can rationally allocate resources according to data collection and even resource utilization. The model consists of five elements, from bottom to top: perception, infrastructure, support platform, application system, user, and terminal. Such an overall structure guarantees the operation and maintenance of the intelligent campus after its completion and enables the connection of campus facilities, intelligent campus security, convenient

campus life, and scientific campus administration. Figure 1 depicts the overarching architecture model diagram of the smart campus.

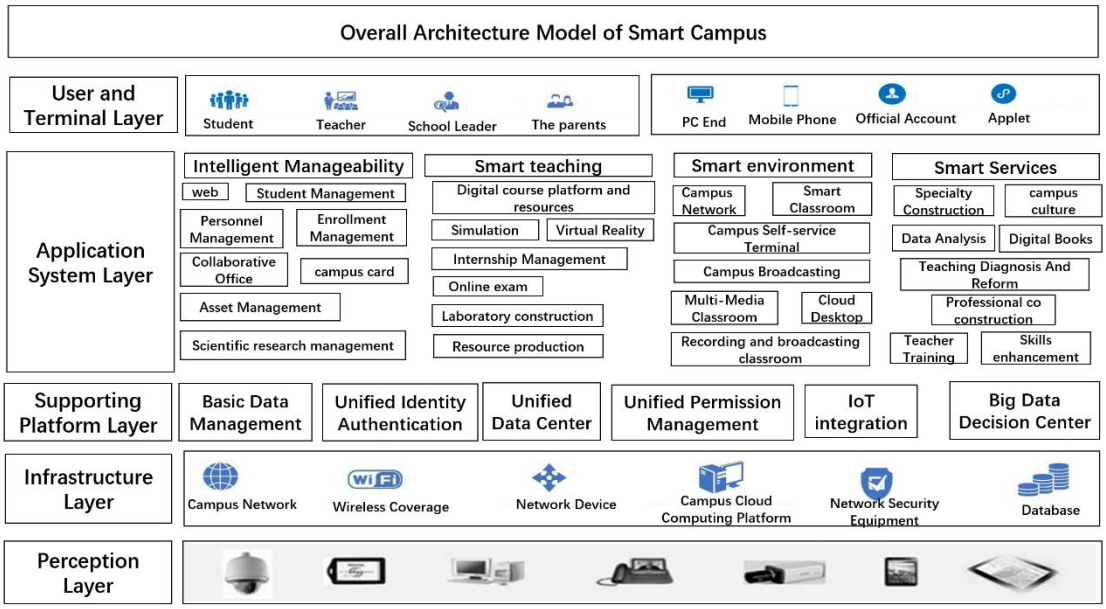

Figure1.Overall Architecture Model of Smart Campus (Hemudu Project Museum)

3.2.1 Perception layer

By configuring various information sensing devices, this layer accumulates and transmits data on the campus's physical quantities, chemical quantities, and biomass, obtains the site's real-time status, and promptly updates the campus management decision center. IoT devices consist of all front-end sensing devices, such as video surveillance at each campus entrance and exit, temperature and smoke sensors at the front end of the fire alarm system, library QR code recognition, asset management system RFID, building monitoring front-end sensors and controllers, etc. Consequently, via the perception layer, monitoring points are installed at school gates, main roads, teaching building entrances, classrooms, corridors on each floor, elevators, and walls, and the smart campus provides detection and alarm, multi-screen video wall centralized monitoring, storage and playback services, and realizes a secure campus (Baidu Encyclopedia, 2023).

3.2.2 Infrastructure layer

This layer is the hardware support of the smart campus. This layer consists of sensor networks, campus information facilities and equipment, databases and servers, etc., which can provide heterogeneous communication networks, extensive Internet of Things perception, and enormous data collection and storage (Baidu Encyclopedia 2023).

3.2.3 Supporting Platform Layer

Data exchange, data processing, data service, support platform, and unified interface functional units are just some of the application services that are driven and supported by this layer, also reflects the cloud computing and service capabilities of the smart campus. Data storage, data aggregation and classification, data extraction, and data push are only few of the modules that make up the data exchange unit. Data mining, analysis, fusion, and visualization are only few of the functional modules found in the data processing unit. Customized API interface, business/system interface, customer/client interface, and middleware. (Baidu Encyclopedia, 2023).

3.2.4 Application Platform Layer

Smart campus applications and services are embodied in this layer.It uses the platform as a foundation to create a smart campus with resources, management, and service apps that can be used by everyone on campus, including students, faculty, and the general public. This encompasses a "smart" classroom, "smart" classroom materials, "smart" campus administration (Baidu Encyclopedia, 2023).

3.2.5 User and Terminal Layer

This layer is responsible for granting access to data. The universal authentication platform portal allows users to access the platform's shared services and resources from any device running any browser, regardless of their location (Baidu Encyclopedia, 2023).

4 VARIOUS MODULES OF SMART CAMPUS CONSTRUCTION

4.1 Access control system

Intelligent access control systems have become standard apparatus for modern buildings as a result of the ongoing development of modern technology and the rise in people's expectations regarding the quality of their lives.One of the most common uses of smart cards on a campus is for entry control.(Mansur, K., Hasanuddin, Z.B., & Wardi,2018).Through the use of swiping cards, passwords, biometrics, and other identification methods, residents' identities can be determined and authorized accurately. Intelligent video intercom access control is more intelligent in the access control system. The identification badge is the most vital component of the gate system (James Gerdeman, 2015,40).Using a combination of Internet of Things technology and intelligent voice recognition technology, the visual intercom access control can automatically activate the intercom function upon recognizing the voice of a resident, thereby enhancing security.

The advantage of the video intercom access control system is that it can determine the identity of visitors via image recognition and verify the identity of residents via pronunciation (Karl Hill, 2021).

First, it is more perceptive. When connecting sensors and cameras, the video intercom access control system monitors the entrance and exit of the access control in real time. In addition, it supports voice recognition technology, which can automatically launch the dialogue function to verify the residents' identities. This system can help building security personnel automate management and improve work efficiency, allowing them to better meet the security requirements of building occupants.

Second, the access control system makes the college safer and more reliable.In traditional campuses, it is simple for anyone to enter because there is no identification card requirement (Mansur. et al, 2018). Internet of Things technology is the foundation of video intercom access control, enabling real-time monitoring of access control by connecting sensors, cameras, networks, and cloudservers. In addition, the system can support voice recognition technology, which can verify the identity of residents and assure the safety of building visitors.

Thirdly, the access control system is more practical and faster. The video intercom access control system is extremely user-friendly. When a visitor arrives, the system will automatically display the visitor's identity information and engage in a one-on-one conversation with each resident. In addition, the system can verify the identity of residents through voice recognition technology, eliminating the need for residents to transport keys or worry about losing them.

Intelligent building access control systems have become a standard component of high-quality communities in the 21st century. Intelligent video intercom access control, as an automated form of the access control system, not only improves the application value, security, and convenience of the

access control system, but also makes building security more intelligent and improves business operation outcomes (M. Zhou, N. Chen, Y. Yang, C. Pan & X. Zhou).

4.2 Library Management

With the advent of the digital age, the traditional library model has become increasingly inadequate to meet the needs of modern students. In this era of information, students' thirst for knowledge is intensifying, resulting in a rise in library attendance and traffic. In addition, it will contribute to new issues, such as the complexity of the traditional management system and the enormous workload of service personnel. These issues demonstrate that the traditional library cannot adapt to the modern instructional environment. Nowadays, intelligent campus libraries are an integral element of many universities. Based on Internet of Things technology, the smart campus library can provide more efficient and convenient book borrowing, search, and reading services to students and faculty. It has significantly increased the convenience and enhanced the students' library experience (Bart Valks. et al,2021,3).

In a smart campus library based on the Internet of Things, the books, equipment, and locations are tightly connected to the Internet, thereby enhancing the efficiency of management and services. RFID technology is the primary component, and RFID tags are affixed to every book. It allows librarians to locate, return, and manage volumes more quickly. Through RFID readers, readers can also obtain and return books independently (Yenurkar, Nasare & Chavhan, 2017).

The significance of constructing an RFID smart library is as follows: enhancing library management productivity. RFID technology can implement functions such as automated borrowing, inventory, and positioning of books, thereby reducing the workload of librarians and enhancing the management efficiency of libraries. Enhance the borrowing experience for consumers. Through RFID readers, readers can borrow and return books independently, eliminating the problems of waiting in line and manual errors, and enhancing the borrowing experience for readers. Enable digital transformation. The RFID smart library can digitize the library's books and equipment, allowing for improved information collection, management, and utilization, which is conducive to the library's digital transformation. The RFID intelligent library can reduce the need for manual administration and the library's management costs. Increase book consumption. Through data analysis and prediction, the RFID-enabled smart library is able to purchase books in a timely manner, which increases the utilization rate of books (G. K. Yenurkar. et al, 2017).

4.3 Classroom management

Smart classroom refers to the use of modern information technology on campus to improve the teaching quality, enhance the teaching effect, and optimize the learning environment, as well as to integrate various technical means, such as information technology, multimedia technology, network technology, and interactive technology, to form a cohesive whole. It is the intelligent classroom. The intelligent classroom system can significantly enhance the level of classroom informatization and the

learning experience of students. The smart classroom incorporates a variety of contemporary instructional tools. These devices are connected to various peripherals, hardware modules, and systems through the terminal. A mature, intelligent educator is equipped with a variety of interactive application solutions that service classroom instruction, resource application, and classroom management. Compared to conventional classrooms, it improves the quality of instruction and the learning environment in every way. Multimedia courseware, for instance, provides a more visceral and interactive learning experience for students, thereby increasing their interest in learning. Students use intelligent classroom resources to improve learning efficacy, increase their participation in the learning process, and deepen their understanding (M.D. Abdulrahaman, N. Faruk, A.A. Oloyede, N.T. Surajudeen-Bakinde, L.A. Olawoyin, O.V. Mejabi, Y.O. Imam-Fulani, A.O. Fahm & A.L. Azeez, 2020).

The system deployment of the smart classroom is often divided into four processes: setting up the smart gateway inside the campus, and then combining with the smart classroom comprehensive management platform and the campus network to access the campus network. IoT sensors and control devices configured according to specific classroom applications, such as environmental monitoring, security equipment, classroom lighting equipment, and teaching equipment. Install the smart classroom management platform on the set server to manage and control the statistical data of the equipment. Figure 2 is a structure diagram of a smart classroom based on the Internet of Things system.

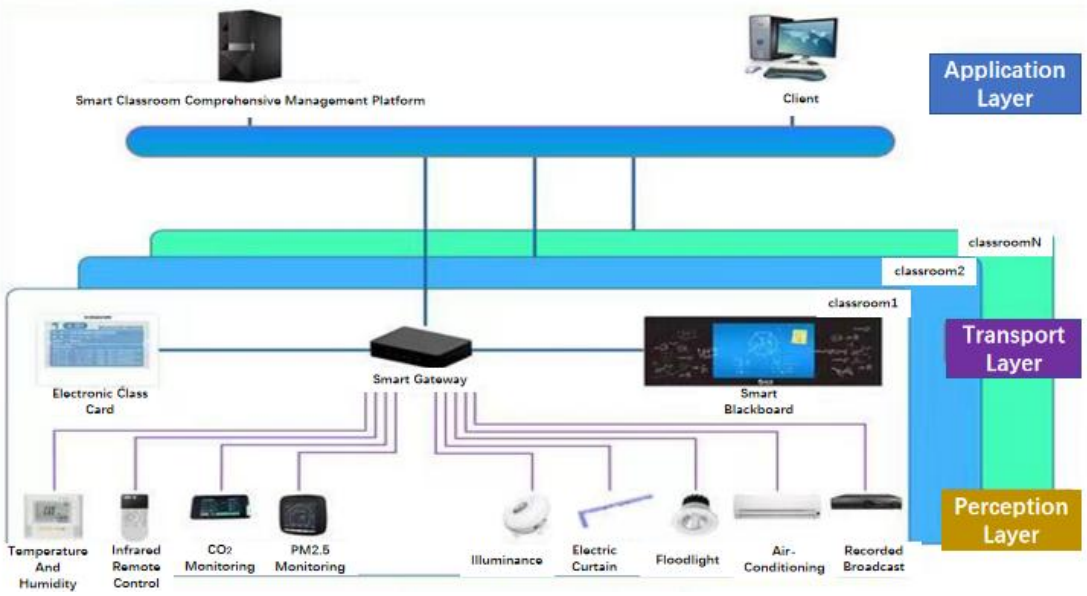

Figure2.Smart Classroom Based on IoT Architecture (Guangdong Xinyuan Information)

The following are some specific applications of smart campus

1.The classroom lighting protocol is remotely, autonomously, and routinely controlled via a zigbee protocol terminal with an illumination adjustment function. Through the system, it is possible to adjust the classroom's lighting, light source, and hue, as well as the response conditions for various scene modes.

2.Multiple functions and a variety of sensors are incorporated into the smart classroom system's environmental control module. The various sensors allow the system to detect the classroom's temperature, humidity, carbon dioxide, PM2.5, formaldehyde, and light anywhere and at any time. The detected data will be transmitted to the data platform for storage, so that data statistics and early warning can be generated. Infrared sensors, humidity sensors, and other equipment within the classroom can alter the indoor environment at any time and place to maintain a healthy environment.

3.Equipment management and control: The integration of apparatus management and control is a feature of the intelligent classroom system. Through the protocol terminal, classroom apparatus such as projectors, computers, air conditioners, lights, access control, and ventilation systems can be remotely controlled at any time. Administrators need only utilize the classroom platform. Supervise classrooms, relieve administrators of the burden of equipment maintenance and administration, and lessen their workload.

4.Control of energy consumption: Typical classrooms frequently experience undervoltage, and overload. In such situations, the power supply is frequently deteriorated and aged. These issues frequently endanger the safety of electrical use, damage classroom apparatus, and even start fires. In the course of classroom use, energy is frequently wasted as a result of forgetting to switch off the power supply. The emergence of the smart classroom system enables real-time statistics, analysis, and monitoring of electricity consumption, as well as the accurate reporting of the energy consumption of each class, grade, and area to the platform. In terms of electrical safety, such as excess, equipment, and circuit failures, the alarm can be issued in real-time, and the automatic power-off protection will be activated for the first time.

5.Classroom access control: Traditional classrooms frequently require a key to enter, and the keys are frequently forgotten or misplaced. The smart classroom's access control management system can authorize the access control switch in real time and control the access control system using face, school card, and biometric recognition, among other methods. The access control system accurately verifies the number of individuals entering each time the door is opened.

4.4 Intelligent sorting and recycling

As urbanization progresses, the quantity of trash continues to increase. Internet of Things plus smart recycling has become one of the most effective means to promote garbage classification as a result of this trend. As a relatively enclosed area, the campus is densely populated and generates a substantial amount of waste; therefore, garbage classification should be implemented. Combining the Internet of Things and smart recycling can make garbage sorting and recycling convenient and fast, improve the efficiency of garbage sorting, and perfectly integrate green campuses and smart campuses (S. T. Nguyen, B. N. Le & Q. X. Dao).

Using Internet of Things technology and the "Internet of Things + Smart Recycling" paradigm, campus waste is managed intelligently via automatic classification and recycling. This mode consists of three layers: the first layer consists of smart trash cans, temperature sensors, humidity sensors, etc., which can detect the types of garbage in the trash can, the state of the garbage, and the real-time temperature and humidity of the environment where garbage is produced. The second layer is the wireless network layer, which includes WiFi, Bluetooth, and other wireless communication technologies that transmit sensor data from the first layer in real time to the third layer's background management server. The cloud computing layer, which includes refuse classification algorithms and intelligent recycling systems, is the third layer. By analyzing the information generated by the refuse, the garbage can be automatically classified according to the type and quantity of garbage, and recycling vehicles can be dispatched to achieve efficient garbage recycling. The intelligent recycling system can also use computer vision and machine learning technology to further enhance the algorithm for classifying incoming waste in order to better handle people's mixed misclassifications. With the aid of the Internet of Things, the model automates and intelligently classifies garbage, which not only increases the efficacy of garbage collection, but also simplifies school work and reduces administrative costs. It possesses considerable application potential (S. T. Nguyen, B. N. Le & Q. X. Dao).

Figure 3 depicts a smart recycling receptacle located on the campus of Yichun Vocational and Technical College in China, and Figure 4 is a composition diagram of the "Internet of Things + Smart Garbage Sorting" model.

Figure 3. Smart waste recycling bins on the campus of Yichun Vocational and Technical College, China（Student news agency ,2022）

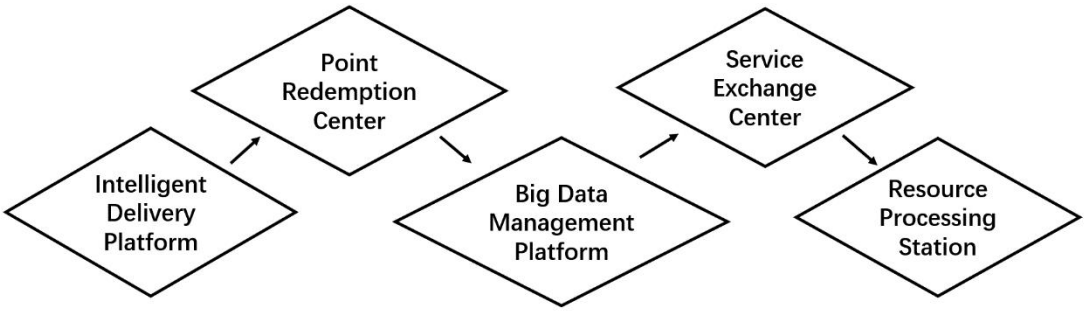

Figure 4. Composition diagram of the "Internet of Things + Smart Garbage Sorting" model（Student news agency ,2022）

The "Internet of Things + Smart Recycling" model also allows pupils to exchange points. Students can earn points by scanning the QR code and throwing away trash, which encourages them to partake more actively in sorting and recycling garbage. In addition, there are rules for earning points: For example, there is a daily limit on the number of points that can be earned for different types of garbage; the mouth of the garbage bag must be secured, and no points will be awarded if the bag is not secured; points cannot be awarded if the classification is incorrect; if one person scans the code, N individuals will not receive points for putting in garbage; scanning the QR code alone and not throwing garbage will not earn points (S. T. Nguyen, B. N. Le & Q. X. Dao).

Before disposing of trash, students can scan the QR code on the smart waste bin's opening with WeChat, log in, and register the "Environmental Protection Smart Recycling" application. After registration is complete, the "scanning" input port for the applet can be generated. Students locate the appropriate bins based on the sorted waste, open WeChat to scan, and use the scan code to scan the QR code on the smart bin. After scanning, the bin's cover will automatically open, and the bin's lid will close. After the lid is unsealed, trash is placed directly into the box, and the lid closes automatically when the placement is complete. After the delivery has been completed, students can select "My Delivery" on the "Smart Recycling" applet to view their delivery record and point information. When the points reach a certain threshold, the user can select their preferred products from the point exchange center and open "My Delivery" prior to payment. "Smart Recycling" applet, select "My Points," and show the cashier the QR code of the points to redeem them for merchandise（Student news agency, 2023）.

Through the IoT intelligent system for statistics and management of waste classification data, the "Internet of Things + Smart Recycling" equipment can also transmit information such as the type and quantity of recycled waste to the recycling machine operation center and the school management department in real time. The core of the big data platform is its traceability, which allows for exhaustive querying and oversight. Teachers at all levels of the school can verify the status of their students according to their own requirements（Qiong Li, Xudong Zhu & Leslie N.K. Lo ,2019).

In addition, students can automatically earn points for correctly disposing of trash in accordance with refuse classification requirements. Consciousness of energy conservation and environmental protection (Student news agency ,2022).

The "Internet of Things + Smart Recycling" classification model is widely used on college campuses. The sifting of campus garbage is both an environmental protection and health-related activity. Efficient garbage sorting can reduce the pollution caused by refuse to the human living environment, improve the appearance of the school environment, and help reduce potential safety hazards that may arise during the garbage sorting process. Application of the Internet of Things and a smart recycling model to campus waste classification is an innovative effort in contemporary society. Intelligent recycling and classification enable the automation of waste classification, which facilitates campus garbage classification and contributes to the development of an ecologically sustainable environment (Qiong Li, Xudong Zhu & Leslie N.K. Lo ,2019).

4.5 Canteen catering management

The smart campus cafeteria is a case study of a new generation of services arising against the backdrop of the evolution of the Internet of Things technology. The promotion of the intelligent campus can significantly enhance campus catering management. Compared to conventional cafeterias, smart restaurants are more convenient, standardized, and sanitary. Together, the Internet of Things technology and the campus smart canteen can meet the school's information construction requirements for the restaurant. The traditional canteens of major universities have always faced the problem of excessive lunch traffic, which the Internet of Things ordering platform system can effectively alleviate. On the market, traditional smart campus restaurant solutions typically offer the following benefits:

1.Tablet reservations, students and employees can reserve the dishes they desire via an electronic platform at the cafeteria's entrance. The cafeteria will get real-time order information and use the system's automatic raw material inversion function to make the food. This model can significantly enhance the cafeteria's operations. Efficiency, thereby reducing traffic reduction (B. Vatcharakomonphan et al, 2019).

2.With the face-swiping dining system, patrons can pay for their meals without assistance from staff. Similarly, diners do not need to bring meal cards because they can pay by swiping their faces. Simultaneously, the face-scanning system is synchronized in real time with the campus app. For the first time, parents can obtain information about their child's dining habits, including the manner and consumption of dishes, nutritional intake, and dietary preferences. The process workload is diminished (Ruiqian An, Tao Xi, 2022).

3.The intelligent restaurant system can track food safety. A comprehensive inspection can significantly reduce the occurrence of food safety incidents by utilizing mobile phone sample retention, pesticide testing, food material circulation records, supplier information, and other data (Ruiqian An, Tao Xi, 2022).

4.The data cloud monitoring system will conduct real-time surveillance of the cafeteria. The manager will collect data on the canteen's operation, personnel dining situation, dining efficiency,

and dish sales situation via the data analysis platform and will then analyze, integrate, and manage the canteen data. Through the system, users can obtain data visualizations (Ruiqian An, Tao Xi, 2022).

4.6 Infectious disease testing

As a result of the emergence of the new crown pneumonia epidemic (T. Pan, 2020), campus epidemic prevention has unavoidably become a focal point of social attention, and the campus is also a location with a high population density. Therefore, campus epidemic prevention measures have become an absolute necessity. Using digital technology, smart campuses can improve the efficacy and precision of school epidemic prevention and control, thereby aiding in the prevention and control of the new crown.

As the epidemic subsides, instructors and students progressively return to campus. Nonetheless, for prevention and control, temperature measurement and information registration continue to be an essential step and a vital component of campus epidemic prevention. Traditional temperature measurement equipment is inefficient and labor-intensive. In addition, the risk of infection will increase due to the proximity of the detection procedure. Internet of Things-based facial body temperature detection equipment can solve the aforementioned issues. The face temperature detection machine employs technologies such as face recognition and detection to ensure that students and teachers only need to encounter each other in order to detect their own body temperature and collect and record data without any human interaction (Vu-Anh-Quang Nguyen. et al, .2020)

The Smart Campus can push relevant information on epidemic prevention and control to students and parents via their mobile apps, such as epidemic notifications, epidemic prevention measures, and medical treatment guidelines, so that students and parents can receive timely epidemic information and take preventative measures (P. Agarwal, R. Kumar G.V.V. & P. Agarwal ,2020).

Through the student information management system, curriculum management system, examination management system, and other modules, the intelligent campus is able to thoroughly comprehend the activity track and physical condition of each student, as well as manage information. This data can be used by schools to detect and monitor suspected cases in a timely manner, allowing for effective isolation and treatment (A. Roy .et al ,2020).

5 APPLICATION EXAMPLES OF SMART CAMPUS CONSTRUCTION BASED ON INTERNET OF THINGS TECHNOLOGY

Beicai High School Affiliated to Shanghai Maritime University, the author's high school alma mater, served as the internship unit during the author's university studies. Since 2018, Beicai High School Affiliated to Shanghai Maritime University has been investigating and attempting to construct a smart campus. In 2020, it became a school for the Smart Campus project in Pudong New District, Shanghai, since 2021 it has served as a benchmarking school for the application of educational informatization in Shanghai (Zhang, Y., Dong, Z.Y., Yip, C. & Swift, S, 2020).

The school collaborates with the Shanghai Yidian Group to construct a smart campus in accordance with the relevant national planning frameworks and requirements for education reform and development, education informatization, etc (China Education News, 2022). The smart campus of the school is based on technologies including big data, fundamental network, cloud computing, and the Internet of Things. Taking advantage of the second phase of school building reconstruction, more than 1,300 sets of smart devices are distributed in every corner of the campus for information capture, Face intelligent attendance, personnel trajectory tracking, and real-time monitoring of environmental quality covering the entire school's physical space, thereby monitoring and adjusting various learning scenarios and campus environments. Smart campuses can help schools implement smart teaching with independent learning, personalized learning, and smart management based on big data cloud platforms, mobile Internet, artificial intelligence, and the Internet of Things, as well as promote school informatization construction with high standards, and create good information. Improve campus management functions like smart teaching environment, smart information push, smart operation and maintenance service, campus security management, etc. to improve the quality of school education and teaching. The smart campus platform plans the system architecture according to the presentation layer, application layer, basic platform layer and infrastructure layer, as shown in Figure 5. It is a general structure diagram of the smart campus modules for the school.

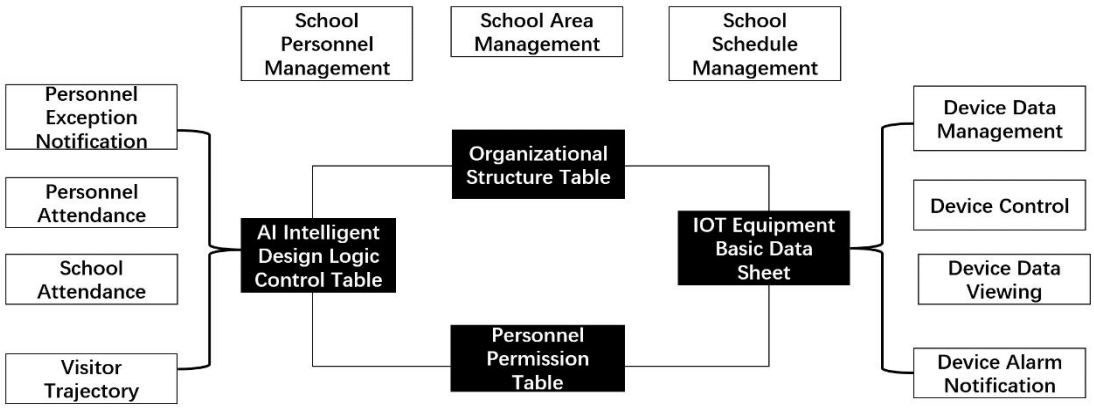

Figure 5.Smart Campus Architecture of Beicai Senior High School Affiliated To Shanghai Maritime University (Smart Campus Basic Platform of Beicai High School Affiliated to Shanghai Maritime University, 2023)

5.1 Three stages of school smart campus development

The construction of the Smart Campus of Beicai High School Affiliated with Shanghai Maritime University was promoted in three stages: planning, design, and construction (Li Bingfeng, 2023).

The first phase focused on the construction of basic systems, such as an integrated pipeline system, backbone optical cable system, campus network system, integrated wiring system, safe campus system, card system, building equipment monitoring system and energy management system, data center system, and video conferencing System, while meeting the campus's basic educational, safety, and life requirements.

The school focuses on the development of intelligent teaching and life application systems, such as multimedia teaching systems, recording and broadcasting teaching systems, standardized examination room systems, smart library systems, campus card systems, television systems, broadcasting systems, information release and query systems, and information release and query systems.

In addition, the institution is concentrating on constructing a smart campus platform, integrating the necessary hardware for smart management, smart education, and smart life, and developing a smart campus platform with comprehensive perception, efficient collaboration, and intelligent control.

Figure 6.Beicai Senior High School Affiliated To Shanghai Maritime University

Smart Campus Platform (Smart Campus Basic Platform of Beicai High School Affiliated to Shanghai Maritime University, 2023)

5.2 The overall construction structure of the school's smart campus

The Smart Campus of Beicai High School Affiliated with Shanghai Maritime University employs the Internet of Things smart campus architecture model that integrates multiple information as the

construction framework. Application layer, platform layer, network layer, and perception layer make up the smart campus.

5.2.1 Application layer

The application layer comprises the smart campus's numerous service subsystems and provides a unified system interface for campus users. Campus management-oriented service system, teaching-oriented intelligent application system, and campus life-oriented service system are its primary components. Role definitions establish different permissions.

The application layer adopts a service-oriented architecture and displays the acquired and processed effective information to users via a graphical system interface, providing campus equipment management, information management, educational affairs management, asset management, administrative management, and other comprehensive management services; providing teachers with comprehensive teaching application services including teaching, teaching aids, teaching plans (Zhennan, 2021).

5.2.2 Platform layer

The platform layer consists of two primary platforms: an infrastructure platform based on computing services, storage services, and backup services, and a support service platform based on cloud computing, data processing, and middleware services.

The basic platform layer must realize the centralization and scalability of resources, the compatibility of heterogeneous hardware and software basic resources and the dynamic flow of resources, and the scheduling of static and fixed hardware resources to form a resource pool.

The primary functions of the supporting service platform are data collection, resource sharing, application integration, and business collaboration (Zhennan, 2021).

5.2.3 Network layer

Internet, Internet of Things, education network, and campus network comprise the network layer. Using IP technology, broadband wireless technology, and optical network technology, data from the perception layer are transmitted to the service platform (Zhennan, 2021).

5.2.4 Perceptual layer

The perception layer employs sensors, RFID, GPS, cameras, laser scanners, and other information collection equipment to collect data on various physical quantities, chemical quantities, or biomass on the campus, obtain real-time scene status, and provide timely feedback to the campus management decision center. The perception layer consists primarily of video surveillance system cameras, building monitoring front-end sensors and controllers, fire alarm system front-end temperature and pollution sensors, student QR codes (Zhennan, 2021).

5.3 The specific application of school smart campus construction.

Frequent interviews were conducted with school administrators, instructors, and students regarding the use of the smart campus platform. In this chapter, the specific application of the smart campus system in schools is discussed later.

5.3.1 Using Internet of Things technology to create an economical campus

Sustainable development is the primary objective of modern the development of society. Saving energy and reducing emissions are also crucial for schools. With the help of Internet of Things technology, various data information such as school resources and energy consumption are collected and organized, and the school's water and electricity resource consumption and teaching equipment usage monitoring are centralized on a full-time monitoring and management platform, so that administrators can accurately understand the energy consumption and usage of various equipment in the school, thereby providing a crucial basis for th Simultaneously, it enables intelligent utilization and monitoring of school resources and energy (Liu Xiaoning ,2020). For instance, light sensors and controllers can be installed in offices, laboratories, classrooms, gymnasiums, and restrooms, etc., and the brightness of lights, indoor temperature, and superfluous water and electricity waste, etc., can be controlled. Through the Internet of Things, the monthly water and electricity consumption of the school can be accurately calculated, and the specific opening time for hot water can be determined based on the actual needs of the students, thereby conserving water resources and reducing energy consumption. Using the Internet of Things system, the school can accurately record the water and electricity consumption of each classroom and dormitory, formulate reasonable water and electricity consumption indicators, and help teachers and students develop good habits for conserving water and electricity. (Li Bingfeng, 2023, 20-21.) Figure 7 displays the daily, weekly, and monthly energy consumption of the floors on the smart campus platform of the school.

Figure 7.IOT Integrated Feedback (Smart Campus Basic Platform of Beicai High School Affiliated to Shanghai Maritime University, 2023)

5.3.2 Using IoT technology to build a safe campus

Security is a significant objective of campus construction, and the Internet of Things can provide information security services for smart campuses and defend terminals and the Internet from remote attacks. Schools must acknowledge the computing capacity and energy limitations of mobile terminals and object tags. Utilize the advantages of the Internet of Things to ensure the information security of the campus as a whole, so as to construct a safe and harmonious campus. (Huang Tianyi, 2022, 18)

Using Internet of Things technology, the school also constructs a monitoring system that encompasses the entire school, dynamically monitors the cellar, building, etc. of the school, and every corner of the school, and can ensure the safety of teachers and students around the clock. Protection, no monitoring blind spots, can keep abreast of the situation of instructors and students at all times, identify potential safety hazards immediately, and connect the monitoring system to the local police station to obtain assistance and rescue in a timely manner. With the help of the Internet of Things monitoring system, the school is able to fully understand how the people in it work together, identify potential threats in and around the campus, and provide a safer learning and living environment for teachers and students. In addition, the comprehensive application of diverse intelligent sensing technologies enables information such as images, temperature, and location to be collected and processed in real time and on a large scale, to obtain diverse monitoring information in real time and comprehensively, and to control temperature and humidity in various locations (Ballard, Z., Brown, C., Madni, A.M. et al., 2021).

With the security monitoring system, the school can monitor the movement of students and teachers in the school at all times. Mobile phones allow school administrators and teachers to access smart campus management platforms (Kashif Naseer Qureshi et al. 2021) . WeChat was initially used to discover the school's dynamics and concealed dangers. They can also access the smart campus management platform through a computer, which allows for a more visual, real-time, and intuitive comprehension of the various campus applications and environmental dynamic data displayed on the computer screen. Figure 8 depicts the air quality feedback interface of the Internet of Things on the smart education platform, while Figure 9 depicts the Internet of Things' real-time display board.

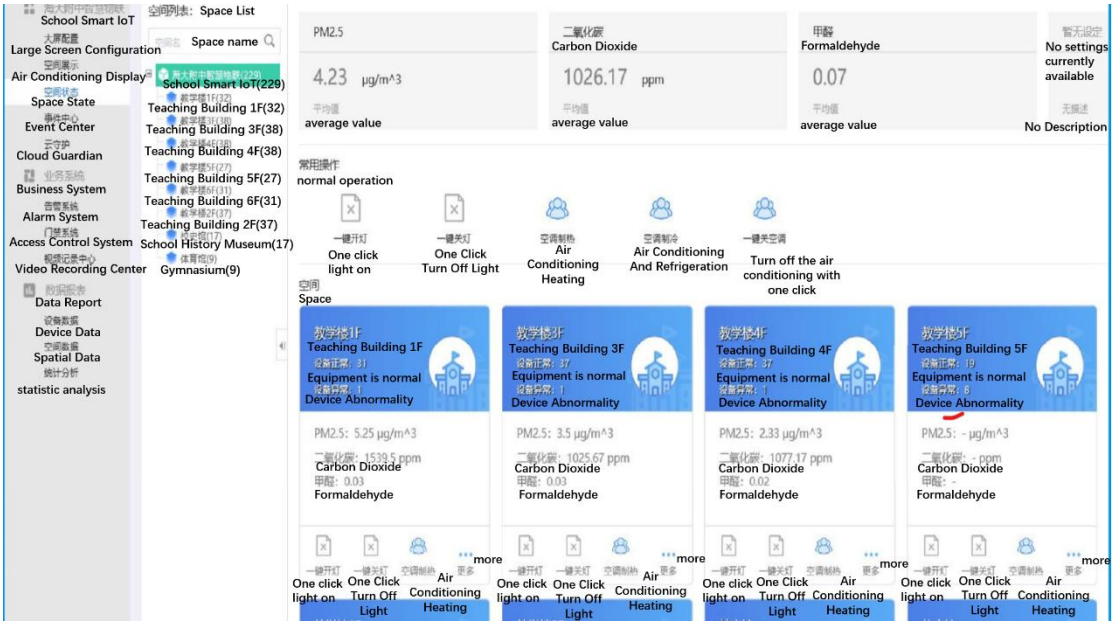

Figure 8.IOT Air Quality Feedback (Smart Campus Basic Platform of Beicai High School Affiliated to Shanghai Maritime University, 2023)

Figure 9.IOT Real Time Display Dashboard (Smart Campus Basic Platform of Beicai High School Affiliated to Shanghai Maritime University, 2023)

5.3.3 Using Internet of Things technology to build a complete one-card consumption system

With the assistance of Internet of Things technology, schools have developed a "campus card," which is also one of the most remarkable accomplishments in the development of smart campuses. The "Campus Card" primarily employs Internet of Things radio frequency technology and database technology. The "campus card" is equivalent to the students' "RFID" tags. It is tied to the school's personal identity, allowing for the identification and control of the personal identity during the consumption process, a reduction in campus administration expenses, and the integration of various system application services. (Wang Bo, 2021, 7)

The "Campus Card" is a natural outgrowth of the Internet of Things applied to intelligent campuses. Internet technology can be used to optimize the functions of "Campus Card" in addition to making it easier for school faculty and students to enter and exit the campus. For instance, the school can implement a comprehensive consumption system that allows campus teachers and students to reload the "campus card" to meet a variety of consumption requirements, such as catering and bathing. Each card is bound with the information of the teachers and students to whom it pertains, allowing it to be recovered even if it is misplaced. At the same time, teachers and students can check the consumption records of the one-card at any time, which not only enables teachers and students to know the balance of the card in real time, but also enables them to determine if there are consumption records in the card that do not correspond to their own consumption behaviors, thereby enhancing vigilance.(P. Wakim & K. Mershad, 2018) Teachers, students, and employees can enter and exit the school, manage school business, participate in school activities, and consume all with this campus card, realizing "one card in hand, walk around campus" Figure 10 depicts the school's smart campus ID.

Figure 10.A campus card from a teacher at Beicai High School

5.3.4 IoT-based smart campus platform realizes resource sharing

The construction of the subject school-based resource library is an essential aspect of the smart campus construction at the school. The institution thoroughly investigates all instructors' own teaching courseware, teaching materials, electronic teaching plans, and other information-based teaching resources, develops the school-based digital teaching resource library, and employs the smart campus platform. Realize the sharing of information-based instructional resources created by teachers. Teachers can share their own teaching resources on the platform, upload their own micro-lessons, teaching plans, courseware, and course sheets to realize resource sharing within the subject teaching and research group, and simultaneously download resources from other teachers, preventing confusion during the teaching process. It prevents instructors from repeatedly creating course materials and increases the efficiency of lesson preparation. Figure 11 depicts the resource sharing of school language instructors.

Figure 11.Resource Sharing for School Chinese Language Teachers (Smart Campus Basic Platform of Beicai High School Affiliated to Shanghai Maritime University, 2023)

5.3.5 The smart campus platform based on the Internet of Things promotes the training of teachers in the school

Through the smart education platform, the school conducts online teacher teaching and research, school-based research and development, and cloud-based teaching and research at any time and from anywhere. The teaching resource sharing platform can provide a diversity of teaching resources, such as teaching videos, lesson plans, teaching materials, etc., as well as facilitate the teaching activities of teachers. Through the smart education platform, instructors can share their teaching methods and experiences in order to advance their careers. After the platform collects data, Figures 12 and 13 depict the achievement of the aim of professional development for teachers' wisdom training.

Figure 12.Statistics On Achieving Professional Development Goals (Smart Campus Basic Platform of Beicai High School Affiliated to Shanghai Maritime University, 2023)

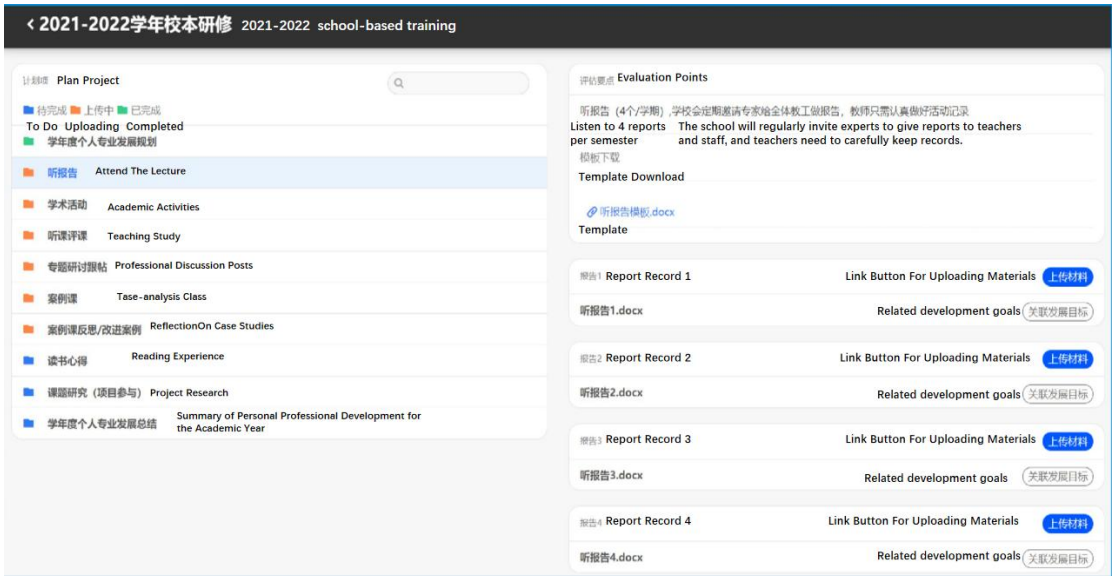

Figure13.Smart Training (Smart Campus Basic Platform of Beicai High School Affiliated to Shanghai Maritime University, 2023)

5.3.6 IoT-based Smart Campus Platform Helps Student Management

The smart campus platform collects all types of accurate data, such as student fundamental data, academic data, learning process data, social practice data, and specialty data, to create a database on student growth. On the basis of this database, the overall record and analysis of the school's students' educational growth process data is conducted in order to form multi-dimensional professional knowledge labels, establish an academic digital portrait index system that reflects the current situation of students, and develop a portrait scene analysis model using big data-related technologies.The smart campus platform based on the Internet of Things can create and present visually appealing digital portraits of students based on their growth data, while reducing the burden on teachers, improving efficiency, improving efficiency, and promoting personalized analysis of student learning and development, learning-oriented , realize individualized teaching, provide decision-making suggestions for teaching managers, and help realize scientific governance.

Eye exercises are a type of gymnastics that prevent and relieve eye fatigue through eye exercises and eye massage.Broadcast gymnastics generally consists of a series of simple gymnastics movements, including stretching, bending and stretching, turning and other movements, aiming at promoting the softness of the body and the mobility of muscles, and improving the coordination and flexibility of the body. In China, radio gymnastics and eye exercises are widely used in schools to help enhance people's physical fitness and health (Huang J, Chen Q, Du K& Guan H ,2020).The student portraits generated by the smart campus platform after collecting various student information can accurately reflect the various process growth information of students and present the growth of students in a more intuitive manner, allowing teachers to carry out educational work after clearly understanding the situation of students and fostering the development of students' overall quality (Zhu Xiuhua, 2020). Figure 14 is a portrait of a pupil displayed on the smart campus platform of the school, and Figure 15 is a weekly assessment of moral education rules for six first-grade classes.

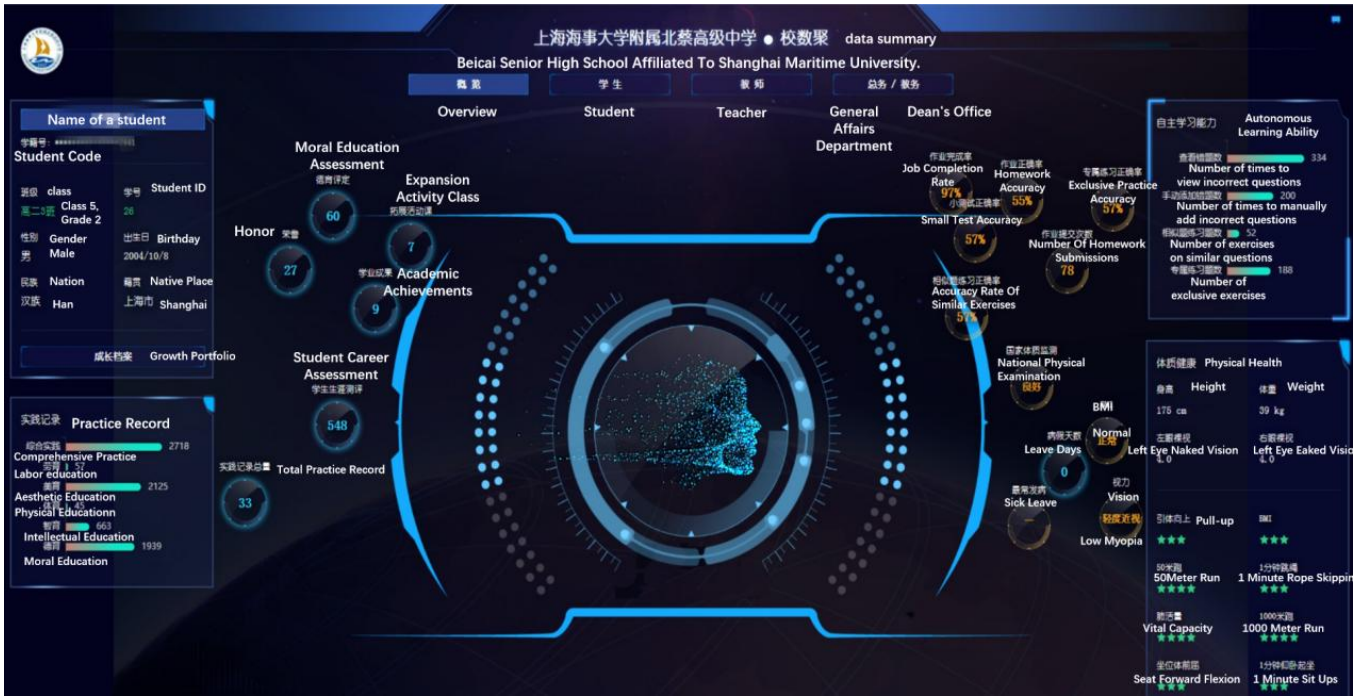

Figure 14.Student Portrait (Smart Campus Basic Platform of Beicai High School Affiliated to Shanghai Maritime University, 2023)

Figure 15.Student Behavior Evaluation (Smart Campus Basic Platform of Beicai High School Affiliated to Shanghai Maritime University, 2023)

5.3.7 AI Learning Smart Education Platform System Helps Smart Teaching

The most important criterion for evaluating the success of the digital transformation of education is the extent to which the teaching and learning processes of instructors and students are supported by digitalization and artificial intelligence. The school implemented the AI learning wisdom instruction platform system in 2019. The AI Learning Smart Education Platform System is an intelligent education platform that provides personalized teaching and learning for education supervision departments, schools, instructors, and students. Through the in-depth integration of core technologies such as big data of the Internet of Things, artificial intelligence problem-solving, and graphic-text recognition with teaching, teaching, and research, it can accurately restore the trajectory of students' learning behaviors, collect and analyze teacher-student behavior data scientifically, and achieve self-adaptive precision. Teaching and personalized learning help managers supervise and make scientific decisions comprehensively, promote education informatization, and advance educational equity. Regarding hardware, the platform provides each teacher and student with a tablet, as well as a smart pen and several digital texts for students. Test questions and school-based curriculum resources of the highest caliber (Zhao Shun& Hu Libin, 2019).

5.3.7.1 Realize handwriting recognition, big data collection and analysis.

Based on the Internet of Things-developed digital pen, students retain the customary practice of writing freely on their assignments. The system digitizes and transmits the penmanship on the

thesis to the computer. Conduct data analysis in the background（Xu Zhikai, 2021, 26). Figure 16 depicts the digital stylus and digital notebook that students use to complete assignments and take notes.

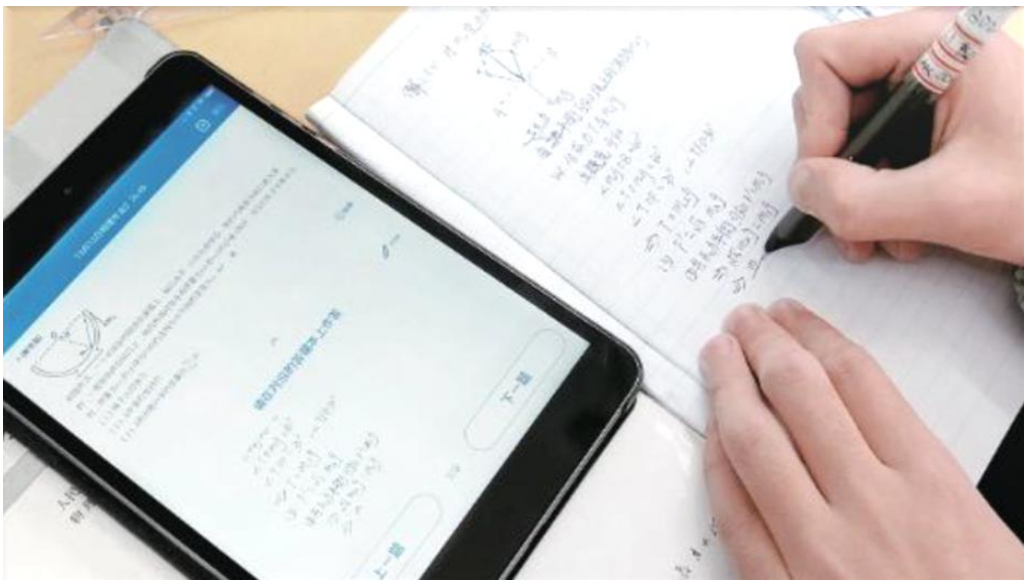

Figure16.digital pen and digital book (Ailearn Smart Learning Platform)

5.3.7.2 Implemented the methodology to grade student assignments

With the assistance of a highly accurate handwriting recognition system and a robust AI system, the system for correcting assignments has been fully realized (Xu Zhikai ,2021). The system will complete the correction of the student's handwritten assignment within a few minutes, and can also correct each step with an accuracy of greater than 99 percent. Figure 17 depicts the traces of the Ai Learning smart education platform system correcting student assignments.

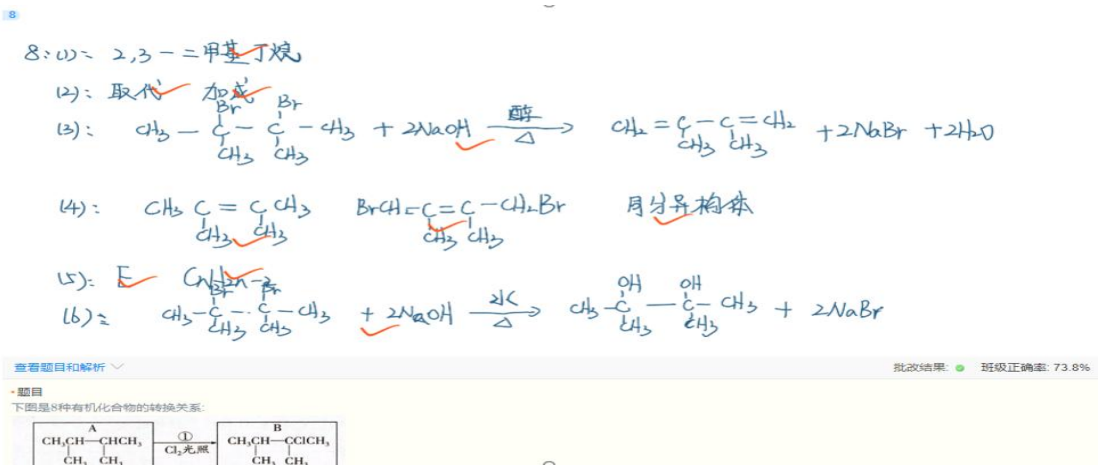

Figure 17.AI Smart Education Platform System Correcting Student Homework (Ailearn Smart Learning Platform)

5.3.7.3 Significantly improve the quality of teaching

Unexpectedly, through the continuous polishing and iteration of front-line teachers, students, and technology companies, this system has progressively integrated into the entire class before and after class. Through it, teachers can not only assign homework to students, but also learn about the mastery of knowledge points by individual students through the homework of each student, and at the same time know the overall homework and exam situation of the entire class, presented to the teacher in real time through big data integration (Zhao Shun& Hu Libin, 2019). Tablet devices are equipped with digital pens and digital journals for students, allowing them to upload their work to an online terminal and receive immediate feedback from their teachers. Importantly, the AI system will autonomously generate a set of incorrect question books for students using algorithms based on their errors. In this set of incorrect question books, in addition to the exercises that students did incorrectly in the past, the AI system will also calculate the relevant knowledge points that cause students to make errors based on the artificial intelligence knowledge map, and match them with corresponding test questions, thereby assisting students in avoiding future errors. Students evaluate their mastery of pertinent knowledge points, assist one another in identifying knowledge gaps and omissions, and draw inferences from a single instance. The value of the Ai Learning Smart Education Platform among teachers and students has been extensively acknowledged. Students' independent learning ability and information literacy, as well as instructors' education information operation and mixed teaching design ability, have been significantly enhanced, along with the teaching effectiveness. Figure 18 Smart learning evaluations generated automatically by the smart campus platform for each class in senior year (Xu Zhikai ,2021).

Figure 18.Smart Learning Evaluation (Smart Campus Basic Platform of Beicai High School Affiliated to Shanghai Maritime University, 2023)

Overall, the school improves the level of computerization in school education by building a smart learning platform. It also looks into how to promote the realization of education management, education, and teaching based on big data and artificial intelligence models, and it works to solve the omnidirectional interaction of campus teaching and the completeness of the campus environment. In the end, the high-efficiency coordination of perception and campus management, as well as the individual convenience of campus life, will lead to the creation of a smart campus-smart classroom that is unified, has advanced technology, covers the whole campus, has in-depth applications, is efficient, stable, safe, and reliable.(Zhu Xiuhua, 2020).

6 ADVANTAGES AND CONSTRUCTION PROSPECTS OF SMART CAMPUS SYSTEM

6.1 Summary of the benefits of an Internet of Things-based smart campus system

6.1.1 The ability to fully perceive the surrounding environment

The smart campus relies on Internet of Things technology to capture and comprehend campus-wide information comprehensively. On campus, the Internet of Things deploys a large number and variety of sensors; each sensor is a source of information, and the information content and format captured by different sensor types are distinct. Real-time data is obtained by the sensor. It captures environmental data at regular intervals and continually updates the data. It can rapidly process, respond, feedback, and process various system information to assure a high degree of real-time operation across the entire smart campus system. There are two components to the smart campus' overall impression. One is that sensors can perceive, capture, and transmit data about people, equipment, and resources at any time and in any location, as well as learning situations. Schools, for instance, can easily complete teacher-student identification and student attendance management with the help of various sensors that can detect personnel activities, including personal voice and temperature, monitor and manage professional teaching environments and living environments, and can be connected to the network transmission layer to implement control. Abnormal situations and hazardous occurrences can be managed in due timem (Yurinova, E.A., Byrdina, O.G. & Dolzhenko, S.G, 2022).

6.1.2 Ability to connect seamlessly

Connectivity is the Internet of Things' foundation. Whether it is a private network, wireless, wired, or sensing objects, they must reflect the "connected" state and be connected to the Internet in order to accurately represent the Internet of Things. According to the International Telecommunication Union, IoT "connectivity" has four dimensions. The first is the connectivity of any time, the second of any location, the third of any object, and the fourth of anyone. The Internet of Things-based smart campus enables the connection of all software systems and hardware devices. After information has been detected, it can be transmitted rapidly and in real time. The management, service, and educational functions of the campus can be interconnected and integrated. Using intelligent campus services The platform connects all information and items on campus, recognizes the interdependence between people, people and things, and things and things, and is intended to serve instructors and students. For instance, the information database can quickly respond to a student's request for admission to a school, while the access control system and the alarm system work together to determine the student's identity and either open the access control or prevent students from entering through remote management (Wang Aijun, 2023).

6.1.3 Data Analysis and Processing Capabilities

The smart campus of the Internet of Things integrates big data into all aspects of the campus through the network data cloud platform using cloud computing. The cloud computing platform is equipped with a robust data analysis and processing system that can analyze and process the data information generated by the objects perceived in the campus environment, guarantee the data's veracity, and return the processed data results to the user. It is characterized by high performance and efficiency. In this way, the Internet of Things smart campus utilizes the big data environment to delegate a large number of repetitive tasks that require manual operations to the computer, thereby reducing the intervention of personnel and the number of non-teaching personnel, such as those responsible for student performance analysis, growth evaluation, security patrols, and fixed assets. Verification, etc., no longer necessitate a large number of personnel and increase the management's timeliness and precision (Du Xuejuan, 2023).

6.1.4 Realize smart education and teaching management

First, IoT technology can be used as a method and tool to improve education and teaching, such as by utilizing IoT sensor technology, augmented reality technology, virtual reality technology, etc. to make complex learning content perceivable, quantifiable, and visualized. Second, IoT technology can aid in the continuous optimization and improvement of education and teaching. By accumulating IoT sensor data such as credit card consumption, attendance, and face recognition, for instance, it is possible to monitor the real-time class attendance rate, the location of absent students, and the content of student lectures. On-site feedback to promote the implementation of the concept of teaching students according to their aptitude; third, Internet of Things technology can improve the teaching quality evaluation, supervision and support system, for example, through the application of Internet of Things technology, collect the status data of the entire process of students' learning and life at school, and conduct Intelligent analysis of classroom status, quantitative evaluation of classroom performance. Fourthly, the Internet of Things technology can actualize the connection between the physical space and the digital information space, allowing for a more effective integration of the real space and the virtual learning environment. The integration of the Internet of Things and the existing teaching platform provides a vast space and intelligent administration services for activities related to distance practice teaching. The smart campus supports the expansion of the resource environment, allowing students to transcend the limitations of textbooks; supports the expansion of the time environment, allowing learning to expand from class to class; and supports the expansion of the space environment, allowing effective learning to take place in real environments and virtual situations (Du Xuejuan, 2023).

6.1.5 Realize smart campus management

The Internet of Things can optimize campus administration and create a secure, comfortable, and intelligent campus environment. Using intelligent sensors, for instance, it is possible to monitor the campus's air quality in real time. Additionally, some institutions use temperature smart control sensors to adjust the laboratory temperature. When the laboratory's temperature is not optimal, the temperature smart sensor will issue a command to modify the temperature to the optimal level. In the process of constructing a smart campus, sensor and intelligent processing technology are combined, and network and cloud computing are used to analyze, process, and process the core data from the massive information obtained by the sensor, as well as to implement remote intelligent control of objects. For instance, the apartment access control management system on a university campus requires the accumulation of student information and the default facial features of a student (such as eye distance and forehead width). When the student attempts to enter the apartment, the system can identify him or her based on the information stored in the database, and a decision is made based on the identification result. When a pupil attempts to enter the apartment, the access control system collects its information and then compares it to the information in the database. After presenting valid identification, the student can enter the apartment; otherwise, the door will be locked and an alarm will sound (Du Xuejuan, 2023). This demonstrates that the Internet of Things can be used to automate and enhance the intelligence of campus management (Wang Aijun, 2023).

6.1.6 Realize a low-carbon ecological campus environment

First, through various sensor devices and identification tags, the Internet of Things technology can systematically organize and analyze resource information more effectively, shorten the time required for information transmission, reduce unnecessary resource waste, and utilize resources scientifically to achieve a variety of goals. To accomplish the ultimate objective of resource sharing, the exchange of educational resources between schools makes full use of a variety of high-quality educational and teaching resources. Establish a wireless environmental monitoring and management system in the smart campus environment. Utilize integrated sensor technology and cloud monitoring to build a campus green information system. Promote the use of clean energy and energy-saving technologies. carbon-neutral campus. Third, during the construction and daily maintenance of smart campuses, intelligently and efficiently classify waste from various sources using hybrid sensors and image classification algorithms, simplify the management of the entire garbage cycle, and increase the recycling rate to decrease waste Recognition latency and energy consumption (Wang Aijun, 2023).

6.2 Prospects for Internet of Things-based Intelligent Campus Construction

The application of the Internet of Things in the construction of smart campus systems is still in the exploration and development phase at this time, but there have been trends such as intelligent sensing equipment, Internet of Things access to private networks, platformization of resource

integration, standardization of Internet of Things business support, and intelligent business applications (Chen Yongjie, 2022, 49). The smart campus brings great convenience and benefits to the teachers and students of the school, but we should still recognize some problems in the construction of the smart campus of the Internet of Things, not only the lack of unified standards for the overall planning of the smart campus, but also the mobile Bottleneck issues in the development of new technologies such as the Internet and the Internet of Things, as well as many other issues such as funding, talent, and infrastructure. Next, the author discusses the possibility of Internet of Things-based smart campus system construction through investigation and research.

6.2.1 Scalability should be considered

Scalability implies that the construction of the smart campus system should take into account future changes and ensure that there is space for optimization based on the routine delivery of services such as management and education. The Internet of Things-based construction of a smart campus system is a long-term, ongoing process. If subsequent protocol expansion and quantity expansion are not fully accounted for at the outset of construction, this will impede the development of subsequent construction work. The number of pupils enrolled in some colleges and universities is increasing annually, and frequently exceeds 10,000 or even tens of thousands of individuals. The administration of large colleges and universities must improve their data processing and interaction capabilities. Nonetheless, when data sources are heterogeneous and multiple data are transmitted via distinct channels Concurrently, it is necessary to evaluate the Internet of Things information's real-time and synchronous processing capabilities. Consequently, when constructing a smart campus system, it is necessary to consider potential future application scenarios, to formulate a construction plan that incorporates future development, and to account for a certain number of access points. , bandwidth, power supply for apparatus, and other aspects of redundancy (Du Xuejuan, 2023).

Moreover, controller area network CAN system technology and the requisite wired and wireless communication technologies can be used as Internet of Things construction and application aiding technologies. The CAN bus system, for instance, can process a large quantity of information synchronously, thereby avoiding the problem of mutual interference, and the transmission of information through independent channels can also improve operation efficiency and resource allocation rationality. If universities' communication requirements continue to grow, the CAN bus system's scalability will increase. In addition to meeting a broader range of communication requirements, the benefits also ensure the Internet of Things' serviceability and support effect for the smart campus system (Chen Yongjie, 2022, 50).

6.2.2 System security should be enhanced

Building smart campus services is predicated on the security of the cloud computing and Internet of Things-based smart campus construction system. Despite the presence of numerous security measures and management system guarantees, there are still numerous security hazards.

First, the vast majority of sensor devices are open to the environment. Outside, there is a high risk of illegal intrusion; second, the sensing data frequently includes information such as user location,

behavior, habits, and preferences, and if it is obtained illegally, it can result in a significant loss of teachers' and students' personal privacy; and third, if the design is completed, there is a high risk of unauthorized access. The Internet of Things platform has incorporated more crucial business management functions and stored vast amounts of sensor data, and its inherent security risks may result in substantial business management losses (Chen Yongjie, 2022, 50).

To enhance the security of the smart campus construction service system, the institution must strengthen its management system, and the following steps can be taken: First, manufacturers participating in the development of the Internet of Things must sign a legally binding confidentiality agreement, and data-using units must apply, be approved, and survive an audit. It is dockable and usable after review. The second objective is to enhance measures of technical support. The "Internet of Things Platform" must implement security measures throughout the entire process, from access to sensing devices to IoT data transmission, storage, and output services. Add protection measures between the Internet and the external network to realize the information security of the smart campus service system. For instance, encryption locks can be implemented within the service system. The third is protection of nodes. Cloud computing and the Internet of Things enable information processing, identification, and command transmission through the transmission and calculation of data in stages. Therefore, by bolstering the security of the information nodes of the smart campus system and ensuring the security and dependability of each node, the information security of the smart campus system as a whole can be effectively ensured. The fourth is the extension of technology. The majority of cloud computing services and smart campus system development are presently provided by third parties, and cloud computing is destined to be complex for campuses to undertake independently (Jason Shi, 2016).

Future smart campus system construction can appropriately strengthen the extension of security technology on the basis of accepting third-party cloud services, so as to cover the cloud and the campus information database, thereby enhancing the security level of the smart campus system based on the Iot (Jason Shi, 2016).

6.2.3 Pay attention to cost control

Data construction has greatly increased the cost. Cost is the direct bottleneck that restricts the construction of smart campuses in schools. During the construction process, we must consider all aspects and reduce expenditures. On the premise of ensuring safety and quality, we should minimize cost expenditures and seek the best Good payback ratio (Jason Shi, 2016).

First of all, choose hardware products with high cost performance. The construction of the hardware infrastructure environment of the smart campus involves many products, the most basic ones are access control, campus network, data center, computer room, broadcasting, monitoring, one-card and other hardware facilities required for daily operation and management. In the construction of hardware facilities, choose products that are suitable for the school's academic situation, and choose products with high cost performance. They are products that can really help the school solve

problems. It is not necessary to choose products of big brands, high configuration, and high specifications (Jason Shi, 2016).

Secondly, choose the corresponding perception means according to the characteristics of each perception object. There are many types of perception objects involved in the construction of a smart campus, and the complexity of the information perceived by each object is quite different, and the requirements for perception positioning are also different. Radio frequency identification technology (RFID), two-dimensional code technology, wireless sensor technology, embedded According to the different characteristics of each sensing object, different sensing means are adopted, such as books, general materials, equipment, etc., which can be identified and sensed by two-dimensional codes and passive radio frequency tags; vehicles, important equipment Active radio frequency tags, satellite positioning and other technologies can be used for positioning and tracking; and some important areas can use smart sensor chips to perceive their surrounding environment and understand their security status. In this way, the corresponding sensing means are selected according to the characteristics of each sensing object, which not only achieves tailoring, but also effectively saves costs (Jason Shi, 2016)

6.2.4 The training of teachers and students should be strengthened

Following an investigation, it was determined that the smart campus systems of many colleges and universities are underutilized, with more than half of teachers and students using the system infrequently and not as an effective daily aid (Huang Tiany, 2022). Teachers and students have not yet fully realized the significance of building a smart campus system, nor do they know what role the development of Internet of Things technology will play in building a smart campus.

In response to the situation described above, instructors and students should first raise awareness of the significance of smart campus design. Schools should focus on promoting the significance of smart campus construction so that all teachers and students recognize that smart campus is an important direction for campus development, unify the ideas of all teachers and students into the action of constructing a smart campus, and ensure the construction of a smart campus. Secondly, the construction and operation of a smart campus necessitates a certain level of information technology literacy among school administrators, instructors, and students. Therefore, the construction of a smart campus must strengthen the training of teachers and students and enhance their ability to use the smart campus system in order to better prepare teachers and students for the future. It is preferable to use the information system to apply the related services of the smart campus to the actual teaching and various recreational activities after class, so that students can enjoy the benefits of the smart campus more fully while also contributing to its construction and organization. The propulsion provides excellent support. The majority of college and university information system users are educators or administrators. Consequently, teachers have an accurate comprehension of it and can operate it proficiently, which has a direct impact on the application

effect of smart campuses. For a smart campus to be genuinely intelligent, it is necessary to cultivate and cultivate a group of intelligent teachers who understand intelligent education and are able to organize intelligent teaching. In order to accomplish this, the construction of a smart campus must empower and encourage the emergence of smart instructors. This is the only way an intelligent campus can become genuinely intelligent (Huang Tiany, 2022).

7 SUMMARY AND DISCUSSION

Incorporating Internet of Things technology into the construction of a smart campus for a school as become a current trend. This thesis describes succinctly the evolution and specific technologies of the Internet of Things technology, as well as its application in the smart campus system, and elaborates on the concept of smart campus and the Internet of Things-based technology. The overall architecture model of the smart campus system was constructed, and the case of Beicai High School Affiliated to Shanghai Maritime University was used to analyze the specific application of building a smart campus based on Internet of Things technology (Zhu xiuhua, 2020). On this basis, the benefits of the Internet of Things-based smart campus and its future development trend are summarized.

The author's investigation is more indirectly and contains numerous flaws. Follow-up research must continue to enhance the construction framework of the Internet of Things smart campus, further validate and refine this framework in conjunction with application cases, and then provide relevant technical personnel and school administrators with ideas. Promote the efficacy, scientificity, and dynamism of IoT technology in the development of intelligent campuses. In addition, further research is required to determine how to dynamically integrate into the construction and development of smart cities and to realize the integration and development of smart campus construction and smart cities. The reform of school education necessitates the support of modern information technology, and the Internet of Things technology, as a representative of modern information technology, can provide more opportunities for the construction of smart campuses, with an increasing number of researchers joining the smart campus. The author will continue to work diligently to make additional campus explorations and research recommendations for the smart campus.

In an era of continuous innovation in information technology, the development of smart campuses is increasingly dependent on Internet of Things technology. Changing the construction and management of traditional campuses through science and technology in order to implement scientific management is an essential aspect of the modern campus. We must correctly understand the smart campus, grasp the correct direction of introducing Internet of Things technology into the smart campus system, create an all-encompassing, multi-level campus perception environment, and reasonably customize the campus management system based on the actual needs of different teachers and students in order to provide teachers and students with personalized Intelligent services and further improve management efficiency.

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This is how to check image copyright: If you search for an image using Google's Image Search tool, then use the Searching Tools and select Access. Select one of the following options: A derivative work means that you have edited the image in question.

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Non-Commercial (NC) The work may be copied, distributed, shown and performed in public and derivative works may be created only when they are not used for commercial purposes.

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The licenses are written with the letter combination CC first. This is followed by a space and a dashed list of abbreviations for license terms. The first of the conditions is always BY, followed by a possible NC and followed by a possible third condition.

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- Attribution – Share-alike (CC BY-SA)
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Example: FIGURE 1. A detail of the Colosseum in Rome (Laamanen 2015, CC BY-SA)

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