Journal of Computing and Electronic Information Management
ISSN: 2413-1660 | Vol. 15, No. 3, 2024

Design of Intelligent Classroom System with Multi-Dimensional Detection using WSN

Haohao Hu

XIDIAN UNIVERSITY
hahahalwv@163.com

Abstract: This paper explores the design of an intelligent classroom system utilizing Wireless Sensor Network (WSN) technology, aiming to enhance teaching efficiency and student learning experience through multi-dimensional detection (environment, behavior analysis, and communication). By integrating Internet of Things (IoT), big data, cloud computing, and other advanced technologies, the system realizes real-time monitoring of classroom environments, precise analysis of student learning behaviors, and efficient teacher-student interaction. The research results indicate that this system can significantly improve classroom environmental quality, provide personalized learning support, and promote effective communication between teachers and students.

Keywords: Wireless Sensor Network (WSN); Intelligent Classroom; Multi-Dimensional Detection; Internet of Things (IoT); Big Data.

1. Introduction

Wireless Sensor Network (WSN) comprises a large number of static or mobile sensors that form a self-organizing and multi-hop wireless network. It is widely used for monitoring environmental parameters such as earthquakes, electromagnetic fields, temperature, humidity, and noise. Recently, with the rise of smart education, the application of WSN in intelligent classroom systems has attracted increasing attention. This paper aims to design a multi-dimensional detection intelligent classroom system based on WSN to improve teaching environments and quality.

While WSN boasts robust applications and markets, it also faces challenges, including limited hardware resources due to its embedded processors and memories, limited transmission capabilities resulting from low bandwidth compared to wired networks, and potential security risks arising from wireless channels, limited energy, and distributed control. Nevertheless, the advantages of WSN outweigh its disadvantages. Its flexibility is well-suited for environments with mobility demands but inconvenient wiring, as seen in schools. Moreover, with advancing technologies and emerging threats, WSN demonstrates a high level of security through enhanced encryption strategies and covert data transmission. WSN is also reliable, avoiding motion-induced damage, and cost-effective compared to wired sensors.

Given these merits, WSN's application in smart education is highly suitable. Smart education relies on IoT, cloud computing, big data, and wireless communication to create an intelligent educational information ecosystem. The development of smart education has received substantial support from the government, leading to well-established facilities and near-universal internet access in universities. Smart technologies have been widely applied in universities, enhancing teaching reforms and constructing exemplary academies and talent training bases nationwide.



Fig.1 Initial Design Objectives

Address potential indoor air quality issues.
Enable students to connect to indoor internet and analyze their explicit learning behaviors (e.g., information search paths, communication paths, problem-solving paths) to

customize personalized learning tasks aligned with their progress. Further, identify hidden associations behind behaviors to accurately predict students' learning paths and trends.

Facilitate teaching behavior analysis, enabling teachers to self-evaluate and improve their teaching skills. This analysis covers pre-class material push, in-class interactive teaching, and post-class summaries, providing big data support for comprehensive analysis and continuous reform of teaching.

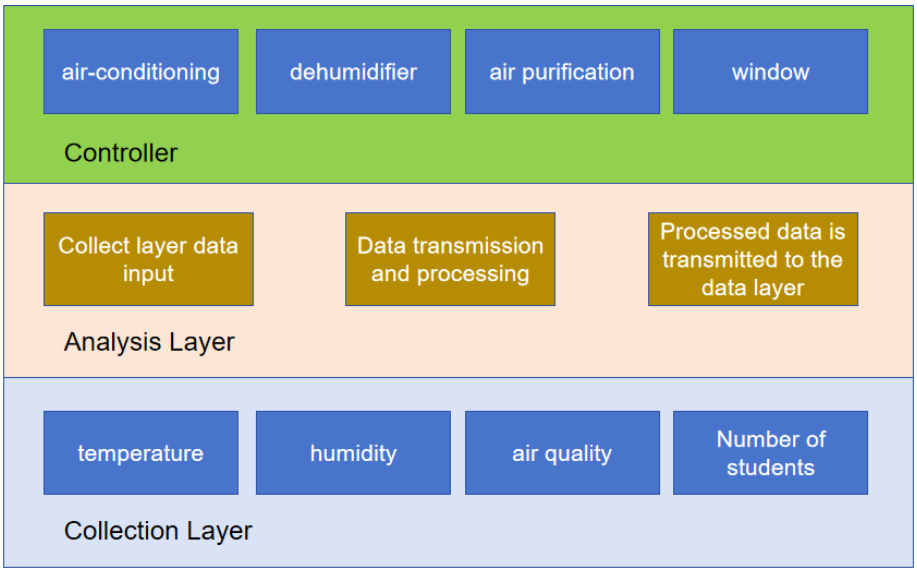


Fig.2 System stratification architecture

2. Literature Review

2.1. The first paper

"The Application of the Intelligent Classroom Based on the Internet of Things Technology"

Using the Internet of Things technology design including intelligent ventilation system, intelligent lighting system, intelligent environment system to control all kinds of mechanical appliances in the classroom, to meet the needs of students and teachers, so that teachers and students in a suitable environment.

Use the Internet of Things technology to design an intelligent access control system, so that students can open the door after face check-in, and then integrate the data and upload it to the attendance system.

Design an intelligent teaching system for students to use e-books, electronic courseware, and submit homework to the teacher online.

Design intelligent security system design smoke sensor, temperature and humidity sensor, earthquake prediction system to ensure the safety of teachers and students in case of accidents.

The hardware includes all kinds of equipment needed by multimedia teachers, intelligent desk, 3D glasses, information sensors and so on.

In terms of software, it applies zigbee technology, cloud computing technology and virtual technology, including its designed intelligent control system, intelligent access control system, intelligent teaching system and intelligent security system.

The system is not mentioned.

This section mainly introduces the overall process of the intelligent classroom control system and the design of each subsystem, including the lighting system, window system, display system, network system, etc. The system uses microCM for data processing and control to realize the intelligent management of indoor environment and facilities. The lighting system realizes the light intensity adjustment through the calibration and control program; the window system conducts the switch control according to the temperature and humidity and other factors; the display system and network system realize the remote control of LCD screen and mobile phone. In addition, the system also includes the number of people statistics and other functions. Finally, the energy saving analysis and numerical statistics experiment, the results show that the system has certain practical and reference value in intelligent classroom management.

“A Study on the Influence of Environmental perception and self-efficacy on Individual cognitive Input in Intelligent Classroom”

This paper mainly answers the following questions: how does the perception of teaching environment and cognitive investment change? How do environmental perception and individual factors affect the cognitive input in specific activities? And what is the influence mechanism?

According to the triangle model of "student-teacher-media" in the teaching process, the interaction between students in the rich media environment mainly involves students and media, students and teachers, students and students. This study focuses on the perception of the teaching environment, mainly including three aspects: media perception, teacher support perception, and social interaction.

In the intelligent classroom environment, learners' perception of usefulness in the multi-screen rich media environment has a positive impact on both deep cognitive input and shallow cognitive input.

In the intelligent classroom environment, teachers' support perception has a positive impact on both deep cognitive input and shallow cognitive input. The significant positive relationship between teacher support perception and cognitive input appears, that is, the higher the level of teacher support perceived by students, the more cognitive investment in learning.

Impact factors of college students 'classroom learning input in the intelligent classroom environment. It is found that social interaction has a significant impact on students'

cognitive input.

Hardware aspects of multi-screen display, electronic whiteboard, projector, camera, student mobile terminal, etc

Software uses the Internet of Things, cloud computing, big data analysis and other technologies to seamlessly integrate physical space and resource space, which can provide learners with appropriate learning resources and tools, automatically record the learning process and evaluate the learning results, so as to promote learners' effective learning.

This paper reveals the intelligent classroom self-efficacy in the environment, teaching environment, the relationship between perception and cognitive input, and illustrates the importance of students 'learning efficiency, the research object is mainly college students, and using the questionnaire survey demonstrates the intelligent classroom environmental change and affect the students' cognitive investment change brings many benefits. In terms of detail, this experiment noted that due to the lack of content, content separation, in terms of content, generally give priority to with multiple screen display, reveals the intelligent classroom environment self-efficacy, teaching environment perception and cognitive input, and combining social cognitive theory and experience sampling method, provides a research framework, used to capture learners in the specific situation of individual, environment and behavior dynamic change, to explore the different levels and size of the change of individual learning law and influence mechanism.

2.2. The second paper

“The Change and Classification of Interactive Behavior in the Intelligent Classroom Environment”

This paper research direction mainly focuses on intelligent classroom environment teaching interactive behavior change, clarify the intelligent classroom environment teaching interactive behavior division principle, analyzes the main types of teaching interaction, interactive teaching efficiency to improve the intelligent classroom environment optimization path, stimulate students' learning enthusiasm and initiative, play a intelligent classroom environment for teaching and learning.

Intelligent classroom pay more attention to achieve more convenient and natural teaching interaction process, pay attention to the traditional classroom teaching process highly structured, immobilized, in addition to the particularly important problems, teachers are reluctant to break the good teaching link designed in advance, students questions difficult to get instant solution, interactive problem of the lag. In the intelligent classroom environment, examining interactive behavior change and classification is the core issue that should be considered in teaching interaction. The analysis of interactive behavior change, division basis and interactive behavior types can show that the teaching interactive behavior in the intelligent classroom environment is rich in types, diverse forms and multiple subjects, which develops the teaching interaction in the non-intelligent classroom environment, and gives play to the role of the intelligent classroom environment in promoting teaching and learning.

This paper discusses the teaching interactive behavior in an intelligent classroom environment. First of all, it is mentioned that teachers and students should be able to express their emotions and cooperate and communicate happily, break the monopoly of teacher interaction, and create an open teaching interactive ecology. Secondly, the timeliness of the teaching interaction is discussed. In the non-intelligent classroom environment, teaching interaction is often asynchronous, which leads to students' questions can not be solved in time and affects the learning effect. In the intelligent classroom, teachers, learning peers and intelligent devices constitute multiple subjects, which can realize the immediate feedback of teaching interaction and improve the timeliness and enthusiasm of learning. Finally, the paper mentions the classification basis of teaching interactive behavior in the intelligent classroom environment, which provides a basis for the subsequent in-depth discussion. It is also proposed that the types of teaching interaction behavior in the intelligent classroom environment can be divided into explicit interaction and implicit interaction, direct interaction and indirect interaction, and single interaction and compound interaction. Explicit interaction refers to explicitly planned, structured interactive activities, while implicit interaction affects respondents through suggestive or indirect means. Direct interaction is face-to-face interaction, while indirect interaction requires the intermediary, which is more objective and rational. Single interaction is based on the interaction of a single subject, while compound interaction is a multi-agent and multi-way interaction form, also known as intelligent interaction. In the intelligent classroom environment, teaching interaction has a rich variety of forms and subjects, which helps to promote the development of teaching and learning.

2.3. The third paper

"Intelligent Classroom Detection System Based on Meta-Learning"

This paper adopts the empirical research method, combining the actual scene design and the experimental verification of the intelligent classroom control system. The hardware solution includes single-chip computer, infrared sensor and other components, the software solution covers design software, functional module software, etc., and the system solution involves iOS, Android and other platforms. Applying the MAML algorithm, the YOLO v3 algorithm, the meta-learning, etc.

Meta-learning is the method of learning how to learn from prior experience in a systematic, data-driven way, based on the experience of previous tasks.

MAML algorithm, focusing on the initialization of the model, is used to find sitar, in meta-learning concepts, the performance of different tasks in tasks is biased, and each task is equivalent to doing classification in the neural network, MAML algorithm, after finding a suitable initial value, the time and cost of this process can be reduced.

The YOLO v3 algorithm. The algorithm is predicted in the three prediction feature layers, each using three scales that obtain nine sets of scales through the k-means algorithm. Yolo is fast for detection, easier for deployment, but less accurate for small and dense targets, and is suitable for use in research intelligent classrooms.

Deep-learning needs to learn from 0, that is, a huge amount of time. Meta-learning, on the other hand, mimics the learning process of human learning, first learning a prior prior knowledge and using this knowledge to learn faster and better in new problems., Generate the models with the task.

In addition, the system also integrates the ESP32 Wi-Fi module and the Internet of Things technology based on the MQTT protocol to realize the remote control of light and Windows by the mobile phone. The system effectively reduces the problem of energy waste, and realizes the efficient,

unified and intelligent management of classroom facilities. The network module design uses the ESP32 Wi-Fi module connected to the Internet for data transmission, using the MQTT protocol. The designed interactive interface will display the collected data on the touch LCD screen and the mobile terminal to improve the convenience of operation. The overall design aims to improve the level of classroom energy-saving management and realize intelligent monitoring. The system uses STM 32 microCM to realize intelligent classroom management, including the monitoring of environmental data and the control of facilities, as well as the application of the Internet of Things and WeChat small program. After many debugging and improvement, the design has achieved a good realization in all aspects, which provides a reference for the development of intelligent classroom.

Based on this paper, the Internet of Things technology and the traditional network communication technology are compared:

Hardware scheme comparison:

Based on the Internet of Things technology: using intelligent devices for data acquisition and control, and realizing the interconnection between the devices.

Based on traditional network communication technology: use network card and other traditional communication equipment for data transmission, suitable for control in the traditional network environment.

Software Scheme Comparison:

Based on the Internet of Things technology: involving network modules and routing and other software design, support remote control and data transmission.

Based on traditional network communication technology: conventional network protocols and software modules are usually used, with high transmission efficiency but limited function.

System scheme comparison:

Based on the Internet of Things technology: it can be combined with mobile phones, tablets and other intelligent terminals.

2.4. The fourth paper

"Design of Intelligent Classroom Control System based on the Internet of Things"

This paper adopts the research method based on the combination of experiment and theoretical analysis. By building the prototype of intelligent classroom control system and conducting practical test and data collection, the system design is deeply discussed with the help of literature review and theoretical analysis.

In the hardware scheme part of the paper, a variety of scheme design, including the use of single chip computer as the control core, pure network card, intelligent terminal devices such as mobile phones and tablets. The advantages and disadvantages of each scheme are relatively analyzed. For example, the stability and flexibility of MCU as the control core are good, but the intelligent terminal equipment has the advantages of portability and user friendliness. This paper introduces the design of intelligent classroom control system based on STM 32, which includes self-inspection, environmental data detection and event processing. The subroutine involves the specific realization and control logic of lighting system, window system, display system, network system, number statistics and other functions. Further analysis and demonstration of curtain control, energy saving analysis and numerical statistics, as well as the systematic error analysis. Through the light intensity sensor and the infrared sensor to collect the indoor light intensity and detect the location of the personnel, the lighting system control, the environmental temperature and humidity monitoring and the intelligent control of the Windows and curtains are realized. At the same time, the use of camera and computer vision technology to achieve the statistics of the number of classroom function. Through the ESP32 Wi-Fi module and MQTT protocol, the mobile phone can remotely control the classroom facilities, which solves the problem of energy waste and realizes the intelligent management of the classroom facilities. The final conclusion points out that the design of the intelligent classroom management system is stable, which provides a reference for the development of the intelligent classroom.

In the software part, the paper involves the design software, functional module software, network module, etc., and discusses the role and effect of different software solutions in the system. For the network software, the importance of network card and routing and functions in the system is analyzed.

In the system solution section, it involves the application of system platforms such as iOS and Android. The applicability and performance of these two systems in the intelligent classroom control system are analyzed and compared. The differences in application development and user experience, and the impact on the overall system performance of the different system platforms may be explored.

sum up:

These five papers mainly focus on the cognitive input of learners, teacher support perception, social interaction, and self-efficacy in the intelligent classroom environment. The results point out that in the intelligent classroom environment, teacher support perception, social interaction and self-efficacy have a significant impact on students 'cognitive input. In order to further promote students' cognitive input in this learning environment, attention should be paid to the following aspects:

Interactive platform: The intelligent classroom system can be an interactive platform for designers, providing real-time interaction and feedback functions to help teachers better support students' learning while promoting social interaction among students.

Strengthening teacher support perception: To provide teachers with more tools and resources to support students 'learning, including personalized teaching content and immediate feedback system, to enhance the positive impact of teacher support perception on students' cognitive input.

Improve self-efficacy: by cultivating students' independent learning ability and problem solving.

3. Main Body

3.1. This theory

In this study, the use of wsn multidimensional detection of intelligent classroom, including environmental dimensions, behavior analysis dimension, and communication dimension, the environmental dimension is indispensable in the teaching, college students in class for less teacher interference classroom discipline, so it is easy to be affected by the environment, so the beautiful environment and suitable learning will greatly ensure the classroom efficiency, improve students' concentration in the classroom. The dimension of behavior analysis is more indispensable. Analysis and

processing of the real-time feedback of students in class and giving responses to teachers will be more conducive to improving the effectiveness of knowledge taught in class, giving teachers more targeted suggestions, improving the classroom content, and trying to optimize the same content in different classes. Finally, the communication dimension is also essential. Among the traditional teachers, the communication and interaction between students and teachers is mostly limited to teachers and enthusiastic and cheerful students. The communication dimension realized by wsn will greatly improve the range of samples, help more students to participate in it, and promote teaching and learning.

This study is preliminarily designed to address the following questions:

Solve the possible problems of indoor air by environment; solve the personalized task of learning progress, while the learning behavior path and learning development trend are unclear; finally, pre-class data push, interactive teaching in class, summary and innovation after class, so as to realize the data problem of classroom teaching process.

Interactive platform: The intelligent classroom system can be an interactive platform for designers, providing real-time interaction and feedback functions to help teachers better support students' learning and promote social interaction among students.

Strengthening teacher support perception: To provide teachers with more tools and resources to support students 'learning, including personalized teaching content and immediate feedback system, to enhance the positive impact of teacher support perception on students' cognitive input.

Improve self-efficacy: By cultivating students 'self-learning ability and confidence in problem-solving, enhance students' self-efficacy, and adopt more deep cognitive strategies in the learning process to improve learning input.

Focus on the diversification of teaching resources: the intelligent classroom system should provide a variety of teaching resources and tools, use advanced technology to provide interactive and personalized learning experience, and help students to better understand and apply knowledge.

Strengthen students 'sense of participation: design teaching activities and interactive links to stimulate students' interest and participation in learning, improve students' recognition of the intelligent classroom environment, and thus enhance their cognitive input.

Today's network sensors are wired and wireless, which are the most common in daily life, and in many cases, wired sensors are one of the most reliable systems because they directly connect the sensors to the device that receives input. This means that wired sensors are also the most durable system and do not need to be replaced frequently. However, it should be noted that the wired system requires a lot of space and is much more complex to maintain. For sensor-based design purposes, the size of this burden increases as more sensors are used. Wireless sensors as an alternative, wireless sensors are becoming more common in sensor-based applications. This is mainly because they are cheap to install and easy to maintain. In addition, it should be noted that wireless sensor networks can provide greater flexibility. This makes it easier to adapt the sensor systems to user needs. But wireless sensor networks have more advantages:

Wireless sensor has high flexibility, suitable for mobile needs but not convenient wiring situation, such as crane, mobile bottling equipment, transportation industry, automatic guide vehicle system and monorail conveyor, etc.

Wireless sensors have high security. With the development of technology and the continuous emergence of new threats, the upgrade capability of security maintenance is essential. New encryption strategies and covert data transmission predict that wireless security will surpass wired systems. In addition, in some dangerous extreme environments, such as inconvenient wiring blasting occasions, wireless sensors can ensure the safety of personnel.

The wireless sensor has high reliability. Wireless sensors can avoid damage caused by motion, such as wire bending caused by long drag chain, twisting and breaking of cable caused by rotating motion. At the same time, the fault factor caused by the connector in the wired network is excluded.

Wireless sensors can greatly reduce the workload of personnel. Affected by Bridges, rivers, mountains and other terrain, where cables cannot be built arbitrarily, wireless sensors can reduce labor costs and engineering cycles. When the fault occurs, the wireless sensor maintenance point is relatively concentrated, which can eliminate the tedious affairs of the inspection along the past.

Wireless sensors are cheap. Wireless sensors have a significant cost advantage over the installation, maintenance, troubleshooting and wiring costs of wired sensors.

Considering the characteristics of wsn, such as low cost, numerous nodes and dense distribution, this paper uses wsn for multi-dimensional detection to realize the design of intelligent classroom.

3.2. Each link

Design the impact of environmental factors on education: integrate the collected data with data algorithms and conduct the quality evaluation of indoor inhalable particulate matter according to the results and national standards. Be responsible for the collection of inhalable particulate matter and temperature and humidity data, and send it to the coordinator module via the wireless protocol. The quality of fine particulate matter in indoor air is divided into four grades: excellent, good, medium and poor, and corresponding measures are carried out.

Perfect the design of the sensor: the influence of education After the temperature and humidity data, judge by the management machine, so as to drive the temperature and humidity execution unit to drive the air conditioning and heating equipment, so as to realize the adjustment of environmental temperature and humidity.

Perfect the design from the perspective of teaching: the classroom and the number of the classroom to WeChat small program, convenient students according to their own needs to study the choice of the classroom, not only that, find out how many people also conducive to the classroom teachers class attendance, in the classroom less automatic control window window ventilation, during the small program to tell students how many classroom in the window ventilation.

Design from the perspective of safety: set up the smoke sensor to judge whether it is a fire and whether the fire extinguishing equipment is driven to work.

3.3. Summary

After the above analysis and paper summary, this paper intends to design the intelligent classroom from the following aspects:

3.3.1. Personalized learning experience

The intelligent classroom system can provide personalized learning content and tasks according to students' learning

needs and characteristics. Through learning analysis and data mining techniques, customized learning pathways and resources can be designed for different students to increase their interest and investment in learning. For example, the 360 learning platform creates personalized learning experiences through content customization, learning path design, learning feedback, and social interaction. In addition, the design of personalized learning path can significantly improve the learning outcomes and experience of learners, and experiments show that the average score of learners at the end of the experimental group is significantly higher than that of the control group.

3.3.2. Interactive learning tools

Design learning tools and resources with interactive functions, such as online discussion boards, virtual laboratory, collaborative document editing, etc., to encourage the interaction and cooperation among students, promote learners' active participation and cooperative learning in the classroom, and thus enhance their cognitive input. For example, Kahoot is a gamification platform that provides tools for building interactive exercises and presentations, and has a variety of engagement modules and AI support capabilities for audience engagement. In addition, interactive learning tools such as smart whiteboards, projectors and tablets have been widely used in schools to improve the learning experience.

3.3.3. Real-time feedback system

The real-time feedback system is introduced to help students understand their learning status and performance in time, and adjust their learning strategies and behaviors in time, so as to improve their learning efficiency and quality, and increase students' learning motivation and self-efficacy. For example, Shivo classroom intelligent feedback system combines educational digital hardware and software products to realize the deep mining and application of teaching data. In addition, the classroom real-time feedback system can effectively connect the teachers 'computer terminals and the students' intelligent devices through the mobile network, so that the lecturers can grasp the learning situation of each student in real time.

3.3.4. Supporting teaching tools

Provide teachers with supporting teaching tools, such as intelligent whiteboard, learning management system, etc., to improve teachers' guidance and support ability in intelligent classroom, create a good teaching atmosphere, guide students to participate in learning and improve cognitive input. For example, the intelligent education platform of intelligent lesson preparation and guidance, classroom, homework and examination data to help teach students in accordance with their aptitude can effectively support teachers' teaching work.

3.3.5. Teacher training and support

Provide relevant training and support for teachers, help them better understand and use the intelligent classroom system, effectively interact with students and promote students' learning input, so as to improve the quality of teaching and learning effect. For example, through adaptive software, personalized teaching can be promoted to meet the needs of individual students.

3.3.6. Multimodal learning resources

Provide rich multimodal learning resources, such as video, audio, image, to meet students' different learning preferences. Multimodal learning is an artificial intelligence technology that involves the processing and fusion of many different types of data and information. It has been widely used in the teaching and learning process to improve the learning effect. For example, multimodal large model has gradually become a hot topic in the field of artificial intelligence, and has been applied in the field of education.

4. Conclusions and Outlook

This paper refers to a number of literature on the design of intelligent classroom system, including research on Internet of Things technology, teaching environment perception, interactive behavior change, and provides theoretical basis and practical reference for the design of this system.

Through the comprehensive design of the above aspects, an efficient, interactive and personalized intelligent classroom environment can be built to provide the best learning and teaching experience for students and teachers.

Through comprehensive consideration of the above design principles and continuously improving the function and performance of the intelligent classroom system, it can better support the improvement of students' cognitive investment and promote the realization of effective learning and teaching effect.

In general, the design of the intelligent classroom system should fully consider factors such as teacher support, social interaction and self-efficacy, so as to improve students' cognitive input and learning effect in the learning process. By continuously improving the intelligent classroom system, strengthening the interaction and personalized support with learners, students' investment and learning can be better promoted for growth. In the future, with the continuous development of technology, the system will be further improved and optimized to contribute more to the development of intelligent education.

Reference

[1] Deng Huangyan, Lin Yuwen. Intelligent classroom application based on the Internet of Things technology [J]. Internet of Things Technology, 2022,12 (12): 107-109. DOI: 10.16667 / j.issn.2095-1302.2022.12.030.

[2] Yang Longfei, Liu Yuxuan, Hou Ting, et al. Intelligent classroom detection system based on meta-learning [J]. Information Technology and Informatization, 2022, (06): 113-116.

[3] Lu Guoqing, Liu Qingtang, Zheng Qing, et al. On the influence of environmental perception and self-efficacy on individual cognitive input in an intelligent classroom [J]. Journal of Distance Education, 2021,39 (03): 84-93. DOI: 10.15881 / j.cnki.cn33-1304/g4.2021.03.009.

[4] Huang Weirong, Wu Xianqiong, Hao Yuqiu. Change and classification of interactive behaviors in an intelligent classroom environment [J]. Teaching and Management, 2021, (07): 1-3.

[5] Xue Qing, Zhou Zichuan, Fu Haodong, et al. Design of an intelligent classroom control system based on the Internet of Things [J]. Journal of Jiangsu Ocean University (Natural Science Edition), 2020,29 (02): 94-98.