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Design and implementation of an IoT-based intelligent teaching environment for art colleges

Tao SUN

Guangzhou Academy of Fine Arts, Guangzhou 510006, China

Abstract: With the rapid advancement of the Internet of Things (IoT), the education sector is moving from digitalization to intelligentization. Artistic education emphasizes creativity and sensory experience, where learning spaces must accommodate specific requirements for lighting, air quality, and interaction. However, traditional classrooms lack real-time sensing and regulation of spatial factors and learning behaviors, leading to delayed feedback and inefficient resource use. This study aims to integrate IoT-enabled smart classroom construction with art creation pedagogy by designing and implementing an IoT-based intelligent teaching environment system for art colleges. The proposed system realizes real-time monitoring, creative process tracking, and personalized feedback through multi-source sensing, edge computing, and cloud analytics. Based on an extensive review of existing literature and current practices, the study constructs a system framework and key functional modules, followed by experimental validation in a fundamental painting course. Results show that the system significantly improves environmental stability, teaching efficiency, and interaction quality compared to traditional classrooms. This research provides a feasible technical paradigm for smart learning space development in art colleges and offers new insights into the deep integration of educational informatization and intelligence.

Keywords: Internet of Things; art education; smart classroom; environmental perception; intelligent feedback

1 Introduction

In recent years, digital transformation in education has become a central strategy for higher education institutions. The application of IoT in educational scenarios transforms learning spaces from static physical environments into intelligent systems capable of perceiving, reasoning, and responding. While science and engineering disciplines have already achieved automated attendance, intelligent lighting, and behavior recognition, smart learning spaces in art education remain underexplored due to the nonlinear and personalized nature of artistic creation.

Artistic teaching focuses not only on outcomes but also on the cognitive and emotional processes underlying creation. Teachers must perceive students' emotional states and creative engagement in real time to provide timely guidance. However, conventional classrooms lack the capacity to capture environmental and behavioral data—such as lighting conditions, posture, and drawing dynamics—resulting in delayed feedback and reliance on subjective judgment.

Field investigations in several art institutions reveal three main challenges:

1. Environmental monitoring systems are isolated from the teaching process and lack adaptive feedback.
2. Teachers have limited access to continuous, process-based data on students' creative activities.
3. Facility managers cannot optimize space design or energy efficiency based on objective data.

To address these issues, this paper proposes an IoT-based intelligent art teaching environment. Through sensor networks, intelligent algorithms, and edge-cloud collaboration, the system realizes real-time perception, adaptive regulation, and data-driven feedback for art education. The paper focuses on system design, core technical implementation, and teaching verification, offering both theoretical and practical contributions to smart learning space development in art colleges.

2 Related work

2.1 International research progress

Internationally, research on smart classrooms started relatively early and has progressed from environmental intelligence to the deep perception of learning behaviors and states. The Massachusetts Institute of Technology (MIT) employs multi-dimensional sensing technology to conduct joint analysis of student attention and environmental parameters, establishing a teaching feedback mechanism based on behavioral data. The University of Oulu in Finland has developed a platform that effectively integrates Internet of Things (IoT) and learning analytics technologies, utilizing edge computing for real-time processing and feedback of classroom data. In the field of art education, the University of the Arts London (UAL) integrates IoT technology into creative teaching, constructing innovative digital creation workshops by combining interactive lighting, networked drawing terminals, and remote collaboration systems. Furthermore, the University of Queensland (UQ) in Australia goes a step further by employing voice and posture recognition models to analyze students' learning states, thereby providing teachers with precise suggestions for emotional intervention. These studies collectively demonstrate that IoT technology has transcended its role as a mere environmental monitoring tool and has become a key support for optimizing teaching decisions and enhancing the learning experience.

2.2 Domestic research progress

Since 2020, universities in China have also been vigorously promoting the construction of smart classrooms and have made significant progress in environmental intelligence and control. Liu and Zeng (2025), taking the Beijing Film Academy as an example, built a smart teaching system based on the IoT. This system uses sensor networks and smart terminals to achieve automatic regulation of environmental factors such as lighting, humidity, and air quality, making the teaching environment better suited to the specific needs of artistic creation [1]. Xia (2024) proposed a teaching environment perception system model. This model utilizes multi-point sensing and cloud computing technology to achieve intelligent management of classroom temperature, humidity, and illumination [2]. At the level of system design and implementation, Liu et al. (2019) successfully designed a university intelligent lighting system based on ZigBee. This system can dynamically adjust lighting brightness based on canvas reflectivity and the light sources required for creation [3]. Li (2022) adopted a more macro perspective, exploring how to integrate IoT and digital twin technologies to build a university-level intelligent information service system [4]. Notably, the research by Gu and Zhang (2020) introduced a cloud-edge collaboration architecture earlier, providing important ideas for the model construction and application of smart teaching spaces [5].

However, although domestic research has yielded fruitful results in environmental perception and control, most still remain at the level of regulating single environmental factors. As reflected in the current situation discussed by Sun (2025) regarding the application of the "Smart Classroom" in online art teaching, current research and practice generally lack a deep integration of the artistic creation behavior itself with the teaching feedback mechanism. This represents a key direction for future breakthroughs [6].

2.3 Research gap and innovations

Existing research exhibits three key limitations:

IoT applications mainly target environmental regulation while overlooking the dynamic aspects of creative processes.

Few studies jointly analyze spatial and behavioral data.

Intelligent feedback systems are often limited to data visualization without actionable instructional insight.

The innovations of this study include:

Multi-source data fusion: simultaneous acquisition and modeling of environmental and creative behavior data.

Edge-cloud collaborative computing: real-time processing with cloud synchronization.

Visualized feedback mechanism: graphical analytics and personalized learning reports for instructors.

3 System architecture of the IoT-based intelligent teaching environment

3.1 System architecture

The system adopts a four-layer architecture: perception layer, network layer, data processing layer, and application layer (Figure 1).

Perception Layer: consists of sensors for illumination, temperature, humidity, air quality, and posture recognition, collecting real-time classroom and student data.

Network Layer: integrates LoRa and Wi-Fi protocols for multi-node connectivity and low-power communication.

Data Processing Layer: utilizes edge devices (e.g., Jetson Nano, Raspberry Pi) for local analytics with cloud database synchronization.

Application Layer: provides interfaces for teachers and administrators, enabling visualization of classroom conditions, energy use, and learning analytics.

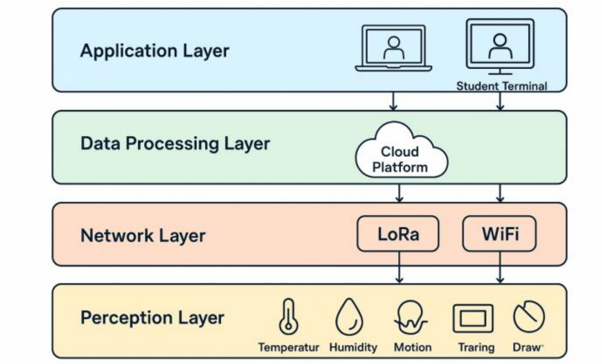

Figure 1. System architecture of the IoT-based intelligent teaching environment

3.2 Functional module design

The system consists of five main functional modules:

Environmental Monitoring and Control– automatically adjusts lighting and air quality for optimal comfort.

Creative Behavior Recognition – analyzes posture, stroke frequency, and creation rhythm.

Resource Management – integrates videos, assignments, and shared materials.

Intelligent Feedback – generates personalized learning suggestions through data analysis.

Energy Monitoring – tracks device status and power consumption in real time.

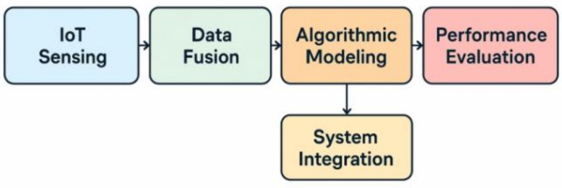

Figure 2. Functional module diagram of the IoT-based smart art teaching environment

4 System implementation and core technologies

4.1 Hardware and communication

The system was deployed in an oil painting studio. The perception layer employed DHT22 temperature–humidity sensors, BH1750 illumination sensors, MQ135 air quality modules, Wacom tablets, and 1080p cameras.

A LoRa gateway connected classroom nodes, using the MQTT protocol for cloud synchronization.

Edge devices such as Jetson Nano performed real-time video processing and posture recognition to ensure low latency.

4.2 Data analytics model

An ARIMA time-series model was adopted to predict environmental parameter fluctuations.

Student behavior data were processed using K-Means clustering and CNN-based feature extraction to identify creative behavior patterns.

The overall performance score for each student S_i is defined as:

$$S_i = \alpha E_i + \beta B_i + \gamma P_i$$

where E_i represents environmental adaptability, B_i behavior engagement, and P_i artwork quality.

4.3 Technical workflow

The implementation workflow is illustrated in Figure 3, encompassing teaching demand analysis, data acquisition, edge computation, cloud analytics, and feedback loops to form a complete closed system.

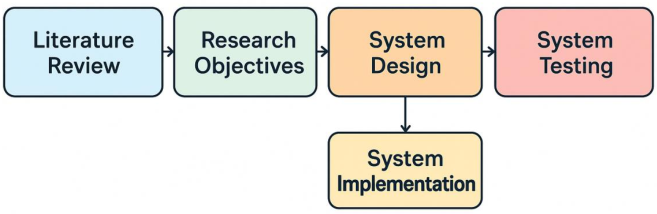

Figure 3. Technical workflow of the IoT-based teaching environment

5 Experimental validation and analysis

5.1 Experimental design

The system was tested in a six-week painting fundamentals course at an art college. An experimental class adopted the IoT system, while a control class maintained traditional conditions.

Evaluation indicators included: environmental stability, teaching efficiency, artwork quality, teacher and student satisfaction.

5.2 Results and discussion

Results indicated that the environmental fluctuation decreased by 17%; teacher operation time reduced by 40%; average student artwork score increased by 10.8%; and satisfaction rates were 94% (teachers) and 92% (students).

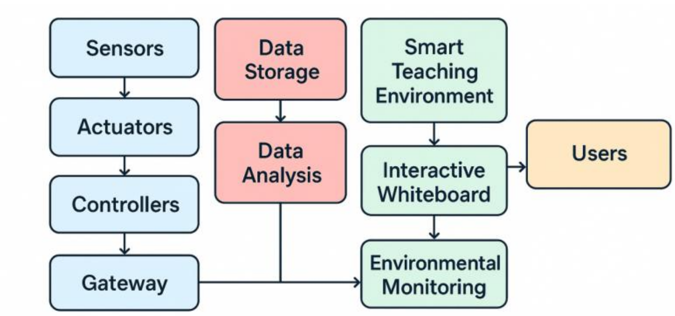

Figure 4. Experimental framework and performance evaluation process

These results confirm that IoT-based systems enhance both environmental stability and creative engagement, enabling a data-supported instructional approach.

6 Discussion and future work

Empirical results demonstrate that the IoT-based system significantly improves classroom comfort, engagement, and instructional efficiency. Teachers reported that real-time environmental and behavioral data facilitated targeted feedback, particularly in lighting adjustment and drawing rhythm recognition. Nevertheless, some limitations remain. Data privacy and authorization mechanisms require refinement; Equipment cost may challenge small institutions; System maintenance depends on technical expertise. Future directions include: expanding multimodal analytics integrating voice, emotion, and eye movement data; enhancing cloud collaboration and cross-campus interconnection for shared resources; integrating VR/AR-assisted critique systems for immersive creative learning; developing teacher training programs to improve data literacy in art pedagogy.

7 Conclusion

This study designed and implemented an IoT-based intelligent teaching environment tailored for art colleges. By integrating multi-source sensing, real-time control, and intelligent feedback, the system significantly improved both learning conditions and creative productivity. Field validation confirmed its practicality and educational value.

The proposed framework not only provides a replicable model for smart classroom construction but also contributes to the theoretical and technical foundation of educational intelligence in creative disciplines.

Conflicts of interest

The author declares no conflicts of interest regarding the publication of this paper.

References

[1] Liu X, Zeng Z. 2025. The new turning point of digitalization in art college education: The role and contribution of smart classrooms—Taking Beijing Film Academy as an example. *Education and Equipment Research*, 41(3): 42-48.

[2] Xia BY. 2024. Design and research of a teaching environment perception system based on Internet of Things technology. *Home Appliance Repair*, 12: 34-36.

[3] Liu XL, Yang W, Hu HC, et al. 2019. Design and implementation of an intelligent lighting system for universities based on ZigBee. *Modern Information Technology*, 3(2): 12-13+16.

[4] Li J. 2022. Research on university intelligent information service system based on Internet of Things and digital twin. *Wireless Internet Technology*, 17: 153-156.

[5] Gu Y, Zhang H. 2020. Research and application of smart teaching space model based on cloud-edge collaboration. *Heilongjiang Researches on Higher Education*, 12: 145-150.

[6] Sun YB. 2025. Innovative application of "Smart Classroom" in online art teaching. *Shandong Education*, Z4: 105-106.