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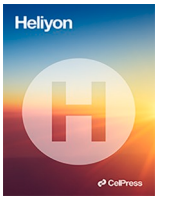

The role of deep learning in the innovation of smart classroom teaching mode under the background of internet of things and fuzzy control

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ABSTRACT

Electronic components are rapidly updated in the context of expanding application requirements, and communication protocols used in combination with various electronic devices are also emerging. On this basis, IoT technology has developed a variety of sensor devices and gateways, which are widely used in cities. In the field of wisdom, applying IoT technology to classrooms can effectively improve the deficiencies of traditional teaching models. Fuzzy control theory is usually based on fuzzy sets in mathematics, and is combined with neural network, genetic and probability algorithms to form a calculation method. Fuzzy calculation has the ability to simplify the system input of a variety of complex variables, and its applications in the field of education are mainly: provide evaluation of teachers' teaching effectiveness. The advancement of science and technology has promoted the change and updating of the teaching mode. With the continuous advancement of basic education curriculum reform and the continuous deepening of classroom teaching reform, classroom teaching is also in urgent need of reform, from traditional classrooms to smart classrooms. Smart classrooms combine advanced technology with teachers' teaching. Through the dynamic data, the analysis instantly understands the student's learning situation, and then integrates it into education and teaching in a targeted manner. This paper conducts a questionnaire survey on the current situation of smart classroom teaching, and summarizes the current teaching problems. Then, combining the Internet of Things, fuzzy control and deep learning technology, from the two aspects of school teachers and students, it is proposed for smart classroom to promote students' learning effect. With its novel and new-style teaching advantages, smart classroom has gradually entered the public's vision and gained the attention and support of the majority of educators. Taking Grand Wisdom Classroom as an example, it uses the "Internet +" way of thinking and the new generation of information technology such as big data and cloud computing to create intelligent and efficient classrooms, realizing the whole process of application before, during and after class, and promoting the development of students' wisdom. Under the mobile Internet model, students and teachers can communicate anytime and anywhere. Combined with the analysis and application of our big data technology, data-based precision teaching becomes possible. In a real sense, learning before teaching can be realized and teaching can be determined by learning.

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1. Introduction

1.1. Internet of things

From the technical point of view of human-machine communication, the main technology of existing human-machine communication is based on the information exchange between human and robot [1]. At present, the number of mobile phone users in the world has exceeded 6 billion, which is not far from the total population of the world, and the room for development and growth is limited [2]. However, the mobile communication application objects related to the mobile Internet of Things technology are more likely to be "things" [3]. Based on the development of IoT communication requirements, IoT technology can be divided into IoT devices and IoT communication protocols according to its characteristics [4]. The current IoT device types mainly include various types of sensors, RFID tags, QR codes, etc., while Communication protocols mainly include Modbus, Bluetooth, Lora, and MQTT. The Internet of Things technology has been applied to all directions in the city during the development process [5]. When it is applied to the teaching field, it can be arranged as smart wearable devices for students and smart acquisition devices for classrooms [6,7]. With the continuous integration of IoT technology and various new technologies, institutions analyze the future development of IoT technology in education, as shown in Fig. 1.

1.2. Fuzzy control

Fuzzy control is a kind of integration of fuzzy set, artificial neural network, probability theory and genetic algorithm, which is used to simplify industrial control, process evaluation and system processing computation. Fuzzy neural network is a kind of learning machine which uses the efficient approximation ability of neural network to find the parameters of fuzzy system composed of fuzzy rules and fuzzy number sets. The fuzzy system and neural network have certain similarity and fit degree in structure, and the fuzzy neural network is formed by combining the characteristics of the two.

Fuzzy neural network is a learning machine that uses the efficient approximation ability of neural network to find fuzzy system parameters composed of fuzzy rules and fuzzy number sets [8]. Fuzzy system and neural network have certain similarity and fit in structure. The characteristics of the fuzzy neural network are formed [9]. In recent years, artificial neural networks have been used by scholars as a tool to study numerical solutions of fuzzy differential equations due to their excellent performance of self-feedback, efficient search for optimal solutions and efficient self-learning, while integrating fuzzy logic and neural networks [10]. The advantage of the fuzzy neural network makes the fuzzy neural network have obvious learning ability, approximation ability and predictive skills, which can not only interpret knowledge objectively, but also have high efficiency in self-learning and quantitative data processing, rapid calculation, and a wide range of accommodation [11]. It meets the generalization requirements, its own operation is flexible and changeable, it has high fault tolerance performance, and it can complete network learning in a short time [12]. The current application of fuzzy control theory in the field of education is mainly related to teaching evaluation [13].

1.3. Deep learning

Although deep learning seems to be an emerging term in recent years, its roots in neural network models and the core patterns of programming with data are centuries old [14]. Since ancient times, human beings have been eager to accurately analyze these data to obtain the know-how of predicting the future [15]. In fact, the data analysis method has also developed into a part of the roots of modern natural science [16]. People are looking forward to mining and extracting its laws from daily observations, and looking for its uncertainties in practice [17]. Usually the output of the system is a series of behaviors, in which case, the single behavior is not important, but the strategy of how to achieve the goal through this series of correct behaviors [18]. There is no optimal behavior in any

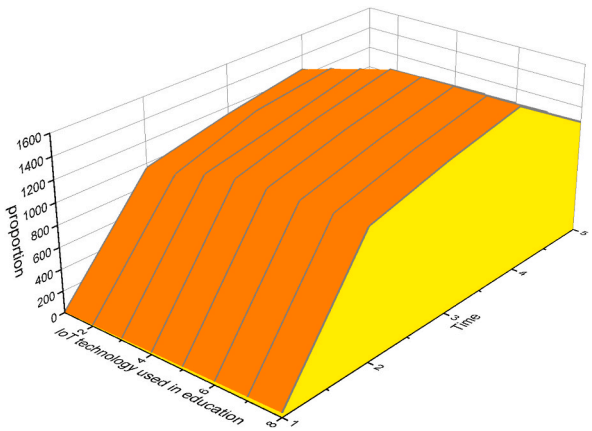

Fig. 1. The proportion of IoT technology used in education.

intermediate process, a behavior is an optimal behavior if it is part of a superior policy, in short, a deep learning program should evaluate the benefits of the policy and learn from the A chain of good behaviors is learned to generate an optimal policy [19]. The way deep learning is applied to smart classrooms is also to generate the best behavioral strategies for teachers or students based on the training set [20–22].

The application of deep learning technology can widely and deeply promote the application and extensive development of smart classroom. Through the integration of Internet of Things technology and big data technology, the teaching reform and integrated development of smart classroom can be better realized. It can better realize the monitoring of teachers' teaching quality and the test of students' learning efficiency.

The smart classroom studied in this paper is an artificial intelligent classroom teaching and learning monitoring and management system based on the Internet of Things and big data. Being able to make full use of existing resources is to realize the comprehensive inspection of the interaction between students and teachers in the classroom, teaching, evaluation and a series of work, which is an important way to promote teaching reform.

At present, deep learning has various development frameworks and tools, as shown in Table 1.

2. Investigation and analysis of the status quo of smart classroom teaching mode

This study was reviewed and approved by Nantong Normal College (approval number: 2022-088). In order to investigate the status quo of the smart classroom teaching mode, this paper distributed 3000 questionnaires to 30 different types of schools and teaching and training institutions, and conducted various surveys on 1000 teachers and 2000 students. The effective questionnaire recovery rate is 99.3%, which is in line with the standards of the questionnaire survey. The main contents of the questionnaire are the smart classroom environment, teachers' teaching evaluation, students' learning interest and evaluation, and the application of smart classroom technology. Among them, smart classroom hardware equipment is the basis for improving classroom intelligence, and the more intelligent equipment, the better the intelligent effect can be achieved. The hardware configuration can also show the current level of classroom wisdom. The hardware configuration of the classroom in this questionnaire is shown in Table 2.

From Tables 2 and it can be found that the multimedia equipment accounts for nearly 70% of the current smart classroom hardware equipment configuration, while the probability of equipping each student participating in the classroom with a personal desktop computer is less than 10%, and the other smart classroom hardware equipment is only 22%.

The teacher's teaching effect evaluation in the smart classroom is the feedback of the overall teaching results in the classroom. A good teaching effect can maximize the value of the smart classroom and allow teachers to experience a sense of accomplishment [23]. The evaluation of teaching effect is often based on the complex parameters, and the evaluation method of teaching effect determines the results of various aspects such as the evaluation accuracy (Table 3).

Through the description in Table 3, we can find that in the evaluation process of teachers 'teaching effect above, the accuracy of students' evaluation and the evaluation of educational administration system is 0.45 and 0.51, while the accuracy of teachers' evaluation by senior leaders is 0.04, which is obviously low. In terms of the complexity of evaluation, the complexity of student evaluation and educational administration system scoring is 0.42 for teacher evaluation and 0.43 for teachers, respectively, while the evaluation complexity of senior leaders is only 0.15, so the higher the complexity of reevaluation, the more accurate the evaluation of teachers. Therefore, by building a more complex and comprehensive scientific evaluation system, the scientific evaluation of teachers can be better and more accurately realized. At present, there are many inconsistent problems in the teaching mode, in the teaching mode reform, teaching quality improvement and other aspects of certain shortcomings, especially in the smart classroom model promotion, technology application and other aspects, there are still some shortcomings, the country needs to provide more sufficient technical and financial support [24].

The ultimate goal of smart classroom is to improve students' learning efficiency by improving classroom intelligence and ensure that students acquire more knowledge [25–27]. Whether the content learned by students is related to their own interests is directly related to the students' subsequent learning interests.

After the above evaluation of teachers' teaching effect, as far as the accuracy of evaluation methods is concerned, student evaluation and educational administration system scoring have higher accuracy for teachers' evaluation, while school leaders' scoring has lower accuracy for teaching evaluation. Compared with the complexity of evaluation, the former two methods are more complex and thus more effective in evaluating teachers' actual teaching ability.

Table 1
Deep learning frameworks and the number of their developers.

Various deep learning frameworks	Number of developers
TensorFlow	51624
Caffe	15955
Keras	11726
CNTK	9564
MXNet	7595
Torch	62312
Theano	5453
Deq-leaming4J	5154
Leaf	4665

Table 2
Classroom hardware equipment configuration.

Num	hardware	allocation rate
1	Smart Multimedia	0.69
2	student desktop computer	0.09
3	other	0.22

Table 3
Evaluation methods of teachers' teaching effect.

Evaluation method	Evaluation accuracy	Evaluate complexity
Questionnaire to students	0.45	0.42
Anonymous Comments on Academic Affairs System	0.51	0.43
Senior leadership scoring	0.04	0.15

It can be seen from Table 4 that the selected three typical students all showed low interest in learning under the learning content of the current smart classroom, which indicates that the teaching content displayed in the current smart classroom does not fully meet the students' learning needs.

The type of technology used in the smart classroom is the key to determining the intelligence of the smart classroom [28]. At present, the smart classroom is still in the conceptual stage, and the degree of integration with the latest technology in the field of scientific research is still low [29].

3. Innovation of smart classroom hardware equipment combined with the internet of things

For example, in the teaching of the intelligent classroom English, installing Promethean interactive tablet can enable students to better interact with learning materials. Through wired or wireless methods, Scanmarker students can quickly scan textbooks, notes, paper and other edited texts into mobile phones, tablets and computers, and Scanmarker can listen to the text content through the reading function. In addition, it can be connected through Ethernet, RS-485 semi-duplex mode, RS-232 serial communication mode, USB link, etc.

Through investigation and analysis, as shown in Table 5, different intelligent classroom technologies are applied in the above five intelligent classroom teaching modes, and the course teaching in different application scenarios is completed with the corresponding design and conception. For students and teachers, different results have been achieved.

The Internet of Things has a wide variety of devices. In order to solve the problem of low configuration rate of smart classroom hardware facilities found in the questionnaire, various wired and wireless network sensors in the Internet of Things technology can be applied to smart classroom data collection, respectively [30–33]. The teaching data of the teachers and the feedback data of the students are collected, and then aggregated to the back-end server [34]. The corresponding developers will develop the corresponding data into unified MQTT data and transmit it to the smart classroom analysis platform for analysis [35]. In the subscription mode, the MQTT protocol is equivalent to the middleman that conveys the message [36]. When the client sends the information message to the middleman, that is, the hands of MQTT, the middleman will send the received message completely to the subscriber [37]. In the process of message transmission, the topic sent should match the topic of subscription, so that as long as the server to which the subscription and the connection are sent is the same address and subscribes to the topic sent by the client, you can receive the various messages sent by the client in real time [38]. For example, the teacher's actions can be obtained through the eye movement sensor, and the data can be compared with the student's seat information, which can be used as a device for analyzing the teacher's attention to each student in the smart classroom. The virtualized scene teaching completed by IoT devices and VR devices is an essential tool for the innovation of smart classroom teaching mode. Although VR equipment is used in the field of education, it will cost a lot due to the number of students. The simulation of the technical solution shows that the smart classroom combined with the Internet of Things technology is more intelligent and technological. By realizing the fast link of simulated MOT devices based on IOT edge, the teaching quality and efficiency of smart classroom can be greatly enhanced. At the same time, edge devices can be added to the teaching process of smart classroom. Through the use of IOT devices, module ids can be added to realize the diversion of classroom teaching content after misoperation. On the other hand, IOT devices support edge intelligent computing, rapidly realize the expansion of classroom teaching, enrich teaching programs, provide SDK, API, point configuration and other services, and provide more comprehensive technical support for smart classroom teaching. The specific situation is shown in Fig. 2.

Table 4
Correlation between students' learning content and personal interests.

Student	Learning Content	Relevance to interest
A	X	0.13
B	Y	0.25
C	Z	0.17

Table 5
Shows the application of intelligent classroom technology in different intelligent classroom teaching modes.

Smart classroom type	Design concept	Application scenarios	Teaching and classroom market share	Good rating from teachers and students
Video multi-screen interactive discussion of the wisdom	Quality recording as the center	Video mode teaching	30%	25%
Interactive discussion of the wisdom classroom	Teaching and learning interaction is centered	Interactive classroom	30%	25%
Fickle seminar classroom	Study groups are centered	Group discussion class	20%	20%
Flexible discussion teacher	The Freestyle discussion is centered	Free speech class	10%	20%
Inquiry-based intelligent classroom	Focus on discussion and inquiry	In-depth research type classroom	10%	10%

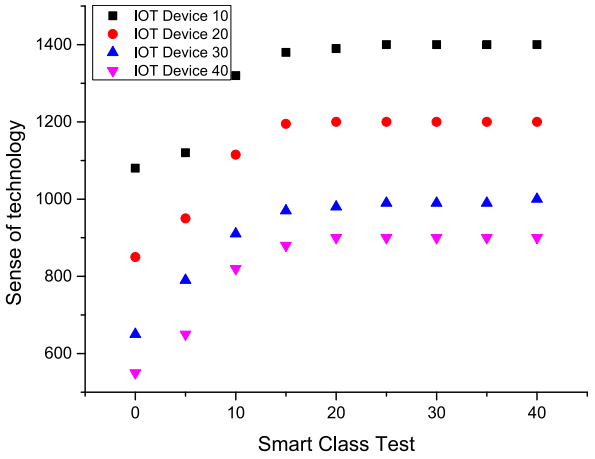

Fig. 2. The sense of technology in the classroom after combining the Internet of Things technology.

4. Evaluation of smart classroom teaching effect based on fuzzy control

Fuzzy control refers to a kind of index system based on certain data, through fuzzy control, giving teachers a certain evaluation. Under the fuzzy index system, it can better realize the evaluation of the actual teaching quality of teachers. Fuzzy control is a kind of comprehensive control method for teachers' teaching quality. Through a certain amount of fuzzy evaluation, it can quantify the teaching index and actual quality of teachers, which is more conducive to the comprehensive evaluation of teachers' quality.

In a domestic smart education pilot school, through the implementation of the smart classroom mode of "Internet + teaching", it has better realized the integration of the Internet of Things system, networked teaching system, smart classroom system, teaching

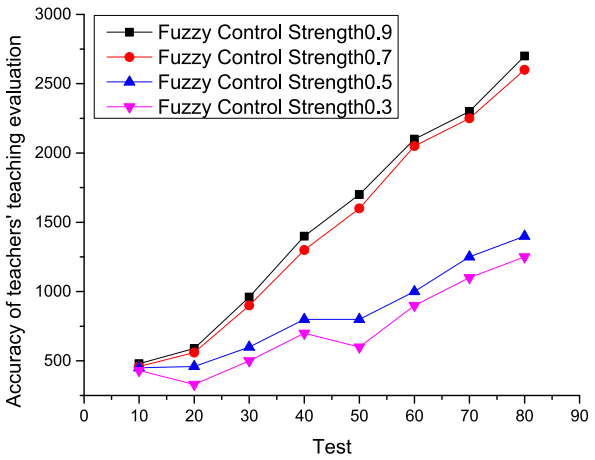

Fig. 3. Changes in the accuracy of teachers' teaching evaluation.

management system, big data teaching quality analysis and feedback system, and interdisciplinary integrated teaching system. It maximizes the practical application of Internet of Things technology in smart classroom.

The fuzzy control comprehensive evaluation method takes fuzzy sets as the premise, can fully consider the different levels of the target object, and reflects the ambiguity of evaluation standards and influencing factors; secondly, it includes the subjective experience factors of individuals, and this method integrates qualitative analysis Compared with quantitative analysis, the conclusions drawn are more comprehensive. Although there are a variety of comprehensive evaluation methods, each method cannot be applied to all fields. For emerging problems, the fuzzy control method has strong applicability and can be used for environmental evaluation, investment benefit evaluation, product quality evaluation, various risk evaluations, market analysis evaluations, etc. For the evaluation of the teaching effect of smart classroom teachers, the comprehensive fuzzy control law will consider the factors more comprehensively, making the obtained results more practical. In practical application, the anonymous evaluation of teachers' educational affairs system, student questionnaire evaluation and senior leaders' personal evaluation and scoring data can be integrated for fuzzy control evaluation processing. In addition, teachers' daily network browsing records can be obtained in combination with crawler technology. In the process of browsing, teachers conduct a comprehensive fuzzy evaluation of the attention characteristics of teaching work, which can make the evaluation results more accurate, and the evaluation process combined with the fuzzy control method will also be simplified. After the simulation of the school's smart classroom technology scheme, found that the smart classroom combined with fuzzy control technology can get more accurate conclusions in the direction of teachers' teaching evaluation, and the school can also provide help for the subsequent employment and promotion of teachers according to the conclusions. The specific situation is shown in Fig. 3.

5. Innovation of smart classroom teaching mode based on deep learning

In view of the low correlation between students' learning content and personal interests, deep learning technology can be combined to recommend different teaching content for each student in the classroom. Even if the smart classroom is the same learning topic, students may obtain the information on their desktop computers. For different learning content, the key data sets in the deep learning system come from students' personal information and their daily performance in smart classrooms. The system can also recommend content based on students' after-school daily concerns and their personalities. When the class can provide each student with the best learning content according to the theme, the utilization rate of the smart classroom will reach the best, and the students' interest in learning will also be greatly improved. It is found that the smart classroom combined with deep learning technology has better effects in the direction of students' learning interests. The specific situation is shown in Fig. 4.

The most important process in deep learning technology is the training of neural network. During the training of neural network, if the training data set is too small and the parameters of the training model are too large, it is very likely that overfitting will occur. Simply put, the training accuracy of the neural network is high and the test accuracy is low. This phenomenon is like training the image of the car to the neural network all the time. If the image of the car is input during the test, the accuracy rate will be extremely high. And if you enter a picture of the aircraft during the test, the test results will be very low.

The specific situation of the Dropout algorithm used in this paper to analyze students' interest in learning is shown in Equations (1)–(4).

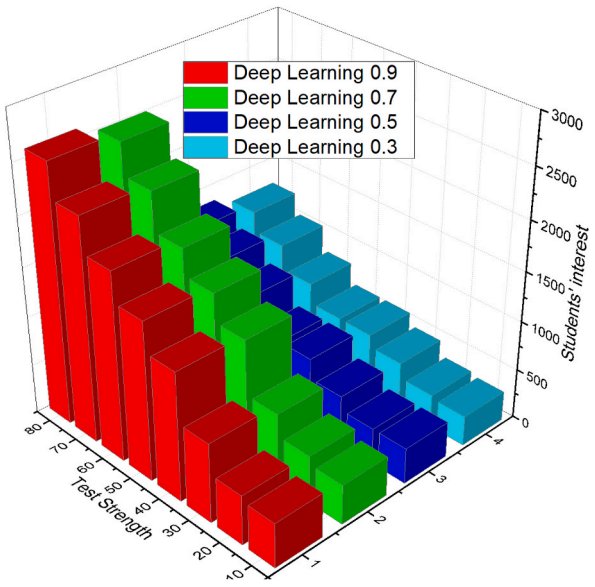

Fig. 4. Students' interest in learning combined with deep learning.

$$E(\text{neural}) = \sum_{\text{node}_j \in c} \left(\sum_{d_i \in D_j} (N\text{ode}_X - K) - N\text{odeProcess}\{N\text{eural}_{i,j}\} \right) \tag{1}$$

$$N\text{ode} - \text{Interest} = \text{between}\{A_{\text{Social}-M\text{edia}}, A - \text{class} - A \text{ inf o}\} \tag{2}$$

$$\lim_{x \to \infty} \left(\text{Rx} - T\text{eaching} - D\text{ata}^{\frac{k!}{k!(x-k)!}} \right) \tag{3}$$

$$\frac{-Student \pm \sqrt{\text{Stu}dent^2}}{2a} = \sum_{stu_j \in Stu_i} \sum_{\in D_j} \left(Interest_{i,j} \right) + \varpi \sum_{d_i \in D} \left(J_i^b - k_i^a \right) \tag{4}$$

Among them, E(.) represents the learning output of the neural network, and K represents the node ignored by the hidden layer, i and j represent the input fitting variables, A represents the student's learning interest set, and R and x represent the test function and error rate, respectively. A represents the total number of smart classroom students.

Using the Dropout algorithm in the case of overfitting often achieves good results. The function of the Dropout algorithm is to ignore some neurons with probability P when training to a certain hidden layer, which can reduce the correlation between neurons. In other words, the neural network will not rely too much on a certain feature during the training process. Of course, the ignored neurons are not really discarded, but temporarily discarded, and these discarded neurons will recover at the end. After the simulation of the school's smart classroom technology scheme, it is found that the smart classroom combined with the Internet of Things, fuzzy control technology and deep learning technology can achieve better results in the direction of teachers' technical richness.

Through the survey of the above changes in the richness of smart classroom technology, we can find that with the continuous deepening of the testing depth of the smart teaching system in the classroom teaching quality, it can better arouse students' interest in learning. Smart classroom provides more comprehensive and sufficient learning resources for students' learning, which greatly increases students' interest in learning [39,40].

In the application of wisdom classroom teaching, we can see from Table 6 that by using different technologies, as well as the Internet of things technology, fuzzy control technology, the application of deep learning technology, can better realize the improvement of classroom teaching quality, and in the process of integration of technology, to learn with students' interest and quality improvement is more obvious.

6. Conclusion

As an important tool to describe system uncertainty, fuzzy control originates from many nonlinear mathematical models in real life, and is involved in statistics, social sciences, biology and other fields. And the complexity of the method, play a leading role in the research direction of fuzzy differential equations, but the solution process of fuzzy control has quite high difficulty and complexity, its exact solution is often difficult to obtain, but the sacrifice of accuracy can guarantee its fuzzy control the low cost and computational convenience of the computational process. The factors for the development of deep learning mainly include three aspects: the first is the improvement of the algorithm, new activation functions such as ReLU and regularization techniques such as dropout. Second is the ever-increasing amount of data. Before the invention of digital cameras and smartphones, the amount of data that needed to be calculated was small. Training a large neural network requires tens of millions of neurons. Without the emergence of new technologies, it is basically impossible to complete this task. Finally, there is the advancement of computers - the use of GPUs. At first, GPUs were not used for deep learning, but for image processing, such as game simulation, rendering, etc. Later, in 2008, people began to use GPU for scientific computing, and in 2012 for deep learning. GPU can be used for parallel computing, which can reduce the original 1-min calculation to 1 s or even tens of milliseconds, and the speed is greatly increased compared to CPU. This paper conducts a questionnaire survey on the current situation of smart classroom teaching, and summarizes the current teaching problems. Then, combining the Internet of Things, fuzzy control and deep learning technology, from the two aspects of school teachers and students, it is proposed for smart classroom to promote students' learning effect. Corresponding suggestions, after the simulation of the school's smart classroom technology scheme, it is found that the smart classroom combined with the Internet of Things, fuzzy control and deep learning technology has the advantages of reducing the burden of teachers' lesson preparation, teachers' teaching evaluation.

By applying MQTT protocol in the teaching process of smart classroom and the evaluation of teachers' quality, it can better realize the transmission of one-to-many teaching information, effectively contact the coupling of application programs, and reduce the network speed with miniaturized transmission, effectively save computing power and reduce the demand for equipment. In the actual teaching process of smart classroom mode, the application based on MQTT protocol effectively integrates the Internet of Things and fuzzy control technology, saves a lot of equipment resources, and improves the teaching quality of smart classroom [41,42].

Ethics approval

The studies titled "The Role of Deep Learning in the Innovation of Smart Classroom Teaching Mode under the Background of Internet of Things and Fuzzy Control" involving human participants were reviewed and approved by Nantong Normal College. The patients/participants provided their written informed consent to participate in this study.

Table 6
Impact of applying different technologies on teaching quality in intelligent classroom.

Technology used in the smart classroom	The complexity of technology	Teaching efficiency of the classroom	Quality of teaching
Internet of Things technology	0.45	1.5	1.5
Fuzzy control technology	0.48	1.4	1.2
Deep learning technology	0.52	1.8	1.9
A variety of fusion technologies	0.96	2.5	2.9

Informed consent

Not applicable.

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Author contribution statement

Xiaoyan Hu: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Data availability statement

Data will be made available on request.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2023.e18594.

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