



## Computer-Aided Design Instruction System Based on BP Neural Network

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**Abstract.** Traditional classroom teaching cannot meet the requirements of students, and the rapid development of computer technology has not been effectively linked with college teaching. Based on this, this study used the BP neural network as the main body to carry out the research of computer-aided teaching system. After analyzing the problems existing in the current computer network-assisted teaching system, based on the characteristics of the course and the educational theory of learning style and the needs of teachers and students, the paper applied a variety of advanced computer technologies to develop a computer-aided teaching system design and implementation. Through research, the system constructed in this paper is close to reality, can be applied to practice, and can provide theoretical reference for subsequent related research.

**Keywords:** BP neural network; computer; auxiliary teaching; system construction; intelligent teaching.

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### 1 INTRODUCTION

With the development of information technology, the education industry has become increasingly important, and it has also brought new changes to teaching. Traditional classroom teaching can no longer satisfy the requirements of students. Nowadays students are growing up in the information environment, so they are not only satisfied with the traditional teaching mode of taking classes in class and doing homework under the class. In addition, the traditional teaching mode is only in a limited class, the teacher-student interaction is relatively small, so there is not enough time to communicate. Although multimedia teaching brings convenience to students and teachers, there are still some problems: the classroom capacity is large, the students are not able to take notes, the difficulty of reviewing the classroom, the difficulty is difficult, and the classroom teaching cannot be reproduced. In response to the above problems, the design of a new type of teaching support system is necessary [1].

Foreign schools started early and developed rapidly, with strong technical support and a stable team to provide services, and our country's schools have just started in this regard. In the process of digitalization and informatization construction of the school, on the one hand, it continuously

develops and implements various application systems such as administrative management, teaching and research and development, and forms a certain field of information development. However, due to the lag of the development process of the entire informatization, insufficient funds, and incomplete theory, the domestic school teaching management system is far from the foreign schools in terms of institutional setup, service scope, service quality and staffing [2].

Foreign education circles generally agree that information technology has a positive effect on education. They try to take advantage of high-speed, high-bandwidth proprietary networks to take scientific integration and provide professional technical support and quality services with a high level of technical team. In the late 1950s, after years of exploration and experimentation, the teaching management model has begun to take shape, the level of information management has become increasingly mature, and the construction of educational informatization has been smooth and smooth [3]. The data shows that the Massachusetts Institute of Technology first made innovations and created a new term, the Digital Campus. From the statistics provided by American education, more than 80% of the schools have the "online course catalog" service function, which can provide comprehensive online courses and teaching materials. At this time, most schools in Europe have also established corresponding information-based teaching management application platforms to facilitate the improvement of teaching management, speed up the exchange of information resources data, and achieve overall scientific layout management [4].

The construction of the campus network in our country is relatively late, and the level of development still has a certain distance from developed countries. Moreover, the development and application of educational informatization does not have a comprehensive and unified overall planning, and there is a phenomenon of "information islands". At the same time, there are loopholes in the sharing and integration of educational information systems, and the phenomenon of repeated construction and resource development is more serious. Due to the different actual conditions of the digital construction of schools, the level of construction is quite different, and the imbalance of education development needs to be solved [5].

The original management information standards are not perfect and lack complete educational management information standards. Many education management departments and schools use their own management information rules according to their work needs. Because of the lack of the same relationship between them and incompleteness is difficult to be compatible, so information exchange has obstacles and errors [6].

The proportion of investment in education is seriously out of balance, and most of the funds are invested in hardware construction rather than software development, and one-sided thinking that hardware updates are the facade of the school is a sign of the improvement of the school's informatization level. But it ignores the fact that if a high-end luxury car has no gasoline, it is a beautiful model and loses its own function. Similarly, a computer without a software system is a soulless shell [7].

In the future, there are 15 business brands, including Learning and Thinking Network, Responsive English and Parents, which are dedicated to building young and quality education, K12 and comprehensive ability, international and lifelong education [8]. EduSoho, an online education website building system based on SaaS model independently developed by Hangzhou Kuozhi Company, was officially released. The system is dedicated to providing corporate, personal and educational institutions with a comprehensive online education solution that includes platform, operations, content and marketing [9]. Later, the company has launched EduSoho network classroom, ES enterprise training, ES smart classroom, education cloud and other products. As of April 2017, there are more than 40,000 enterprises and educational institutions and more than 200 colleges and universities use the company's products and services [10]. In 2018, Beijing Dream Star launched the "Exam Star" to provide customized exams and homework services. It is the first service system in China to provide online exams, and it can meet the test needs of various scenarios such as after-school homework and model test exercises. Moreover, the system can support the computer-side exam and the mobile-side exam, and the mobile-side supports the WeChat exam, and the user can freely choose the exam mode according to the actual situation [11]. With the

development of computers, the computer development of the education industry has begun to grow, so some online teaching platforms have begun to appear at home and abroad. For example, the most famous MOOC [12] abroad, the online teaching platform was proposed by Brian Alexander and Dave Cormier. The basic idea is open education and free access to the public, and it does not limit the number of participants. The introduction of this educational method has enabled many people to learn the courses they are interested in and to play the initiative and enthusiasm of users. As users continue to grow, users can interact, even without the influence of time and geography, and can communicate and learn at anywhere and at any time. The introduction of MOOC has had a major impact in the education sector. Similarly, a good teaching support system in teaching will be a new form of teaching, which is produced by the connection between "program teaching" and computer [13].

## 2 RESEARCH METHODS AND TECHNIQUES

### 2.1 UML Unified Modeling Language

Large-scale system design is quite complex, and how developers communicate with users to understand the needs of the system and how well developers work together requires system modeling. For effective modeling, a standard language is required for description. This language is called a modeling language, and the modeling language can be composed of pseudo code, instance code pictures, and the like, pictures and the like. The modeling language commonly used in development is the Unified Modeling Language UML [14].

UML uses views to divide aspects of the system, each of which describes the characteristics of one aspect of the system. A complete system is described by different views from different perspectives so that the system can be precisely defined. There are five views in UML: use-case view, logical view, concurrent view, component view, and deployment view [15].

**Use case view:** The use case view is mainly a user perspective to describe the function and describes the function that the system should have. The use case view is the core of other views, and its content directly drives the development of other views [16].

**Logical view:** The primary user of the logical view is the design developer, which is used to complete the functionality of the use case view.

**Concurrency view:** The users of concurrent views are mainly developers and system integrators. Its main function is to consider resource optimization, concurrent execution of code, and other processing in the system [17].

**Deployment View:** The Deployment View is primarily designed for three people: developers, system integrators, and testers. It shows the physical deployment of the system and describes the deployment of running instances on the nodes, and also allows for evaluation of allocation results and resource allocation.

The UML view is composed of single or multiple graphs. The graph is the representation of the system architecture on one side. All the graphs together form the view of the system. UML provides 9 different diagrams, which mainly have two main categories: One of them is a static graph, which mainly includes use case diagrams, class diagrams, object diagrams, component diagrams, and deployment diagrams. The second is dynamic graphs, which mainly include collaboration diagrams, sequence diagrams, state diagrams, and activity diagrams. Five pictures are briefly introduced due to limited space [18].

Use case diagram represents a use case link for multiple affiliates outside of the system and other systems.

The core of a class diagram is a class, and the elements in the diagram either belong to the class or are associated with the class.

Object diagram is a variant of a class diagram that uses the same class symbols.

State diagram is an addition to a class diagram that describes all the states and other changed events that a class has.

Sequence diagram represents dynamic collaboration between multiple objects, and the focus is on displaying the sequence of events in which messages are sent between objects.

It has the following features: powerful modeling, user-friendly interface, and visualization, and can support UML use case modeling, static modeling, dynamic modeling, physical modeling, etc. [19].

## 2.2 BP neural network

The BP neural network is a non-cyclic multi-level network and it has wide adaptability. When it was proposed, it soon became a widely used multi-level network training algorithm and played a very important role in the promotion of artificial neural networks. Its structure is mainly composed of the following parts.

### (1) Neurons

Neurons are the most basic building blocks of neural networks. The activation functions used by these neurons must be steerable everywhere, and most designers use s-type functions. For a neuron, the network input is generally a formula:

$$net = x_1w_1 + x_2w_2 + \dots + x_nw_n \quad (1)$$

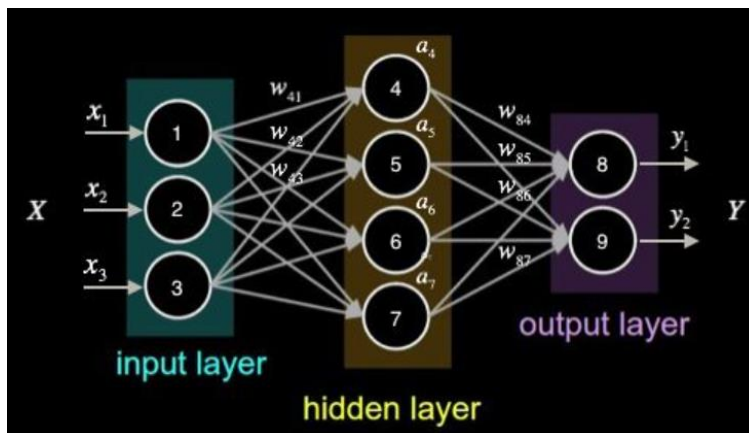
Among them,  $x_1, x_2, x_n$  are the input accepted by the neuron, and  $w_1, w_2, \dots, w_n$  are their corresponding join weights, respectively. The initial input value of net should be controlled as much as possible within the range of faster convergence.

### (2) Network Topology

The input sample data set of a general BP network is set to:  $\{(x, y)\}$ .  $x$  is the output vector and  $y$  is the ideal output corresponding to  $x$ .

The network has  $N$  layers, and the number of neurons in the  $H(1 \leq h \leq n)$ -th layer is represented by  $L_h$ . The activation function of this layer of neurons is denoted by  $F_h$ , and the connection matrix of this layer is denoted by  $W(h)$ . The dimension of the input vector and the output vector is determined by the problem to be solved. The number of neurons in the hidden layer of the network and the number of layers in the hidden layer are related to the problem.

The current research results are also difficult to give a functional relationship between them and the type and size of the problem. The structure of the Bp neural network is shown in Figure 1.



**Figure 1:** Structure of the neural network.

### (3) Momentum term

A momentum term is added during the weight adjustment process, and a layer weight matrix is represented by  $w$ , and  $x$  represents an input vector. Then, the weight adjustment vector expression including the momentum item is  $\Delta W(t) = \eta \varepsilon X + \alpha \Delta W(t-1)$ . The momentum item is a part of the previous weight adjustment amount and is superimposed on the current weight adjustment amount,  $\alpha \in (0,1)$ . The momentum term reflects the adjustment experience and has a damping effect on the change at time  $t$ . However, when the error surface shows severe turbulence, the oscillation trend can be narrowed, and the training speed can be enhanced.

#### (4) Learning rate

The learning rate  $\eta$  is also called the step size. It can be seen from the error surface that  $\eta$  is too small in the flat area to increase the number of trainings, so it is desirable to increase the value of  $\eta$ . However, where the error changes drastically,  $\eta$  is too large to cause the adjustment amount to be too large and to cross the uneven pit, which causes the training to oscillate and the number of iterations to increase. For faster shrinkage, a better idea is to adaptively adjust the learning rate so that it can be increased when it needs to be large, and it can be reduced when it needs to be small. A learning rate is set. If the total error  $E$  is always increased after the first round of weight change, the round modification is invalid, and  $\eta(t+1) = \beta\eta(t)$ . If the total error  $E$  is always decreased after the weight adjustment is modified again, this adjustment is effective in this case, and  $\eta(t+1) = \theta\eta(t)$ .

#### (5) BP network training

The functions used by the BP network for training mainly include the following, Traingd, Traindm, Traindx, Trainrp, Traincgf, Traincgp, Traingb, Trainscg, Trainbfg, Trainoss, Trainlm, Trainbr. These functions have their own unique features. Whether used in the approximation of functions or in the recognition of patterns, these functions can only be applied to a certain aspect of training. Training first needs to determine the samples needed for training, and these samples mainly contain input  $Y$  samples and output  $T$  samples. During the training, the system continuously increases or decreases the weights and thresholds, and finally the function reaches the minimum value. The BP neural network first builds the network and then sets the training algorithm. The most basic batch training function  $Train(\ )$  is called.  $Net = newff(PR, [S_1, S_2, \dots, S_N], \{TF_1, TF_2, \dots, TF_N\}, B_{TF}, B_{LF}, P_F)$ .

Artificial neural networks can increase their processing power based on the experience gained in practical applications and its learning is not completed at one time. The BP network requires the user to hand over all the samples to be learned to it at the beginning. The training algorithm requires that the outermost loop be the precision requirement, and the second is to loop through the concentrated samples. The specific approach is to modify the weight  $W_1, W_2, \dots, W_N$  according to the total effect of the sample set  $\{(x_1, y_1), (x_2, y_2), \dots, (x_N, y_N)\}$ .

The process of learning: Input sample - input layer - hidden layer - output layer; Whether to go to the back-propagation stage is judged; Error back propagation, the error is expressed in some form at each layer, and the weight of each layer is corrected; The error in the network output is reduced to an acceptable level and is carried out to a preset value.

#### Standard algorithm of BP network

In the first step, after the initialization of the network, an error function  $E$  is set, and its accuracy is calculated. Each connection weight is assigned to  $(-1,1)$ .

The second step is to select the  $K$ th input sample and the expected output.

$$\begin{aligned} X(k) &= (x_1(k), x_2(k) \cdots x_n(k)) \\ Do(k) &= (d_1(k), d_2(k) \cdots d_n(k)) \end{aligned} \quad (2)$$

The third step is to determine the number of input and output of the hidden layer.

In the fourth step, the partial derivative  $\varepsilon_o(k)$  of the error function to each neuron in the output layer is calculated by using the expected output and the actual output of the network.

In the fifth step, the partial derivative  $\varepsilon_h(k)$  of each neuron in the hidden layer is calculated by using the connection weight of the hidden layer to the output layer, the partial derivative  $\varepsilon_k(k)$  of the output layer, and the output of the hidden layer.

In the sixth step, the connection weight  $W_{ho}(k)$  is corrected by using the  $\varepsilon_k(k)$  of each neuron in the output layer and the output of each neuron in the hidden layer.

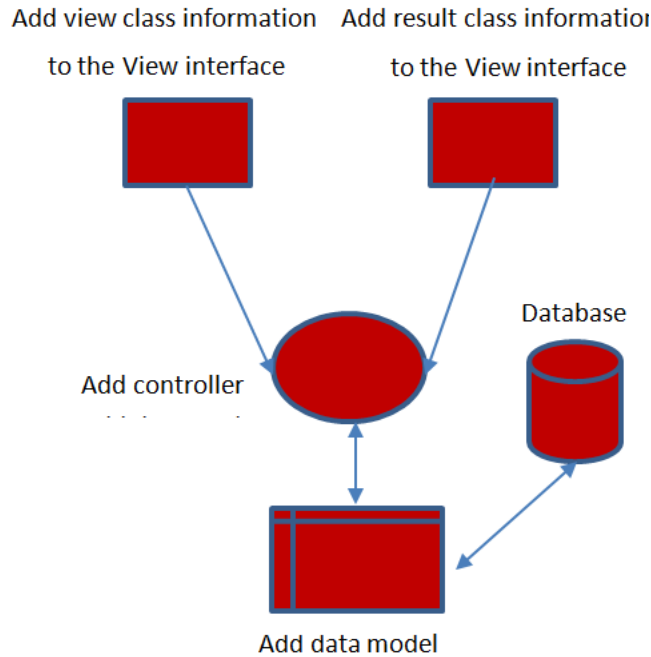
In the seventh step, the connection weight is corrected by using the  $\varepsilon_h(k)$  of each neuron in the hidden layer and the input of each neuron in the input layer.

In the eighth step, the global error is calculated. The global error is  $E = \frac{1}{2m} \sum_{k=1}^m \sum_{o=1}^q (d_o(k) - y_o(k))^2$ .

In the ninth step, the network error is checked to see if it meets the requirements. The algorithm is introduced if the error meets the preset requirements or if the number of learning exceeds the set maximum number of times. If not, the learning sample and the corresponding expected output are re-selected, and the algorithm returns to the third step and proceeds to the next round of learning.

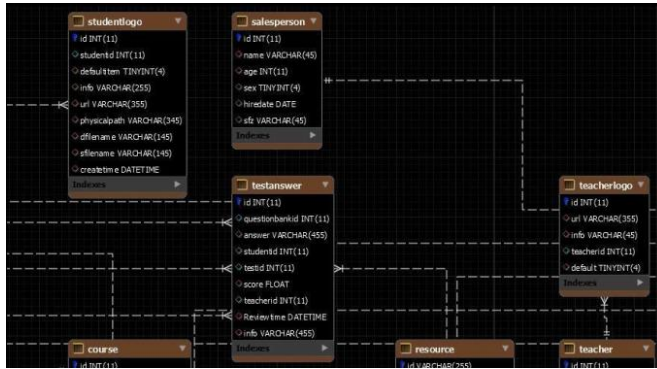
### 3 SYSTEM CONSTRUCTION

As shown in Figure 2, the view of add view class is mainly used to meet the requirements of information entry. It is closely related to the insert operation in the data model, accompanied by a large number of select operations. The interface for add view class mainly includes an information input interface and an information processing result interface, and the second interface does not have to appear, which is different from the query view class.

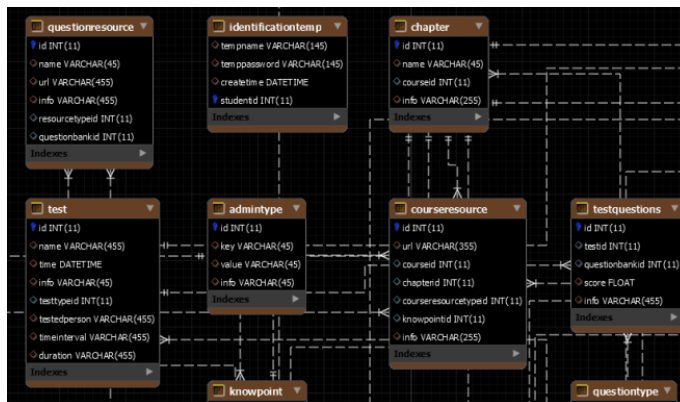


**Figure 2:** Add work flow chart of MVC mode.

The Data Model is an abstraction of real-world data features, or a real-world data simulation. In the database, the data model is used to abstractly represent the real-world application objects. The three elements of the data model are: data structure, data manipulation, and integrity constraints. The system's EER diagram (Extended Entity-Relationship) describes the relationship between the entity class and the database relational table, as shown in Figure 3 and Figure 4:



**Figure 3:** The above figure of System Extended Entity-Relationship (EER).



**Figure 4:** The following figure of system Extended Entity-Relationship (ERR).

According to the needs of the project, the following table needs to be established through the relational database. The administrator table is used to simulate the administrator's two-digit table as shown in Figure 5.

Table Name:  Schema: leiscema  
 Collation: utf8 - default collation Engine: InnoDB

Comments:

Column Name	Datatype	PK	NN	UQ	B	UN	ZP	AI	G	Default/Expression
id	INT(11)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
name	VARCHAR(45)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	NULL
password	VARCHAR(45)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	NULL
admintypeid	INT(11)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	NULL

Column Name:  Data Type:   
 Collation:  Default:   
 Comments:

Storage:  Virtual  Stored  
 Primary Key  Not Null  Unique  
 Binary  Unsigned  Zero Fill  
 Auto Increment  Generated

Columns Indexes Foreign Keys Triggers Partitioning Options

**Figure 5:** Administrator table.



Teacher Logo Table: teacher logo. A relational two-dimensional table simulating relationship of teacher is shown in Figure 6.

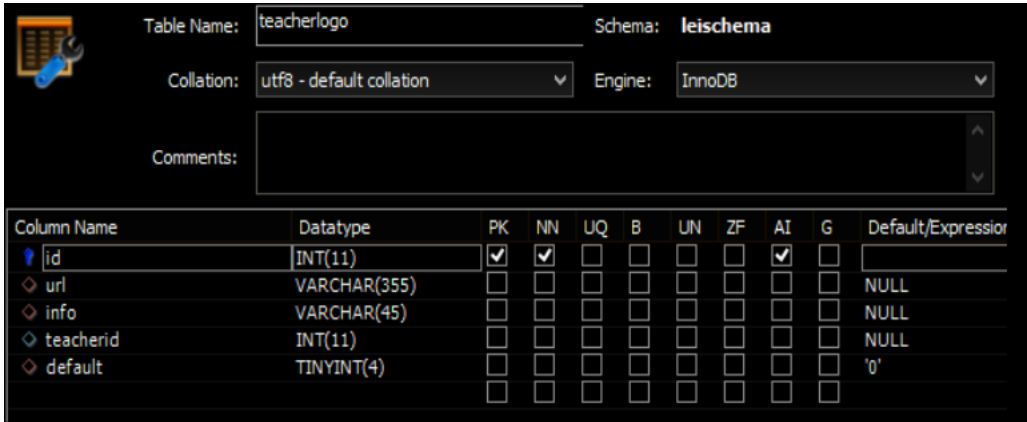


Figure 6: Teacher logo table.

Student table: student. A relational two-dimensional table simulating a realistic student is shown in Figure 7.

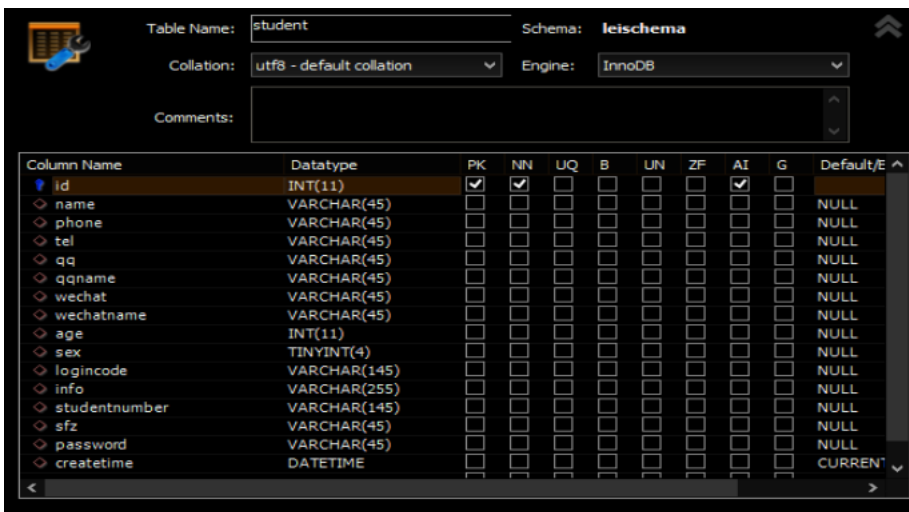


Figure 7: Student Table.

Course Schedule: course, the relational two-dimensional table of the simulation course is shown in Figure 8.

#### 4 ANALYSIS AND DISCUSSION

With the continuous development of the Internet, a teaching system for college students based on the B/S structure is proposed. This system adopts a browser/server architecture and can be easily selected by a network and a browser. It has great flexibility, and the student can learn anywhere and at any time without downloading the client. An efficient and useful online teaching platform must



improve its effectiveness in the teaching process, manage it in a unified manner in teaching management, and play a practical role in the reform of education. It not only improves the ability of students to learn independently, but also can really reduce the workload of academic staff. It is believed that the network teaching support platform will be more and more widely used in the teaching management and teaching implementation of the school, and it will play an increasingly important role.

Column Name	Datatype	PK	NN	UQ	B	UN	ZF	AI	G	Default/Expression
id	INT(11)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
name	VARCHAR(45)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	NULL
typeid	VARCHAR(45)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	NULL
author	VARCHAR(45)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	NULL
info	VARCHAR(2000)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	NULL
coursetypeonelevelid	INT(11)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	NULL
coursetypetwolevelid	INT(11)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	NULL

**Figure 8:** Class Schedule

Among the two subjects in the classroom teaching, the teacher's teaching behavior is more important, and it dominates the classroom teaching process. Each teacher uses a different behavior in class teaching. However, there are several kinds of classroom teaching such as classroom data sorting, theoretical teaching, practical teaching, question and answer exercises, academic layout, practical guidance, stage assessment, and classroom attendance are commonly used. The other subject is a student. In classroom teaching, student behavior is generally passive behavior, which needs to be completed under the guidance of teacher behavior. Commonly used behaviors include classroom lectures, practical exercises, coursework exercises, answering questions, project training, examinations, and attendance responses. In addition to the intuitive classroom teaching behavior, it is especially important to assist students in pre-study and after-school review. To achieve such results, teachers and students are required to complete different behavioral norms. Teachers need to provide classroom instruction to students in some way before class. After the class, the teacher needs to provide the recording resources such as video and audio of the classroom teaching to the students through some means, so that the students can preview the course in advance and review the content of the class after class.

The classroom data collation behavior in teacher behavior can be provided through the Internet application mode to provide students with pre-study through the web application before the lecture, so that the students can understand the classroom learning content in advance and achieve the effect with half the effort. The theoretical teaching and practical teaching of teachers in the classroom teaching can be recorded by technical means and packaged into corresponding video resource files. These video resource files can be provided to students in a certain form, which is convenient for students to consolidate the knowledge in class after class.

The Q&A practice session can provide questions, options, and other content to the students through the application of the Internet + mode. The questions can be from the question bank or temporarily created by the teacher in the system. Temporarily created topics will be entered into the question bank to provide information for future teaching. The practice of the students in the classroom will be recorded as the basis for performance assessment and various types of assessment. The course arrangement can be arranged by the application of the Internet + mode to arrange the questions in the question bank and arrange them for the homework. The title content can also be

from the question bank or published after creation. After the student completes the assignment and submission online, the completion will be processed automatically, and the results will be provided to the relevant statements and statistical system. Project training content can also be deployed and produced via the Internet + application, and features can combine video recording with academic placement. The work of the examination and examination section can be combined with the question bank and related examination system, and the production of the question bank should be flexible and diverse, intelligent processing and other functions.

On the whole, it is completely feasible to convert the existing classroom teaching behavior into the Internet + mode. It will reflect its simple, swift and intelligent side in terms of teaching effects and learning effects. A large amount of first-line information will also be provided for the relevant educational research work.

## 5 CONCLUSION

The classroom teaching assistant software system of colleges and universities in this project consists of three modules: system background management module, classroom teaching assistant software system teacher module, classroom teaching assistant software system student module. Each module follows the traditional classroom teaching method, which transforms the necessary teaching methods into Internet + mode, from offline to online, from handwriting to clicking, from inefficiency to high efficiency, from disorder to chapters, and stores a large amount of teaching and learning information in the form of electronic symbols in the server. After analyzing the problems existing in the current computer network-assisted teaching system, according to the characteristics of the course, the educational theory of learning style and the needs of teachers and students, this paper applied a variety of advanced computer technology to develop a computer-aided teaching system design and implementation.

## 6 ORCID

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## REFERENCES

- [1] Cassady, J. C.; Smith, L. L.; Thomas, C. L.: Supporting emergent literacy for English language learners with computer- assisted instruction, *Journal of Research in Reading*, 2017, 00:1-20, <https://doi.org/10.1111/1467-9817.12110>
- [2] Rogowsky, B. A.; et al: Playful learning with technology: the effect of computer-assisted instruction on literacy and numeracy skills of preschoolers, *International Journal of Play*, 2017, 1-21, <https://doi.org/10.1080/21594937.2017.1348324>
- [3] Gazza, E. A.: The experience of teaching online in nursing education, *Journal of Nursing Education*, 56(6), 2017, 343, <https://doi.org/10.3928/01484834-20170518-05>
- [4] Johnson, C.: Teaching music online: Changing pedagogical approach when moving to the online environment, *London Review of Education*, 15(3), 2017, 439-456, <https://doi.org/10.18546/lre.15.3.08>
- [5] Christine, F.; et al: Faculty perceptions of online teaching effectiveness and indicators of quality, *Nursing Research and Practice*, 2017, 1-6, <https://doi.org/10.1155/2017/9374189>
- [6] Du, G.; et al: Online robot teaching with natural human-robot interaction, *IEEE Transactions on Industrial Electronics*, PP(99), 2018, 1-1, <https://doi.org/10.1109/TIE.2018.2823667>
- [7] Xu, J.: A study of extension strategies of multimedia online teaching platform in sports teaching of universities, *Journal of Computational and Theoretical Nanoscience*, 2017, <https://doi.org/info:doi/10.1166/jctn.2017.6131>

- [8] Badia, A.; Garcia, C.; Meneses, J.: Approaches to teaching online: Exploring factors influencing teachers in a fully online university, *British Journal of Educational Technology*, 2016, <https://doi.org/10.1111/bjet.12475>
- [9] Stanny, C. J.; Arruda, J. E.: A comparison of student evaluations of teaching with online and paper-based administration, 2017, <https://doi.org/10.1037/stl0000087>
- [10] Nordin, N.; Samsudin, M. A.; Harun, A. H.: Teaching renewable energy using online PBL in investigating its effect on behavior towards energy conservation among Malaysian students: ANOVA repeated measures approach, *Physics Education*, 52(1), 2017, 015001, <https://doi.org/10.1088/0031-9120/52/1/015001>
- [11] Kholis, N.; Syariffuddin, Z. M.; Rahmadian, R.: Innovation online teaching module plus digital engineering kit with proteus software through hybrid learning method to improve student skills, *IOP Conference Series: Materials Science and Engineering*, 336, 2018, 012036, <https://doi.org/10.1088/1757-899X/336/1/012036>
- [12] Shelton, L. R.; et al. Developing an instrument for evidence-based peer review of faculty online teaching, *Nursing Education Perspectives*, 2017, 38, <https://doi.org/10.1097/01.NEP.0000000000000130>
- [13] Müge, A.: Professional development in the transition to online teaching: The voice of entrant online instructors, *ReCALL*, 30(1), 2017, 1-24, <https://doi.org/10.1017/S0958344017000106>
- [14] Jianqiu, L.: Construction of real-time interactive mode-based online course live broadcast teaching platform for physical training, *International Journal of Emerging Technologies in Learning (IJET)*, 13(06), 2018, 73-, <https://doi.org/10.3991/ijet.v13i06.8583>
- [15] Jennie, G.; Nicola, B.: Developing pedagogies for a synchronous online course on teaching pre-university mathematics, *Teaching Mathematics and its Applications: An International Journal of the IMA*, 37(2), 2018, 98-112, <https://doi.org/10.1093/teamat/hry010>
- [16] Brinkley-Etzkorn, K. E.: Learning to teach online: Measuring the influence of faculty development training on teaching effectiveness through a TPACK lens, *The Internet and Higher Education*, 38, 2018, 28-35, <https://doi.org/10.1016/j.iheduc.2018.04.004>
- [17] Vega, G. S. A.; et al: Peer evaluation of teaching in an online information literacy course, *Libraries and the Academy*, 17(3), 2017, 471-483, <https://doi.org/10.1353/pla.2017.0030>