Design of Online Teaching System for Architecture Major Based on Virtual Reality Technology

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Abstract. Architecture is one of the basic technical courses of civil engineering. The traditional architectural teaching method ignores the influence of architectural space imagination on teaching, resulting in poor teaching effect and unable to meet the existing architectural teaching needs. Therefore, the design based on virtual reality technology. The new online teaching system for architecture majors was designed. The hardware part designed the GLIPS language developer and the WPF graphics generator. The software part first designed the classification structure of the online teaching platform for architecture majors, and then designed the online teaching function modules based on virtual reality technology. Finally, a database is designed to realize the online teaching of architecture major. Experiments are carried out, and the results show that the designed online teaching system for architecture major has good teaching effect, high efficiency and certain application value.

Keywords: Virtual reality · Architecture major · Online and offline · Teaching system

1 Introduction

In recent years, with the deep integration of disciplines and information technology, the development of virtual simulation experiment teaching is in full swing. In response to the call of the Ministry of Education [1], major universities across the country have successively carried out the construction of virtual simulation experimental teaching centers to improve the level of teaching informatization and promote the open sharing of high-quality teaching resources. Virtual simulation experiment teaching refers to relying on human-computer interaction, multimedia, virtual reality and database technology to provide students with a virtual experimental teaching environment to make up for the defects of real experiments, so as to better meet the requirements of the syllabus.

Foundation engineering is a compulsory professional basic course for undergraduates majoring in civil engineering. It requires students to master the design principles of

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foundation foundations, the design calculation methods and construction techniques of common shallow foundations and pile foundations, and have certain engineering design and planning capabilities [2, 3]. However, the teaching content in the classroom is limited to design principles and design methods. Students have not undergone practical design training and on-site visits to learn, lacking a systematic understanding of various basics, and it is difficult to meet the needs of the cultivation of advanced engineering and technical application-oriented talents. The traditional cognitive practice mode is often limited by the project location, construction conditions and construction period, and simple visiting and learning cannot cultivate students' engineering design ability [4], which has become an urgent problem to be solved in the teaching of basic engineering courses.

The building foundation intelligent selection 3D teaching simulation system trains the independent foundation under the column, the strip foundation under the column and the pile foundation that are required to be mastered in the syllabus [5]. The theoretical knowledge learned in the classroom is put into practical application. Students first enter the basic parameters required for the design into the system, the system will automatically analyze and give students some "friendly tips", the calculation process of the design and the referenced specifications will be fed back to the design through model selection and design reports after the design is completed. Students, students can find out the problems in the design by reading the report [6, 7], and can also observe the structural form and real appearance of the design foundation through the three-dimensional simulation model, which not only helps to improve the students' autonomous learning ability It can also enhance students' interest in learning and strengthen students' understanding and understanding of foundation design. In addition, students can improve their practical ability by operating software and searching for normative provisions [8], adapting to the work of the design department in advance, and helping to improve the core competitiveness of students in employment, which can be said to serve multiple purposes.

At present, scholars in related fields have made research on the online teaching system of architecture major. Reference [9] proposes an implementation method of the Chinese architectural history teaching system based on mixed reality technology. The mixed reality device Microsoft HoloLens is used as the teaching platform of the case. First, based on the collected data, 3ds Max is used to model the wooden structure of the main hall of Baoguo Temple, and an architectural model library is established. Then, the three-dimensional space operation interface of the virtual teaching system is built in unity3D, and the key technologies such as environment understanding and various human-computer interaction are realized by using C# script, and the HoloLens teaching system with building structure recognition and cultural cognition as the core functions is constructed. Reference [10] designed a practical teaching plan for the optimization design of building cooling and heat source systems assisted by virtual simulation technology. The design process of cold and heat sources is divided into multiple stages. At each stage, students can understand the selection method of different design parameters, and can conduct investment analysis and operating cost analysis of different schemes. Finally, the entire system can be simulated according to the design scheme. Obtain the optimal design scheme under different climatic conditions or operating conditions. As a teaching link of the professional course "Refrigeration Technology", the platform uses

virtual simulation technology to connect the relevant knowledge points of several courses in series, and shows students how to use these knowledge to solve some problems in the optimal design and operation adjustment of the cooling and heat source system.

With the rapid development of computer science and technology, the concept of virtual simulation experiment teaching provides new impetus to the teaching reform of geotechnical engineering. A set of virtual teaching simulation system for basic engineering can be developed by combining expert system, decision support system and three-dimensional simulation technology to assist students to complete autonomous learning. This simulation teaching system has the functions of intelligently selecting the basic types of buildings and assisting students in basic design training, and can generate selection and design reports according to relevant industry specifications. At the same time, the system clearly displays the three-dimensional models of various foundations for students, enabling students to observe the building foundation from multiple angles, as if they were on the scene. The application of this platform will make up for the lack of knowledge and practice in basic engineering courses, and achieve the purpose of saving teaching costs and promoting the improvement of teaching quality.

2 Hardware Design

The overall block diagram of the online teaching system for architecture major based on virtual reality technology is shown in Fig. 1.

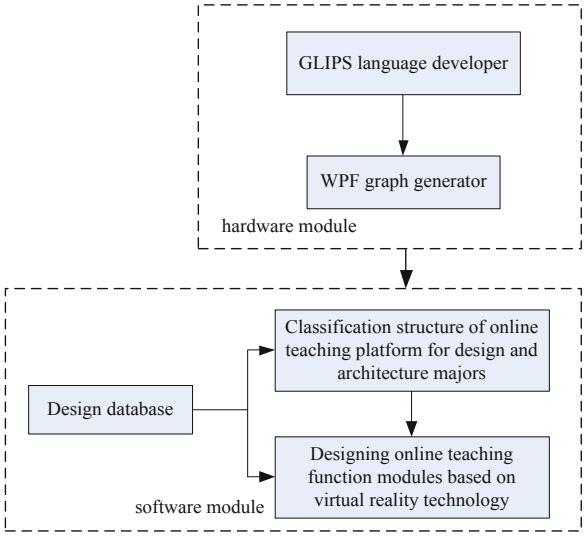

Fig. 1. Schematic diagram of the operation of the GLIPS language developer

2.1 GLIPS Language Developer

The knowledge base is the "brain" of the expert system, and the intelligence of the expert system depends on the quality of the knowledge in the knowledge base. Domain

knowledge is centrally stored in the knowledge base in a certain way of expression, and qualitative analysis is realized under the guidance of a given reasoning strategy. There are four main ways of expressing knowledge: rules, productions, semantic web and frames. Knowledge bases of expert systems usually express knowledge in production rules. The rule is expressed in the form of "IF…THEN…", IF is followed by the antecedent of the rule, and THEN is followed by the consequent of the rule. If the antecedents of the rule are satisfied, the corresponding consequent is executed. Both the antecedent and the consequent can be compounded by logical operation AND, OR, and NOT. Therefore, on this basis, a GLIPS language developer can be designed to carry out basic development of the designed teaching system. The development diagram of the language developer is shown in Fig. 2.

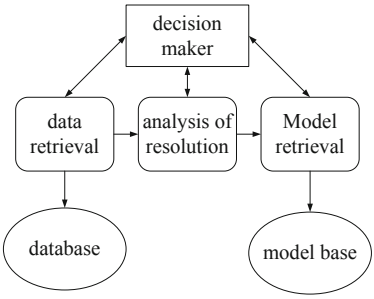

Fig. 2. Schematic diagram of the operation of the GLIPS language developer

As can be seen from Fig. 2, the CLIPS language developer is a widely used expert system development tool. It was first released at the NASA Johnson Space Center in 1986. It is compiled by the C language and supports rule representation, custom functions and object-oriented design. The CLIPS language developer is a typical production system, supports integration with other languages, can be installed and used on various platforms, and uses heuristic solutions that are easier to implement and maintain than algorithms. The CLIPS language developer adopts a forward inference mechanism. When the fact matches the antecedents of the rule, the rule is activated; all activated rules are put into the stack structure according to the established priority; then the rules are taken out from the top of the stack and executed. Corresponding actions, including inserting facts, deleting facts, and printing messages, etc.; until there are no activated rules or the maximum number of cycles is met, a forward inference is completed. The CLIPS language developer has the advantages of easy design, flexible expression, high operating efficiency and good compatibility.

2.2 WPF Graph Generator

WPF Graphic Builder is Microsoft's next-generation flagship user interface framework product, which is part of the NET framework. It makes the division of labor between designers and developers possible. The designers design the visual interface through XAML, and then hand it over to the developers to complete the internal control code. The

WPF Graphics Builder integrates text, controls, and graphics in the same programming model. Before that, developing a Windows application could require the use of several different technologies at the same time. For example, in order to add forms and user controls to the application, it is necessary to use the Windows Forms development tools under the .NET framework; the drawing of 2D graphics needs to be completed by GDI or GDI+; the drawing of 3D graphics is realized through DirectX or OpenGL technology, etc. The emergence of WPF provides a unified description and operation method for documents, multimedia, 2D/3D graphics and user interface, and realizes the seamless integration of different technologies.

As a new generation graphics system, WPF graphics generator has the following characteristics: It implements a vector-based graphics model, so that graphics can be scaled according to the specific resolution of the screen, without losing the quality of the image, which is impossible for fixed-size raster graphics of. The rendering of 3D models is based on Direct3D technology, allowing users to create a library of custom 3D graphics that can be reused in projects, making it easy to integrate 3D graphics anywhere in the application. Extensible Application Markup Language (XAML) is introduced to allow applications to dynamically parse and manipulate user interface elements at design time or runtime, making it easier for users to interact with the UI. The graph generation and development process is shown in Fig. 3.

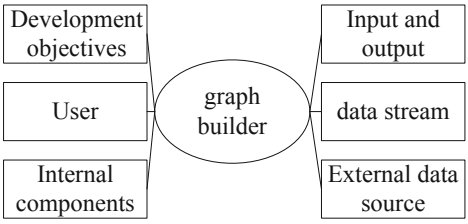

Fig. 3. WPF graphics generator development process

As can be seen from Fig. 3, dynamic layout is adopted, which means that the layout of UI elements on the form is controlled by its parent container and available screen space. UI is driven by data, which is different from the traditional message-driven model. Data is at the core, and UI is subordinate to and expresses data. XAML is a markup language created by Microsoft to realize the separation of UI and logic code, which describes the components and layout of user interface, and is specially used for UI design in WPF technology. XAML can not only design a professional user interface, but also has the advantages of being easy to learn and high development efficiency.

By drawing on the idea of separation of interface design and functional logic, XAML forms a "high cohesion-low coupling" development mode, which forces the logic code to be stripped from the user interface, which greatly improves the development efficiency. A WPF program generally contains both XAML and corresponding program code. The program code is stored in a file with the same file name but with a .cs extension after it. To write application runtime logic, you can add code in this file. It should be noted that XAML is strongly typed, and the interface can only be presented to the user if

the elements and attributes are recognized. This paper comprehensively analyzes the multiple requirements of the system for user interface, documents, multimedia and 3D animation, adopts the latest WPF technology to develop many requirements under the same framework platform, and designs an online teaching system for architecture majors.

3 Software Design

3.1 Classification Structure of Online Teaching Platforms for Design and Architecture Majors

The object model applies not only to programming languages, but also to database, user interface and even system architecture design. The four main elements of the object model are: abstraction, encapsulation, modularity and hierarchy. Abstraction is a basic means to simplify complex problems. The basic idea is to separate the behavior of an object from its internal implementation, and provide the behavior of an object to the outside world through an interface. Abstraction originates from human cognition of the similarity of things. Encapsulation is to hide the details that do not involve the essence of the object, and focus on the realization of the behavior of the object, which is a complementary concept with abstraction. Modularization is to divide a program into modules that can be compiled independently, and each module is connected to each other through interfaces. The goal of modularization is to achieve independent design and modification of modules without affecting other modules. Hierarchy is an abstract analysis or ordering, and inheritance is the most typical kind of hierarchy. When designing complex system software using object-oriented methods, the most basic building blocks are classes and objects. A class abstracts the common structure and common behavior of a group of objects, provides an external view through an interface, and defines the implementation of operations within the interface. The relationship between classes can be established through association, inheritance, aggregation and dependency, and an object is an instance of a class. The state and externally visible activities of an object are described by properties and behaviors, respectively, and objects are distinguished from each other by identifiers. There are two types of relationship between two objects: link and aggregation. The link provides an end-to-end relationship, and the aggregation represents a hierarchical relationship between the whole and the part. Online teaching parameters can be selected according to the hierarchical relationship. The selection formulas are shown in the following (1) and (2).

$$A = \frac{\sqrt[2]{C}}{E} \tag{1}$$

$$F = A\sqrt{E} \tag{2}$$

In formulas (1) and (2), A is the link relationship between teaching objects, and F is the aggregation relationship between teaching objects. C represents the number of people in basic teaching, E represents online teaching indicators, and the basic design class is the base class of the independent foundation design class under the column, the strip foundation design class under the column, and the pile foundation design class. Soil

layer, groundwater, column network, material, and substructure are the data members of the basic design class. The soil layer class can be derived from the soil class and the rock class, and the material class can be derived from the steel bar class and the concrete class. Basic design functions are implemented through instantiation of related classes.

The data members and corresponding operations are encapsulated inside the soil layer class. The data members of the soil layer class include soil layer number, soil layer name, soil layer depth, natural weight, natural void ratio, compressive modulus, foundation bearing capacity characteristic value and The standard value of the limit side resistance of the single pile, etc., the corresponding operations include calculating the saturation weight, calculating the effective weight, and obtaining the liquid index. The layered state of soil is described by the soil layer object array, and the soil layer object array is used as the basic data member of the basic design class.

The foundation design is not only related to the soil conditions of the foundation, but also closely related to the load of the superstructure, the depth of the substructure, groundwater level information, reinforced concrete materials and other factors. In this paper, the above-mentioned influencing factors are taken into account in the basic design class by constructing the relevant parameter class, which is used as the data member of the basic design class. Relevant parameter classes include column network, substructure, groundwater and material. The column class is used to describe information such as the size, load and coordinates of each column, and the information of the entire column network is described by constructing an array of column objects. Substructure parameters, groundwater level information, and reinforced concrete materials are described by substructure class, groundwater class, and material class, respectively.

The common characteristics of shallow foundation design and pile foundation design are abstracted and encapsulated into foundation design classes. The independent foundation design class under the column is inherited from the foundation design class. First, the characteristic value of the foundation bearing capacity is corrected according to the depth and width of the foundation, and then the base bottom area is preliminarily estimated according to the axial load, and then the eccentric distance is comprehensively considered., increase the bottom area of the foundation by 10%–40%, and determine the length and width of the bottom surface of the foundation according to the aspect ratio input by the user, and finally check the bearing capacity of the foundation under the eccentric load. After trial and error, the size of the bottom surface of the foundation was finally determined. According to whether the punching failure cone of the independent foundation falls within the bottom surface of the foundation, different formulas are selected to check and calculate the punching bearing capacity at the junction of the column and the foundation and at the changing step of the foundation. If satisfied, determine it as the final base height; if not, increase the base height and re-check.

3.2 Designing Online Teaching Function Modules Based on Virtual Reality Technology

Virtual reality technology is the combination of virtual and reality. In theory, virtual reality (VR) is a computer simulation system that can create and experience virtual worlds, using computers to generate a simulated environment and immerse users in the environment. Virtual reality technology is to use data in real life, electronic signals

generated by computer technology, and combine them with various output devices to transform them into phenomena that can be felt by people. These phenomena can be real objects in reality, or it can be a substance that we cannot see with the naked eye, which is represented by a three-dimensional model. Because these phenomena are not what we can see directly, but the real world simulated by computer technology, it is called virtual reality.

The building foundation intelligent selection 3D teaching simulation system is mainly composed of intelligent selection and burial depth reasoning, basic design parameter control, basic design model control, 3D graphic display control four components and the system user interface. The intelligent selection and burial depth reasoning are responsible for Intelligently recommend reasonable foundation types and foundation depths for users. The latest "Code for Design of Building Foundation", "Code for Design of Concrete Structure", "Technical Specification for Building Pile Foundation" and other industry specifications and the experience and knowledge of experts in the field of foundation selection are coded and stored in the knowledge base in the form of rules, and CLIPS reasoning The machine determines the facts required for basic model selection through user input and the information obtained from the basic design parameter control components, and performs qualitative inference on the matching of facts and rules according to the priority, and obtains the optimal basic type under the current conditions. In the process of reasoning, it is necessary to read the established rules from the knowledge base, and input the new rules derived from the knowledge base, and also needs the support of the system database. Determining the type of foundation is the premise of foundation burial depth reasoning. The reasonable burial depth range of the current foundation can be determined based on the known foundation type, foundation soil conditions and substructure design requirements. Find the optimal burial depth.

The basic design parameter control is responsible for accessing the basic design parameters and specification coefficient tables. It uses the database management system to provide data support for intelligent selection, burial depth reasoning, and basic design model control components. The system obtains parameters such as engineering geological conditions, superstructure loads and reinforced concrete materials through the user interface, and stores complex and commonly used parameters in the database as static data like the specification tables, parameters, other data can be stored in memory as dynamic data. Because the amount of data involved in the system is not large, and considering the object-oriented characteristics, the Microsoft Access database is selected. Access database has the advantages of friendly interface and easy operation.

The basic design model control is responsible for providing the corresponding model library support for the basic design. The basic design model library uses the object-oriented method to realize the basic design function and engineering algorithm program in the basic design class, which belongs to quantitative calculation. The basic design function is realized in the member function of the class, and the realized functions include foundation bearing capacity check, weak substratum check, foundation deformation check, foundation size calculation and reinforcement calculation. The basic design model objects are defined hierarchically, which can improve the expansibility of the model library. The engineering algorithm includes the calculation program of the

uneven settlement of the column network, the calculation program of the internal force of the beam of the Winkler elastic foundation, and so on.

The 3D graphic display control adopts the WPF unified graphic technology to realize the 3D display and control of the building foundation. The production and rendering of the 3D model is done in the 3D Studio Max software. The designed model is exported to .obj format, and then imported into Expression Blend for animation design and rendering. Finally, the display of the 3D model is realized through the WPF background code control and perspective changes. The system user interface is responsible for the interaction between the system and the user. The user's operation behavior is transmitted to the overall system operation control through the user interface, and the corresponding components are selected and invoked according to the operation performed by the user. The system user interface is also responsible for transmitting the system parameters input by the user and feeding back the information processed by the system to the user. The friendly user interface greatly improves the vitality of the system.

The overall idea of system operation is to recommend reasonable foundation types and foundation depths for users according to the parameters such as the upper structure, engineering geological conditions and material strength input by users. Users can choose to accept the recommendation of the system or set them by themselves. If the shallow foundation design is selected, the calculation of the size of the base bottom, the verification of the strength of the foundation, the verification of the weak substratum, the verification of the foundation deformation, the calculation of the internal force of the foundation and the calculation of the reinforcement of the base plate are performed; if the design of the pile foundation is selected, the estimation of the number of piles is performed., bearing platform layout, single pile bearing capacity check, weak substratum check, pile foundation settlement check, bearing platform internal force calculation and bearing platform reinforcement design process. It should be noted that there are two possibilities of satisfying and not satisfying the results of the above verification calculations. If it is satisfied, it means that the previous choices are reasonable, and you can continue to the next step; if not, the system will prompt the user and provide the user with a solution, and the user will modify the design parameters and recalculate according to the system prompt.

3.3 Design Database

Firstly, according to the requirements of the network teaching system, on the selected SQL Server database, design the database structure and establish the database. According to the results of the demand analysis of the network teaching system, the main data managed in the network teaching system include user, teacher, file and document data. Each user has user role information, so the network teaching system mainly includes data tables such as role table, user table, teacher table, file table, and document table. Then create the above data table in SQL Server 2005 database.

Classes are at the heart of any object-oriented system. The structure of a system consists of a set of fragments commonly called objects. Classes describe the types of different objects in the system, while class diagrams describe the classes and their relationships to each other. According to the demand analysis and system use case modeling, the main objects in the network teaching system can be obtained as the User

class, the Administrator class, the Teacher class, the CourseIntr class, the Article class and the File class.

The User class is the parent class of all classes, and contains attributes such as login name, password, contact number, and user email. The methods include logging in to the system, obtaining user information, obtaining roles, and encrypting user information. The Administrator class is an administrator class and an administrator has properties that identify their administrator status. The methods are mainly to verify the upload of the file, certify File, add user add User, delete user delete User, modify user information modify User Info, etc. The Teacher class is a teacher class. In addition to inheriting the attributes and methods of the parent class, it also includes attributes such as name, gender, course taught, phone number, and class taught. The new methods include update Course Info, update Teacher Intro, and upload File, etc. The Course Intro class is a course introduction class. The attributes of the course introduction class are: course name, college college, teacher teacher, course credit score point, class time, class place, and teaching plan teaching plan. A method to modify the class modify. The File class is a system file class. The attributes of the system file class are: file name file Name, file type file Type, file size file Size, file introduction short Intro, file address file URL, file creator Creator and upload time create Time, The methods of the file class include: check the file size check Size; modify the file information modify; file storage store; cancel uploading; delete the file delete.

4 System Test

In order to test the teaching effect of the designed online teaching system for architecture majors, this paper builds a relevant online teaching test platform and conducts system tests, as follows.

4.1 Test Preparation

After coding the system, the next job is to test the system. Software testing is an important stage in the software development process, and the quality of the developed software is closely related to software testing. The purpose of testing is to try to show that the system can do what we expect it to do and to find bugs in the program before it is put into use. The testing process has two distinct goals: to show developers and users that the software meets requirements. To identify defects and deficiencies in software, i.e. software whose behavior is incorrect, undesirable, or does not conform to its description.

During development, testing can be done at 3 levels of testing granularity: Unit testing, which is testing individual program units or object classes. Unit testing focuses on testing the functionality of an object or method. Component testing involves combining multiple program units to create a composite component. Component testing focuses on the interface of the component. System testing, that is, testing of some or all of the components in an integrated system as a whole. System testing should focus on testing the interaction of components. During the development process of the network teaching system, the unit test and component test are gradually completed during the coding implementation. Therefore, the system test is completed after the system integration to

test the interactive function of the system components. The system test example is shown in Table 1.

Table 1. System test cases

Steps	Input data	Checking point	Expected output
1	Interactive exchange search keywords	Topic search function	A list showing the searched topics
2	Click on the message to enter the message interface	Message board	Jump to the message interface
3	Enter the wrong verification code in the verification code box	Captcha function	Prompt verification code input error
4	Enter title click test	Student message function	Prompt message posted successfully

It can be seen from Table 1 that in the online teaching system, the black-box testing method is adopted, and the corresponding test cases are designed according to the system function to test whether the output corresponding to the input data is the same as the expected result. A test case is a description of the input and expected output in a specific environment and the object under test, and the test data is the input designed to test the system.

4.2 Test Results and Discussion

On the basis of the above test preparation, the online teaching system designed in this paper is used for teaching, and the system response time changes under different numbers of people are detected. The test results are shown in Table 2.

Table 2. Test results

Login	Response time (ms)	Test results
5	0.011	Test success
10	0.013	Test success
20	0.015	Test success
30	0.016	Test success
50	0.019	Test success
100	0.022	Test success
200	0.026	Test success

It can be seen from Table 2 that the response time of the online teaching system for architecture majors designed in this paper changes little when the number of people

changes, which meets the current online teaching needs, is effective, and has certain application value.

On this basis, the method of literature [9] and the method of literature [10] are used as experimental comparison methods to test the improvement level of students' performance after the application of the three methods. The results are shown in Fig. 4.

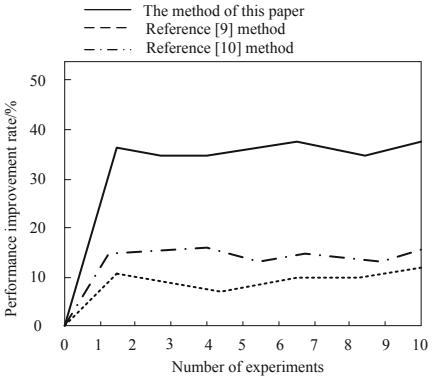

Fig. 4. Schematic diagram of the improvement level of students' performance

Analysis of Fig. 4 shows that after the application of the method in this paper, the average student's academic performance has increased by 36%, which is much higher than the literature method. It can be seen that the designed system can effectively improve the teaching effect of architecture students.

5 Conclusion

This paper designs an online teaching system for architecture majors based on virtual reality technology. The 3D teaching simulation system for building basic intelligent selection integrates an expert system, a decision support system and a 3D simulation system, which can assist students in completing basic selection and basic design training. Students can deepen their understanding of basic design through practical operations, discover their own problems by reading selection design reports, and clearly understand various basic structural forms by observing 3D simulation models. Teaching resources and teaching space have a great impact on improving students' comprehensive quality.

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