Teaching Method of Building Energy Conservation Based on Virtual Simulation Platform
Take the Teaching of Building Sunshade Design as an Example

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Abstract. There are two problems in the course of Building Energy Conservation: "theory" cannot be effectively converted into "idea", and the basic knowledge connection is not perfect. In order to solve these problems, a new teaching mode will be developed by using the virtual simulation laboratory. This paper takes the design of building sunshade as an example, uses Mars software to simulate the walking path of the sun at 28° north latitude in a year, substitutes the reasonably designed length of building sunshade into the 3D model, and simulates the effect of the above parameters on the VR equipment, so that students can fully understand the relationship between sunshade design and the sun path.

Keywords: building energy conservation · virtual simulation environment · sunshade design · Mars software

1 Introduction

The course of building energy conservation is produced with the development of the building market. However, with the continuous emergence of new building energy conservation standards and regulations, higher requirements have also been put forward for the professional courses of building energy conservation. It requires universities to gradually attach importance to professional courses, and teachers should also timely supplement important contents related to new technologies and new norms in professional teaching [1]. For example, combining with the emerging virtual simulation software in the society, it can increase the practical operability of students, and also enrich the classroom teaching, meet the needs of buildings, and track the new development of modern building energy-saving technology in real time [2].

This paper will simulate the sunshine environment at different time points of the year corresponding to the building shading design through parameter adjustment under Mars software, in order to achieve the effect of blocking sunlight in summer and introducing sunlight into the room in winter. Mars software under Sheencity platform can be perfectly compatible with many 3D software (such as SKETCHUP, REVIT, 3DSMAX, RHINO,

MAYA, ARCHICAD). At the same time, it can simulate the sunshine conditions at different time points in different seasons of the year, and can effectively carry out virtual simulation teaching for sunshade design.

2 Problems in Teaching Practice of Building Energy Conservation

2.1 Design Theory Cannot be Fermented into Design Concept

The knowledge points of Building Energy Conservation are mostly the research achievements in building physics, and most of the achievements cannot be directly used for architecture design [3]. Some of the data are not of high practical value. Although the acquisition process of some achievements is not easy, the conclusions are clear common sense. It is sometimes far-fetched to combine these theories with architectural design. In this case, the teaching of Building Energy Conservation in combination with architectural design has remained in the form of "an afterthought" in which knowledge points are applied afterwards [4]. For example, in building sunshade design, the thinking of sunshade design is usually concentrated after the architectural scheme design. At the later stage of design, the building sunshade design structure was substituted, and then the completed sunshade design was parameterized. In this way, the design practice and theoretical knowledge will be disconnected. I hope to reconstruct the teaching process and integrate the theoretical knowledge into the architectural design, so that students can already have the concept of Building Energy Conservation in their minds before carrying out architectural design and design with the concept of energy conservation [5]. Compared with the application after the event, the design with the concept will be more flexible and integrated.

2.2 Phenomenon and Data Lack of Underlying Connection

Another "pain point" is that students cannot fully remember the performance of parameters. For example, in the design of building sunshade, even if students can fully understand the relationship between the sun orientation, shading method and shading size in the course, they can also skillfully calculate the shading length, but they cannot accurately estimate the relationship between the shape and parameters when designing a specific scheme. This is because students lack the one-to-one effect of each specific operation on shading parameters in their minds [6]. Just like the multiplication table, we remember all the results from 1 to 9 in the simplest way, and then we can calculate larger numbers in column vertical form. In the course of building energy conservation theory, what students lack is the memory of the most "stupid" bottom result. It is not enough to master a set of formulas and calculation methods. The visual image and energy saving parameters of architectural design must be one-to-one corresponding, so that students can understand the application of each parameter change in the design [7]. This requires virtual simulation technology as a bridge to connect building energy conservation design parameters and architectural design 3D models, so that students can clearly see the actual effect of each parameter [8].

3 Teaching of Architectural Shading Design with Virtual Simulation Platform

In the undergraduate teaching system, we adhere to the experimental teaching concept of student-centered, interactive teaching and immersive learning, and apply high-quality experimental resources originally used in scientific research to undergraduate teaching, so as to improve students' professional quality and practical ability, and better meet the needs of the industry [9].

The course of building energy conservation needs to make full use of the resources of the virtual simulation laboratory to display the design products in the virtual reality world, which just meets the above requirements, allowing students to integrate the knowledge points of building energy conservation into the design, forming a new teaching method of visual and abstract knowledge points.

During the teaching process of building sunshade design using Mars software, it is first necessary to select a representative time node, import the sun path data corresponding to the time node and the building 3D model with sunshade design into Mars software for observation, then adjust the time node through Mars software to simulate the time period near the time node, and further observe the shading effect of sunshade design.

Figure 1 is the sun path map at 28° north latitude. We need to select three groups of time nodes in summer, spring (autumn), and winter. The time nodes in summer and spring (autumn) need to block the sun, and the time nodes in winter need to introduce the sun into room. Nine time points of the year are selected from Fig. 1, 6 a.m., 12 p.m. and 6 p.m. in June (summer), 7 a.m., 12 p.m. and 5 p.m. in September (autumn), 8 a.m., 12 p.m. and 4 p.m. in December (winter). Table 1, Table 2 and Table 3 list the sun orientation, shading direction, shading form and shading length in June, September and
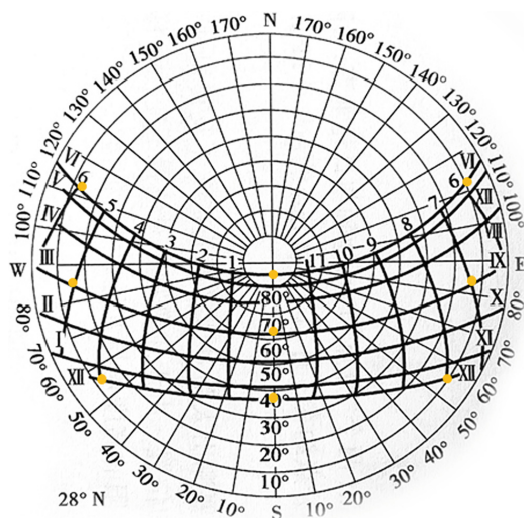

Fig. 1. 28° north latitude flat shadow sun path map and 9 selected time nodes

December respectively.

$$L = H \cot h_s \cos \gamma_{sw} \tag{1}$$

$$L_1 = B \cot \gamma_{sw} \tag{2}$$

L-Projection length of horizontal sunshade,
H-Height from the lower edge of the horizontal sunshade to the window sill,
h_s-Solar altitude angle,
γ_{sw}-The difference between the sun azimuth and the wall azimuth,
L_1-Projection length of vertical sunshade,
B-Clear distance between vertical sunshade panels (or the distance from the panel to the other side of the window)

a. Assume that 3D model of the building is arranged in the north-south direction,
b. At 12p.m. the sun is due south, the horizontal sunshade formula (1) should be used,
c. At 6 a.m. and 6 p.m. in June, the sun is in the northeast and northwest directions, the vertical sunshade formula (2) should be used,
d. At 7 a.m. and 5p.m. in September, the sun is in the southeast and southwest directions, the vertical sunshade formula (2) should be used,
e. The length of the sunshade should be greater than the parameter value in June and September and less than the parameter value in December

Table 1. Sun orientation and shading design parameters in June

Time	Sun Altitude Angle	Sun Azimuth	Sunshade Form	Sunshade Length	Sunshade Direction
6a.m.	10°	East113°	Vertical sunshade	0.42B	North
12p.m.	85°	South0°	Horizontal sunshade	0.09H	South
6p.m.	10°	West113°	Vertical sunshade	0.42B	North

Table 2. Sun orientation and shading design parameters in September

Time	Sun Altitude Angle	Sun Azimuth	Sunshade Form	Sunshade Length	Sunshade Direction
7a.m.	14°	East85°	Vertical sunshade	0.09B	North
12p.m.	63°	South0°	Horizontal sunshade	0.51H	South
5p.m.	14°	West85°	Vertical sunshade	0.09B	North

Table 3. Sun orientation and shading design parameters in December

Time	Sun Altitude Angle	Sun Azimuth	Sunshade Form	Sunshade Length	Sunshade Direction
8a.m.	10°	East55°	Vertical sunshade	0.7B	North
12p.m.	37°	South0°	Horizontal sunshade	1.33H	South
4p.m.	10°	West55°	Vertical sunshade	0.7B	North

In the laboratory, students are divided into two groups. According to the parameters in Table 1, Table 2 and Table 3, targeted sunshade design is carried out for June and September respectively. The parameters in December are used to check whether the winter sun can enter the room, to ensure that the length of the sunshade is not designed too long to block the winter sun. Students can conduct 3D modeling of the shape and structure of building shading within a reasonable range of parameters. Mars software can simulate the sun's position at specific latitude, season and time, and is compatible with many 3D software and VR devices. After the modeling is completed, students under the guidance of the teacher, import the 3D model of the building sunshade design into Mars software, connect the VR equipment, adjust latitude, season and time, and roam the rooms in different directions, then observe the impact of the students' building sunshade design on the indoor lighting of rooms in different directions at the nine selected time nodes mentioned above. After that, change the season and time parameters in Mars software, observe the sunshine outside the time node, such as 1:00 p.m. in May and 11:00 a.m. in August, so as to completely simulate the corresponding situation of the sun and shading effect in a year.

Practical teaching is the bridge between theoretical teaching and engineering application, which can improve the application ability and practical ability of students' theoretical knowledge, and then cultivate high-quality engineering application talents [10].

4   Conclusions

Architectural design is a process in which form design and parameter design are carried out simultaneously. However, the teaching of auxiliary disciplines such as building energy conservation, building physics, building structure, and building materials only focuses on the explanation of parameter design such as principles and calculation methods, ignoring the teaching of the corresponding basic connection between form design and parameter design. If we can strengthen the connection of knowledge and result, it will be of great help to the auxiliary disciplines of architectural design. The advantage of this is that "design inspiration" can be raised to a theoretical level, and "design theory" can be lowered to perceptual knowledge which is of great significance for students to freely apply theoretical knowledge in architectural scheme design.

References

1. Wu, C.L., Ren, K., et al. (2021) Energy consumption simulation and energy-saving transformation of teaching buildings in colleges and universities based on BIM technology. Modern Architecture Electric.,7:52–58.
2. Wang, C.F. (2022) Ideological and Political Connotation and Extension Design Practice of the Course "Building Energy Saving Technology". Education and Teaching Forum., 19: 69–72.
3. Lin, D.G.(2022) Research on the Teaching Reform of the Course "Building Energy Saving Cases" under the Background of Engineering Education Certification—Taking Hunan University of Humanities and Science and Technology as an Example. Journal of Hunan University of Humanities Science and Technology.,4:124-128.
4. Wang, L.X., Dang R. Introduction to Building Energy Conservation [M]. Beijing: China Architecture Press,2018:162–163.
5. Fu, X.D. Principle and technology of building energy conservation [M]. Chongqing: Chongqing University Press,2016:108–109.
6. Wang, R. Building energy conservation design[M]. Wuhan: Huazhong University of Science and Technology Press,2020:82–83.
7. Chen, G.J., Luo, Q.H., et al.(2019) Research on optimization of teaching content of building energy conservation course. China Modern Educational Equipment.11:57–59.
8. Ren, Z.G., Zhou, M., et al.(2019) Research and practice on mixed teaching mode of building energy conservation course. Journal of Architectural Education in Institutions of Higher Learning.02:93–100.
9. Zhu, H.P., Chen, C.H., et al.(2021) Construction of virtual simulation platform for energy-saving technology of civil building envelope. Experimental Technology and Management., 4: 240–243.
10. Zhang, L.F., Yao, L.(2021)Discussion on Teaching Method of "Building Energy Saving Technology". Education and Teaching Forum.,21:149–152.