Construction of Eco-Landscape Art Design System Based on Virtual Reality Technology

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Abstract. In recent years, with the rapid development of the global economy, each country has accelerated the pace of urbanization. Urbanization has become the main direction of development and is the power to promote rapid economic development. However, the development of urbanization is restricted by many factors, such as resource pressure and environmental pressure, which have a direct impact on the development of urbanization. For this problem, the concept of sponge city is put forward. In this paper, virtual reality technology is applied in the design of ecological landscape of sponge city, which can effectively alleviate the urban ecological environment and solve the urban pollution problem. In the stage of urban planning and construction, the combination of virtual reality technology and sponge city concept maximizes the characteristics of natural ecological system, has the functions of absorbing, slowing down and storing precipitation, better control of urban rainwater runoff, and promotes the healthy development of the city. This paper outlines the virtual reality technology, analyses the components and basic structure of the virtual reality system, uses the virtual reality technology as an auxiliary support for ecological landscape design, designs the sponge city ecological landscape based on the virtual reality system process, and calculates the runoff control value. Finally, some of the Experiencers are selected to evaluate and analyze the effect of this sponge City eco-landscape art design. The highest real evaluation is the real evaluation of ground paving, the result is 85.03%, the lowest real evaluation is the experience comfort, the value is 10.54%. The average value of simulation perception is 90.98% when 11 virtual scenes are selected. 65.2% of the people who have verified that VR technology has simple hardware and software operation and good practical value.

Keywords: Virtual Reality Technology, Sponge City, Eco-landscape art design, VR Technology
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1 INTRODUCTION

At present, people put forward higher requirements to the environment, such as urban living environment, ecological landscape, etc. Eco-landscape is the main part of the urban living environment, which can improve the quality of living and living environment of urban community residents. Therefore, designing urban eco-landscape can significantly improve the quality of housing and living environment [6]. Sponge city is a new concept put forward in recent years, which can effectively alleviate urban water accumulation and realize the recycling of water resources. In this paper, virtual reality technology is used in the design of ecological landscape of sponge city, and the technical advantages are fully used to show the ecological landscape effect [12].

Virtual reality technology uses software and hardware devices to simulate the real space scenes and ecological landscape, making people feel the spatial effect from the aspects of hearing, vision and touch, and has a feeling of immersion. Designers use this technology to simulate and display the effects of eco-landscape art design, to help designers modify plans and find problems, to better meet people's requirements [2].

The main innovations during this research period are as follows: (1) Focus on the analysis of virtual reality technology, including the basic concepts, characteristics, system composition, system structure of virtual reality technology, based on which the design of sponge city ecological landscape is applied. (2) Define the basic process of virtual reality system in eco-landscape art design of sponge city, complete the eco-landscape art design of sponge city according to this process, set up various facilities, and calculate runoff control in the eco-landscape. Design normal sunken green space, rainwater garden, rainwater filtration and build sponge City.

2 RELATED WORK

A mature rainwater management system has been formed in foreign cities. Sponge cities are considered as the main development mode of water eco-cities, and become an important direction for the development of each city [15]. Amelia points out that sponge city technology was used to rethink and analyze the connections between rivers in the design of the Riverbank landscape of Lepelle Perreux on the Man River in France [2]. Shen N proposed that the basic characteristics of sponge cities are to balance water ecology across scales, establish regional urban flood control system, protect the ecological environment, restore the original appearance of the ecological environment, and solve urban problems that affect people's lives and even threaten people's health [14]. Phommaly deeply explores the connotation of sponge city, pointing out that the traditional urban model only pays attention to economic development, which causes serious damage to the ecological system. Combining biological, physical and ecological technologies, Phommaly repairs and restores the urban ecological environment system, and uses virtual reality technology to promote the development of sponge city [13]. Adham analyzed the urban low impact development rainwater system and established a sponge city to reduce the disturbance of water circulation to the system, using wetlands and green squares in the city to form a sponge city [1]. Bindu proposed that urban construction should incorporate new concepts to build an eco-civilized city, accelerate the development of sponge cities, build the concept of natural drainage, water storage and water dissolution, and build a complete ecological cycle system with urban ecological land [4]. Zhang S W proposed the sponge city landscape design based on the ecological concept, using the ecological landscape design to improve the ecological benefits of the city, completing the urban landscape design through natural purification and natural infiltration, and building a new sponge city [17]. Zhang H X et al. combines the numerical simulation with the measured data to get the mechanism of environmental generation by various types of greening modes, which provides guidance for the design of residential eco-landscape greening design. Using the measured data to verify the numerical simulation results, further adjust the parameters so that the simulation results meet the research needs [16]. Zhang X applies the concept of sponge city in urban park landscape design to provide a better resting environment for urban development and to manage regional flood control with "sponge ecology" effect [18]. Li F et al. Using the concept of sponge city to complete the design of urban eco-landscape, and analyzing the characteristics of urban eco-landscape and sponge city, choosing the distance between Longquanshan Forest Park and living water park, integrating the concept of building sponge city into the design of urban eco-landscape, and designing an urban eco-landscape with ecological restoration and prevention and control of water pollution [9].

3 VIRTUAL REALITY TECHNOLOGY

3.1 Definition of Virtual Reality Technology

Virtual Reality (VR), as a common computer-aided technology, is essentially to design a very realistic three-dimensional virtual space environment by using computers, to make people experience immersion in the virtual world sensorily by using some special devices and objects in the virtual space to interact. The purpose of using virtual reality technology in eco-landscape art design is to use this technology to strengthen the scheme and design assistant scheme. The eco-landscape art designed by designers shows strong intuition and interactivity, and fully reflects the vividness, visuality and authenticity of the scene. People and designers use the VR demonstration system to enter different scenes, interact with each other better to understand the design concept, experience the feeling of immersion, this advantage is that the sand table model, effect diagram, animation can not be achieved. In addition, the VR technology is used to simulate the eco-landscape construction site, which makes it easy for designers to grasp the construction situation and progress in real-time, guide the quality and safety of the project in a scientific way according to the current situation, and reduce the waste of construction.

3.2 Technical Features of Virtual Reality

In recent years, image recognition technology has been developed rapidly and has achieved good results in identifying different objects. However, the accuracy of identifying moving human body is low because the external environment during image collection can not be controlled, such as background factors, ambient light, shadows and occlusions.

Here are a few of the common situations that occur in virtual reality environments:

- Reproduce the real environment. Real environment part already exists, some are being formed and some are being destroyed, such as virtual community, virtual campus, virtual museum, virtual battlefield, etc. By building virtual environment, users can be immersed, interactive and realistic.

- Create an environment that people imagine or don't exist, often in science fiction movies, game scenes.

- Simulating and simulating the real and difficult-to-perceive environment, such as simulating the micro-phenomena and macro-phenomena of molecular structure and celestial movement, makes it difficult for people to directly perceive this real environment. Simulating and displaying it in front of people using virtual technology.

3.3 Virtual Reality System Composition

Virtual reality technology design is a kind of comprehensive technology, which integrates sensor technology, computer graphics, network technology and interaction technology. The requirement for virtual reality technology is that it can interact with users in real time. Therefore, the components of virtual reality technology include input and output devices, computers, databases and application software, which are shown in Figure 1 below:

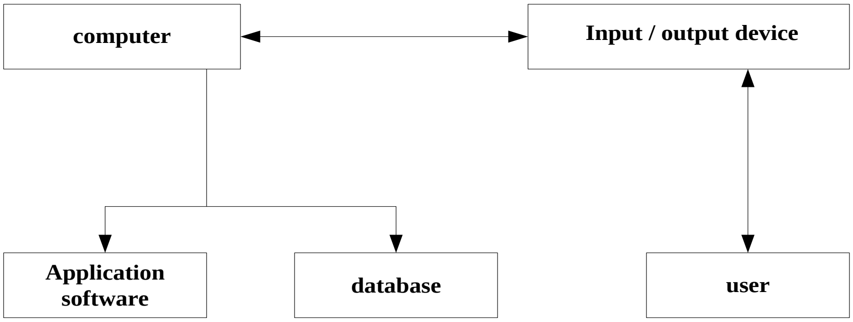

Figure 1: Virtual reality system composition.

3.4 Virtual Environment System Structure

Virtual reality environment refers to the computer using physical model and set model to generate and store in the computer, and using some special equipment to feel the real environment. In this environment, real-time interaction with users is required. Users have absolute autonomy. This environment is called virtual reality environment. Figure 2 shows the structure of virtual environment.

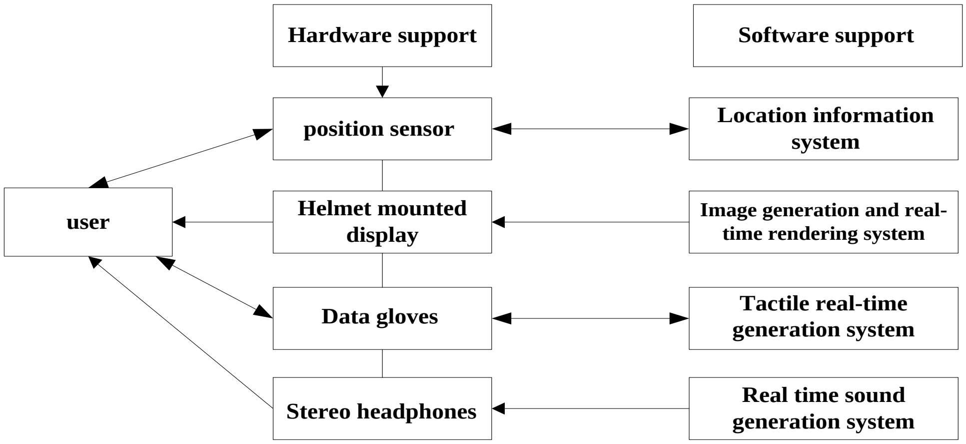

Figure 2: Virtual environment system structure.

4 ECOLOGICAL LANDSCAPE DESIGN OF SPONGE CITY

4.1 Virtual Reality Technology Provides Auxiliary Support for Landscape Design

The process of using virtual reality technology in the ecological landscape design of sponge city is introduced. First, the design scheme is defined, and the plans of different scenes of ecological landscape are involved in the software [3]. After cleaning up the redundant lines, import the sketch up software, add the materials to the established model, import the simplified model into the virtual reality platform, readjust the scene care and model materials, compare the model volume and materials, complete the auxiliary scheme design and drawing, and export the static effect drawing, landscape roaming animation and executable file after completion, as shown in Figure 3 [8].

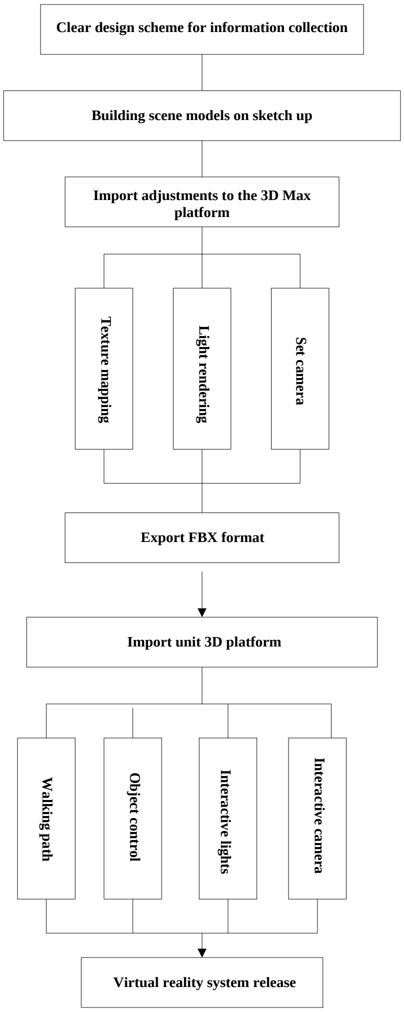

Figure 3: Ecological landscape design procedure of sponge City.

4.2 Residential Landscape Design Of Sponge City

Sponge city refers to an ecologically livable city with strong absorption and handling capacity similar to sponge. It can absorb and store rainwater after rainfall in the face of natural disasters and natural environment changes. It can reuse and release the stored rainwater according to demand. When using virtual reality technology to design the ecological landscape of sponge City, this paper analyzes the basic technologies required for the construction of sponge City, and deeply analyzes the community drainage safety system through the organic combination of natural methods and artificial measures, so that the community can collect, store and purify rainwater, realize the full utilization of rainwater resources, and optimize the ecological environment. The three-level collection system should also be analyzed in the ecological environment landscape design of sponge city. First, the primary collection system needs to use biological, phytochemical and physical characteristics to purify rainwater, so as to enhance the seepage quality; The secondary collection system is to establish an open water system in the residential area and use the water environment to filter the sewage, so as to improve the groundwater environment. The three-stage water collection system makes full use of groundwater flow and soil purification and filtration technology to purify and store rainwater. The following figure 4 shows the landscape design system of sponge City.

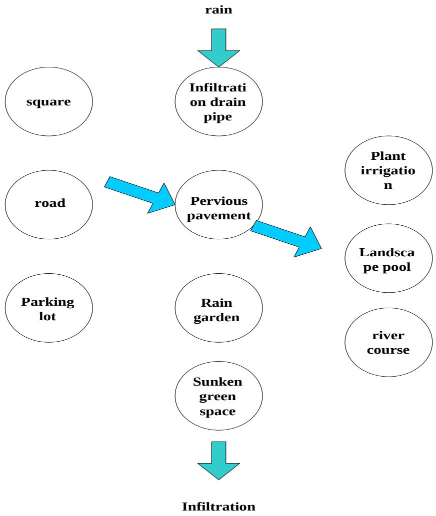

Figure 4: Sponge city landscape design system.

In the above sponge city landscape design system, residential areas should establish application facilities from the following four aspects [5]:

- The construction of concave green space, combined with the shaping of the site topography, fully utilizes the concave green space to establish a depression runoff planting area, which can be used to filter and purify water, forming a circular ecological rainwater garden, so that the rainwater can stay in the green space for a longer time.
- Paving water-permeable devices and structures, selecting pottery bricks, bread bricks and other paving materials with strong water-permeability, can quickly penetrate into the underground after rainfall, making the underground water content increase, can play the role of purifying air and adjusting humidity.
- Using landscape water bodies with suitable diversion facilities to better store rainwater runoff can be used in irrigation gardens and landscape water use [19].
- To collect and drain rainwater, landscape drainage open ditches should be built in paved sites and road green spaces in green space.

4.3 Runoff Control Calculation

In the low impact development environment, the source control scheme is used to control the runoff speed, and the volume method is used to find the way to control the runoff quality and total amount, so as to achieve the rational use of rainfall resources. The following are the main calculation formulas:

$$V = 10H\Psi A \tag{1}$$

The top V represents the control volume in m3; H represents the design rainfall, mm; Ψ Indicates the catchment area of China's total rainfall runoff coefficient; A represents catchment area in hm2.

The size of source control facilities should be calculated according to the type of facilities and control objectives. When controlling total runoff, the design process of rainfall should be judged based on historical rainfall data over 20 years. Statistical analysis of 24 hours a day rainfall value, without calculating events with rainfall less than 2.0 mm, can obtain the corresponding curve between the annual total runoff control rate and the designed rainfall in the region, and the corresponding design rainfall for each year and the total runoff control rate can be obtained. In order to better control water quality, standardized management of pollution indicators for runoff control of dividing drainage system is carried out according to outdoor drainage design when designing rainfall. The value space is between 4 mm and 8 mm.

In this paper, the daily precipitation data of a city for 30 years from 1991 to 2020 are selected and classified according to the size of precipitation. All precipitation less than 2 mm is ignored and not calculated. The precipitation is clearly designed according to the statistical annual total control rate, which is shown in Table 1 below.

Annual total runoff control rate (%)	*60%*	*65%*	*70%*	*75%*	*80%*	*85%*	*90%*	*95%*
Design rainfall (mm)	*12.3-12.6*	*14.2-14.8*	*16.7-17.2*	*19.8-20.4*	*23.7-24.5*	*29.1-30.2*	*36.6-38.5*	*50.3-53.4*

Table 1: Precipitation corresponding to total runoff control rate in different years.

Here are the basic parameters for this design：

- Select soil permeability as 0.06m per day.
- Choose a daily evaporation of 2. 5 mm, average daily transpiration 1.8 mm.
- Average elevation of groundwater level based on 1.2m of the Yellow Sea.
- Adjust the gap volume of infiltration system and set the cycle of drainage and air conditioning storage facilities to 24 hours.
- Adjust the gap volume of infiltration system and set the cycle of drainage and air conditioning storage facilities to 24 hours.
- Rainfall runoff factor: green space area Ψ Coefficient 0.3, road and roof Ψ Coefficient 0.9, general green space Ψ The coefficient is 0.25, rainwater garden, seepage-enhancing green space Ψ Coefficient 0.15, general parking Ψ Coefficient 0.9, Permeable pavement and parking spaces Ψ Coefficient 0.4, other Ψ 0.85.

index	*Company（m2）*	*Proportion（%）*	*Discharge runoff coefficient*	*Weighted runoff coefficient*

Floor area	*13241*	*20*	*1*	*0.200*
Green area	*19926*	*30.2*	*0.26*	*0.074*
Pavement and road area	*19701.7*	*10.5*	*0.8*	*0.095*
Permeable car seat	*3331*	*5*	*0.4*	*0.03*
Pervious pavement	*2000*	*34.5*	*0.4*	*0.138*
Total land area	*66196.7*		*Comprehensive runoff coefficient*	*0.527*

Table 2: Runoff system calculation table.

Calculated annual runoff precipitation to be controlled locally:

$$V2=22\times66196.7\times0.527/1000=767m^3 \tag{2}$$

Daily greening water consumption for pouring and rinsing roads:

$$V=19926\times0.28/200+(19701.7+3331+10000)\times0.4/1000=41.1m^3/d \tag{3}$$

Flushing Road water and greening sprinkler reservoir volume:

$$V1=V\times3=125m^3 \tag{4}$$

According to the practical application, a rainwater collection tank is set up outdoors with an area of 767 m3 and a water storage capacity of 125 m3 for reuse facilities.
Calculate LID design size:

1. Design of normal sunken green space

One of the main LID facilities is the general sunken green space, which is laid out in front and back greening of the garden house. The roof rainwater is connected with the sunken green space, and the area of the general sunken green space is 4000m2 according to the calculation. The surface layer is used to store precipitation resources in this area. The optimal storage depth is 5 cm and the total storage capacity is 200 m3. The surface water storage decreases after evaporation, seepage and transpiration of green space plants, and the drainage time at design time is 24 hours.

2. Rainwater Garden

At the time of eco-landscape art design, the rainwater garden had an area of 100 m2, a water storage depth of 30 cm and a total water storage capacity of 30 m3[7]. Designing the sponge City eco-landscape from bottom to top, the lowest layer is undisturbed soil, the second is the water reservoir depth of 20 cm, then the water-permeable engineering cloth, the filling and planting soil depth of 30 cm, the upper layer is the soil cover thickness of 8 cm, and the upper layer is the water reservoir thickness of 20 cm.

3. Storm water filtration

Eco-landscape installs filter facilities at the end of storm water pipes and must ensure that the treatment area exceeds 441 m3.

5 APPLICATION ANALYSIS OF ECO-LANDSCAPE ART DESIGN IN SPONGE CITY

5.1 Analysis of Virtual Design Elements of Eco-Landscape in Sponge City

This paper designs the sponge City eco-landscape based on virtual reality technology, further analyses the design elements, and chooses the sponge City eco-landscape that some of the

Experiencers feel the design [11]. Starting from VR technology mastery, age, learning and technical ability, academic qualifications, this paper summarizes and analyzes the real evaluation results of each design element in eco-landscape art design, which is shown in Fig. 5 below.

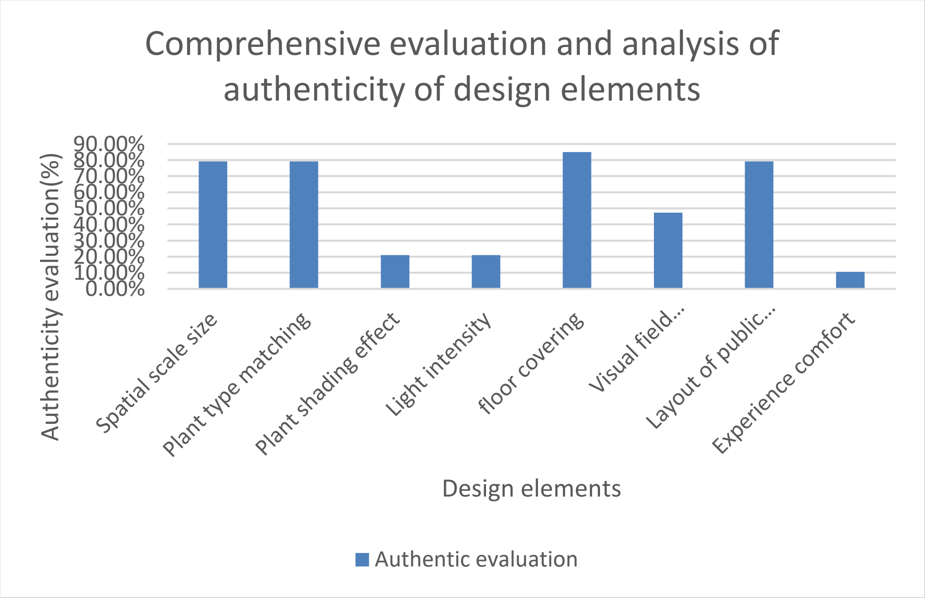

Figure 5: Comprehensive evaluation and analysis of design element authenticity.

According to the results shown in Fig. 5 above, the real evaluation of spatial scale, plant type matching and layout of public facilities are all equal, 79.24%. The real evaluation results of light intensity and plant shading effect are the same, 20.96%. The real evaluation results of ground paving are 85.03%. The real evaluation of visual field permeability is 47.39%. The lowest real evaluation is experience comfort, and the result is 10.54%. Summarize each element in the eco-landscape art design to get five core design elements, that is, material, spatial scale, plant scenery, lighting and shading, and facility layout. According to the evaluation results given by the experiencer, most elements in the virtual scene have a high degree of authenticity, with an average of 52.83%.

5.2 Perception Analysis for Virtual Scene Simulation

Statistical analysis of 11 virtual scene experience matching data is performed. The results of authenticity are listed in Table 3 below. The average experience matching degree of the data in the analysis table is 90.98%, which means that virtual space can display 90.98% of the real space sense, which indicates that virtual reality technology has a high value in space design.

scene	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*
Authenticity（%）	*81.26 %*	*87.4 %*	*100 %*	*70.79 %*	*89.5 %*	*100 %*	*88.25 %*	*100 %*	*91.78 %*	*91.78 %*	*100 %*

Table 3: Virtual Scene Experience Matching Data.

5.3 Application Validation of Virtual Reality Technology

In order to verify the effectiveness of virtual reality technology in eco-landscape art design, 308 Experiencers were selected to enter the experience, and their experience results were analyzed and summarized, drawing as the result of Figure 6 below.

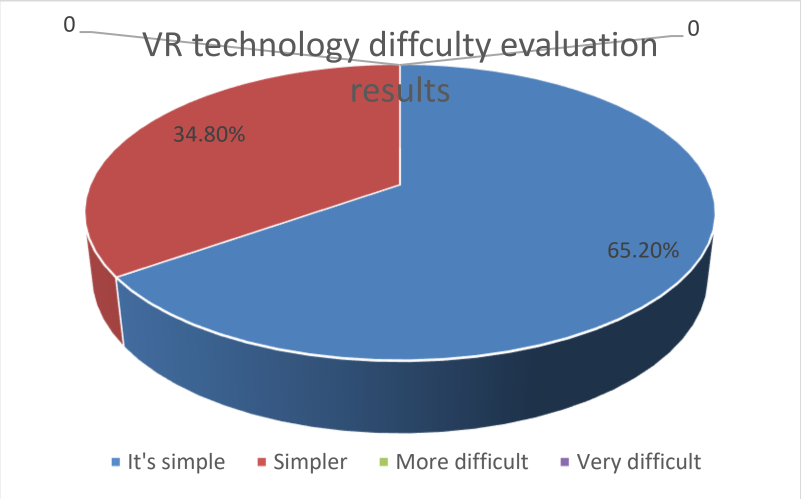

Figure 6: VR Technology Difficulty Evaluation Results.

65.2% of the Experiencers feel that the process of VR technology software and hardware operation is very simple, easy to use, and can be quickly familiarized and used. 34.8% of people think that the operation of technology is very simple and can be mastered through simple learning and practice. Basically I find it difficult and long to learn. This selection of Experiencers has different qualifications, they have different academic qualifications, age, experience, learning ability, etc. They seldom know and master knowledge about virtual reality technology. The Experiencers use VR technology to experience multiple virtual scenes in ecological landscape design, further evaluate the authenticity of different design elements in the virtual scene, and finally make a comprehensive analysis of the personal conditions and authenticity of the experiencers.

Through analysis, the experience selected in this paper is different in education, age, learning ability, etc. However, the result of authenticity evaluation of each design element in the scene is basically the same as the perception ratio, sufficiently indicating that the personal condition of the experiencer has no effect on the application effect of virtual reality technology in eco-landscape art design, and the higher perception in sponge City eco-landscape art design is shading by light, Spatial scale and layout of public facilities.

6 CONCLUSIONS

In recent years, the rapid development of the global economy has led to the growing size of cities. However, the area of land hardening has rapidly expanded, and the area of land that absorbs rainwater has gradually decreased, resulting in urban heat island effect, waterlogging and other issues. Eco-landscape art design has become the main measure to improve the urban environment. This paper uses virtual reality technology to design the eco-landscape of sponge city, simulate and analyze the eco-landscape state of sponge city, which is conducive to designing more reasonable buildings, unified planning and better handling of rainwater problems, taking sponge measures to increase the intensity of rainwater control, and improving traditional hard paving, natural infiltration strategies. Design and build high-quality sponge city eco-landscape. Finally, some Experiencers are selected to evaluate and analyze the effect of this sponge City eco-landscape art design. The highest real evaluation of ground paving is 85.03%, the lowest real evaluation of experience comfort is 10.54%, and the average real evaluation is 52.83%.

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