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On the application of virtual reality technology in the teaching of "landscape architecture design"

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Abstract
"Landscape Architecture Design" is an important basic design course for undergraduates majoring in landscape architecture in China. The teaching focus is to cultivate students' cognition and design of three-dimensional garden space. At present, the classroom teaching of "Landscape Architecture Design" has a limited space dimension of course teaching. Virtual reality (VR) technology has immersive, the three characteristics of interactivity and conception can help teachers to enrich the form of classroom teaching, cultivate students' spatial thinking, and enhance students' spatial simulation experience. Focusing on the key points of virtual reality (VR) technology, this paper discusses the application of virtual reality (VR) technology in the specific implementation method in the course of "Landscape Architecture Design": in the teaching preparation process, teachers can use virtual reality technology to build a three-dimensional panoramic courseware library of landscape architecture cases, and students can break the geographical restrictions and enter the virtual scene to experience all parts of the world. Excellent garden landscape, at the same time, teachers can select excellent garden space cases according to the teaching theme, and collect VR information; secondly, in the classroom teaching, teachers can use projection equipment or students to use simple VR glasses to watch the panoramic cases that have been made.

Keywords
Landscape architecture design; Virtual reality technology; Teaching link

Introduction
The "Landscape Architecture Design" course is an important basic design course for undergraduates majoring in landscape architecture in my country. The teaching goal of the course is to cultivate students to have the basic concepts and design thinking of landscape design, to be familiar with the procedures and links of landscape design, and to be able to independently complete the creation and expression of design schemes [1]. The course is offered from the second semester of the sophomore year to the first semester of the senior year. According to the needs of different grades and majors, the teaching and research group arranges 1 to 2 design assignments per semester, and each design assignment is completed within 8 to 10 weeks. The teaching content of the "Landscape Architecture Design" course includes the principles of landscape architecture design, various types of garden green space and urban public space design. In the course teaching, teachers will arrange different design topics to carry out key training for students, such as functional layout, space design, terrain design, plant design, drawing expression, etc. [2]. Teachers teach theory, task explanation, case analysis, field investigation methods and design guidance in class. Students design plans during and
after class, and finally form a formal design plan, expressing the design plan in the form of complete drawings. Among them, space design is the core content of the "Landscape Architecture Design" course, which runs through the course teaching, mainly to help students establish a spatial thinking mode, improve space design ability, and train students to master the scale, proportion, atmosphere, layout and design of garden space. relationship between combinations [3].

Different from the traditional teaching method, the teaching of "Landscape Architecture Design" requires the help of certain media to carry out the communication between teachers and students and the collision of ideas, and finally form the landscape design scheme. It is understood that the teaching of most of the "Landscape Architecture Design" courses at home and abroad mainly relies on the case teaching of teachers, drawing and scrutinizing the design scheme by hand-drawing, hand-modeling and commenting. The course teaching of senior grades can be combined with computer-aided design software, such as Auto-CAD, Photoshop, Sketch-up, Lumion, etc., to conduct space design deliberation [4]. Virtual reality (VR for short) technology is a new multi-channel human-computer interaction interface. People use virtual reality helmets and combine with the physical space environment to generate realistic images, sounds and other sensations. Simulate user interaction with the environment in a virtual environment. At present, the VR system is mainly composed of a graphics processing computer, an application software system, an input device and an output device [5]. Virtual reality technology first originated in the United States in the 1860s, and in the 1980s, the concept of virtual reality technology was gradually extended to the fields of medical treatment, flight simulation, automobile industrial design and military training. Since 1990, virtual reality technology has been widely used in business, and with the continuous updating of display equipment products such as VR headsets and simple VR glasses, virtual reality technology has begun to enter the public eye and become the mainstream of the game industry. At present, major technology companies in our country have project departments dedicated to developing virtual reality products, and virtual reality technology has begun to be used in a wider field [6]. Virtual reality technology makes the interaction between users and computers more natural, just like the interaction between humans and nature in reality, users are completely immersed in the virtual environment generated by the computer, making it an immersive interaction look and feel. At the same time, this interaction also facilitates designers to scrutinize the scheme during the design process and feel the real effect of the design. In addition, the display operation cost of virtual reality technology is relatively low, and it can be operated skillfully in a few minutes of learning. Even if the general public does not have strong professional skills, they can clearly feel the real scene of the venue, making it easier for the public to understand the effect of garden design has improved the effect of popular science education for the public [7].

At present, there are two forms of display of common virtual reality technology: one is the real scene obtained by using the panoramic camera to collect information from the actual environment; the other is the virtual scene rendered by computer graphics software. Although the presentation methods of these two technologies are different, they both provide users with an immersive experience. If teachers master these two technology display methods, they can apply virtual reality technology in the teaching of design related courses [8]. The panoramic data collection of real scenes requires the use of panoramic photography equipment for real scene shooting [9]. At present, there are professional independent panoramic cameras on the market, such as Detu F4, Insta360 Pro, GoPro360, etc. There are also portable devices that support mobile phone connection, such as Insta360 one, Ricoh, THETA, etc. The working principle of this type of equipment is to capture data information in different directions through all-glass fisheye lenses in different directions, and then synthesize panoramic photos or videos.
through image stitching technology [10]. For example, when collecting the physical space information of landscape architecture, the panoramic photography equipment must first select the sample points of the collection object. The open and open site is the best collection location, and at the same time, it should avoid tourists as much as possible to ensure that high-quality images are obtained [11]. After the data collection is completed, the required panoramic photos or videos are obtained by using the picture stitching technology, and then projected to the user's eyes through the VR equipment [12].

The construction of the virtual scene model requires the use of computer software to create the scene that needs to be displayed. For landscape architecture, it is an outdoor space composed of landscape architecture elements, including mountains, water features, vegetation, terrain, structures, squares, roads, etc. Commonly used software includes SketchUp sketch master software, Lumion software, etc. The producer first completed the basic model construction of the scene's terrain, roads, water bodies, squares, structures, etc. in the Sketch Up software, and then poured the model into the Lumion software, adjusted materials, added plants, and performed background and ambient lighting. After setting, a more realistic scene model is obtained [13]. The producer uses the "VR panorama setting" function in the Lumion software to perform virtual reality rendering of the produced scene model. There are currently two formats for producers to choose from, one is the "cube panorama" format, which renders 12 square images stitched together. Although this kind of picture has high precision, it requires manual picture stitching in the later stage before it can be applied to VR equipment products [14]. In this link, teachers can select excellent garden space cases according to the teaching theme, collect VR information, and use 360-degree panoramic cameras to take photos or short videos. Then, the VR model source files and basic information, floor plans and analysis diagrams are synthesized, edited, and virtual space cases are produced, thereby forming a real and three-dimensional garden interactive experience case courseware. When students master the generation skills of virtual reality panoramic model, they can connect the garden scene they designed with the mobile terminal of "720 Cloud Platform" to generate the link of panoramic effect, and then enter the panoramic experience interface through VR simple glasses, and continue to scrutinize Whether the design of the spatial scale of the design scheme is reasonable and comfortable. If it is unreasonable, students can quickly make adjustments in the model to obtain the most satisfactory garden space design scheme.

### Materials and Methods

Virtual reality technology (Virtual Reality) originated in the United States, and currently the United States is at the leading level in the development of virtual reality in countries around the world. The Department of Computer Science of the University of North Carolina is the first institution of higher learning to conduct research on virtual reality technology. The main work is aircraft simulation driving training, surgical simulation training, virtual building simulation, etc. In display technology, the University of North Carolina has developed a parallel processing system that helps users create real-time dynamic display in a huge visual environment.

The Massachusetts Institute of Technology (MIT) has been leading the research work of high-tech science and technology. In 1985, the Massachusetts Institute of Technology established the Digital Media Laboratory and carried out research work on virtual reality technology at the same time [15].

In order to study the future development of existing virtual reality technology, Stanford Research Institute established the "Visual Perception Project". In 1991, Stanford Research...
Institute conducted research on simulated driving training for military aircraft and vehicles using virtual reality technology. Attempts to use virtual reality technology to simulate real training scenarios to reduce accidents that may occur during actual operation. At the same time, the Stanford Research Institute also conducted a simulated operation experiment on surgery [16]. The Human-Machine Interface Technology Laboratory of the Washington Technology Center, affiliated to the University of Washington, has also made achievements in virtual reality technology, and is also conducting research on perception, perception, cognition, and motor control. The technology center brings virtual reality research into education, entertainment, construction and design. For example, the V22 Osprey transport aircraft developed by the American Boeing Company was put into use after the completion of the virtual simulation experiment in this research center [17].

Europe has also made great achievements in the technical research of virtual reality technology. The United Kingdom is a leader in some aspects of virtual reality technology development in Europe, especially in the aspects of decentralized parallel processing, related supporting equipment design and technology application research [18]. Wi industries is a well-known virtual reality technology research and development organization, which mainly develops a series of products using virtual reality technology in entertainment. They have been trying to change this situation and expand their products to popular fields such as industrial design and visualization, and it is planned to launch a new lightweight head-mounted display and high-performance graphics rendering engine [19-21]. Brought, a branch of British Aerospace (BEA), is combining virtual reality technology to design advanced fighter cockpits under the leadership of Professor Roy Kalawsky. Professor Roy Kalawsky is the first person in the UK to engage in virtual reality technology research, and is a member of the University of Hull, UK. He is also a professor who emphasizes people-oriented research in the applied research of virtual reality technology in the UK. The Virtual Environment Configurable Training Aid (VECTA) developed by BEA is a test platform that integrates the latest technology at the time to study and consider ways of virtual reality technology to replace traditional simulation devices. A sub-project of VECTA, Real And Virtual Environment (RAVE), was first shown at the Farnborough Aviation Expo in 1992 and was developed specifically for pilots training in simulated cockpits.

Since the 1990s, the United States and European countries have begun to use virtual reality technology in architectural design. They use video creation technology and virtual reality technology to simulate architectural design activities and watch virtual architectural styles from their own perspective. As well as the urban environment, and during the viewing process, you can adjust the planning scheme and design method according to your own ideas, and can also simulate buildings, lighting equipment, decorations, vegetation and other things in real life, such as flowers, rivers, soil, birds and beasts etc., making the virtual space environment infinitely close to the real environment, the virtual reality system breaks the previous real estate sales form, and is welcomed by many people, which also promotes the application and growth of virtual reality technology in western countries. However, some defects were also found in the actual use process. In the early stage of development, a large amount of research and development costs and the limitations of computer technology have reduced the breadth and depth of the popularization of virtual reality technology, which also makes virtual reality technology become some strengths The exclusive use of powerful enterprises, ordinary individuals or small companies just starting out cannot afford their huge expenses. However, with the continuous advancement of science and technology, the decline of computer hardware manufacturing costs and the improvement of performance, the threshold of virtual reality technology has been continuously lowered, and the number of browsing items has continued...
to increase. Whether it is production costs or image effects, consumers can be satisfied. 

Whether it is production costs or image effects, consumers can be satisfied. [22-24].

All in all, the development of virtual reality technology in western countries represented by Europe and the United States is in a leading position in design and plays a role in leading the development of technology, followed by virtual reality research in my country. The characteristics of virtual reality technology itself and the development potential of great development value have deeply attracted many scientific researchers to participate in it, including architectural landscape planning, environmental planning and design and other disciplines that have also introduced virtual reality technology into more far-reaching research directions, virtual reality technology has more research space waiting to be explored.

Results and discussion

Interactive controls based on user gestures

User gesture-based interaction controls include navigation controls, line interaction controls, surface interaction controls, and box interaction controls. Navigation, line, and surface interaction controls are classified as handleless ball-related controls, and the position of the handleball in such controls will not depend on any of them. The overall change is caused by the change of the handle ball. After the user holds the gesture to update the position of the handle ball, the display state of the control can be updated according to the final position of the handle ball. Its realization method can be expressed as: set the position of the palm of the user’s current frame as H, then the updated position P of the handball can be obtained:

\[ P_i = H \] (1)

The box control is classified as a handle ball-related control. The position of all the handle balls will change due to the user’s interaction with a handle ball. The box control is composed as shown in Figure 1. It is composed of display points, whose positions can be expressed as P(i=1...6), C, D respectively. Let the position of the user’s hand in the current frame be H, the position of the center handle ball at the end of the previous frame is C, and the position of the box surface handle ball at the end of the previous frame is Pli (1=1...6), then the control moves in the mode, the handle ball changes according to the following rules: In the mobile mode, the user changes the position of the box control by moving the center handle ball, there are:

\[ C_i = H \] (2)

\[ P_i = P_{li} + (H - C_{li}) \] (3)

The rules in stretch mode are as follows: the user pulls the box handle ball through a grasping gesture, thereby changing the shape of the entire box interaction control, wherein the stretching of the box handle ball should not destroy the overall shape of the box interaction control, and should keep it as cube. Set the following correspondence R:

\[ R = \{\{P_1, P_2\}, \{P_3, P_4\}, \{P_5, P_6\}\} \] (4)

E.g:

\[ R(P_1) = P_2, R(P_{li}) = R(P_{li}) \] (5)

Then Pi can be expressed as:

\[ P_i = P_{li} + \frac{(P_{li} - R(P_{li}))(H - P_{li})}{|P_{li} - R(P_{li})|^2}(H - P_{li}) \] (6)
At this time, the handle balls except Pi and R(Pi) should be moved to the corresponding position Pj (where j represents the handle balls except Pi and Ri), and the positions of the remaining handle balls in the previous frame are set as Pij, and c can be obtained with Pj:

\[ C = \frac{P_i - R(P_i)}{2} \]  

\[ P_j = P_{ij} + C - C_i \]  

The rotation mode of the box interaction control is determined by the initial position of the user's hand when entering the state relative to the position of the center of the box control, set the position of the hand in the previous frame as H1 and the center position of the box as C (the position of the center of the box remains unchanged in the rotation mode.), the hand position of the current frame is H, the handle ball position is Pli, the rotation axis A and rotation angle \( \theta \) of the control can be obtained:

\[ A = (H_i - C) \times (H - C) \]  

\[ \theta = \cos^{-1}\left( \frac{(H_i - C)(H - C)}{|H_i - C||H - C|} \right) \]  

Finally, according to the rotation formula around any axis in three-dimensional space as shown in Figure 1, the rotation matrix \( M(A, \theta) \) can be obtained from the rotation axis A and the rotation angle \( \theta \), and then the coordinates Pi of each handle ball can be obtained:

\[ P_i = M_{(A,\theta)} Pl_i \]  

Figure 1 Schematic diagram of the implementation of box interactive controls

**Parameter configuration panel based on user gaze and gesture**

In order to meet the parameter configuration requirements of the visualization algorithm, an interactive interface based on user gaze and gestures is developed, and a parameter configuration panel based on user gaze and gestures is implemented in combination with the QT development framework. The working method of the interface is shown in Figure 2. After the interaction panel receives the collision point between the user's gaze vector and the interaction panel, it converts the world coordinate of the collision point into the plane coordinate based on the interaction panel through UV coordinate solution, and passes the plane coordinate.
coordinate and gesture confirmation event to the QT interface to trigger QT interface interaction logic.

Among them, the UV coordinate solution method is obtained from the HTC Vive Pro device that the user's gaze emission point is A, its coordinates are \((a_1, a_2, a_3)\), the vector is \(R\), and its value is \((r_1, r_2, r_3)\). Let the origin of the UV coordinates of the interactive panel be \(O\), its world coordinates are \((o_1, o_2, o_3)\), the normal vector of the interactive panel is \(W\), and its value is \((w_1, w_2, w_3)\), and the V-axis vector of the interactive panel is \(V\), Its value is \((v_1, v_2, v_3)\), and the U-axis vector of the interactive panel is \(U\), and its value is \((u_1, u_2, u_3)\). The available user gaze vector equation is:

\[
\begin{align*}
    x &= a_1 + r_1 \ast t \\
    y &= a_2 + r_2 \ast t \quad (12) \\
    z &= a_3 + r_3 \ast t 
\end{align*}
\]

The interactive panel plane equation is:

\[
    w_1 \ast (x - o_1) + w_2 \ast (y - o_2) + w_3 \ast (z - o_3) = 0 \quad (13)
\]

Lian Li (12) (13) can obtain the intermediate variable \(t\):

\[
    t = \frac{\sum_{i=1}^{3} (o_i - a_i) \ast w_i}{\sum_{i=1}^{3} W_j \ast r_i} \quad (14)
\]

Substituting \(t\) into Equation (1), the intersection point \(B\) of the user's gaze and the interactive panel can be obtained, and its value is \((x, y, z)\). According to the three-dimensional coordinate system transformation method, the intersection point \(B\) is changed from the world coordinate to the coordinate system with \(U, W, V\) as the coordinate axes, and the UV coordinate of point \(B\) can be obtained, which is expressed as \((u, w, v)\):
This chapter mainly expounds the implementation process of the GG-based immersive virtual reality flow field visualization system, mainly expounds the implementation methods of the interactive controls based on user gestures and the interactive panel based on user gaze and gestures.

**Result analysis and discussion**

The research conducted a questionnaire survey on "VR use intention and situation" for students and teachers who used virtual reality-assisted design in teaching experiments. The students distributed and recovered 41 valid questionnaires. Among them, there was only one valid questionnaire for students in the poor group, and the sample size was too small. Correlation analysis did not consider poor students; teachers distributed and recovered 23 valid questionnaires. The results of the questionnaire analysis are as follows:

### Reasons for using VR

The collected data are made into Figure 3 and 4. It can be found that in the multiple-choice question "Reason for using VR", the selection trends of students of different genders are roughly similar. auxiliary role. However, boys are more willing to use than girls in the four options of "first-person perspective (real experience)", "understanding space", "thinking ideas", and "convenient communication with teachers and classmates". " and "VR display effect is good" two options, girls are more willing to use than boys. This is due to the difference in the way of thinking between men and women. Boys are more rational and attach importance to the auxiliary design function of VR; women are more perceptive and attach importance to the visual performance ability of virtual reality.

The selection trend of students with different abilities on this issue is also very similar, but the subtleties are different: ① Compared with the excellent and medium groups, the good group students are in the "understanding space", "easy to communicate with teachers and classmates", "model available". The percentages of the three items are different, which is presumed to be the difference in the focus of the students in the good group, and they put more emphasis on the design performance function of virtual reality, hoping to improve the drawing efficiency and performance ability. ② Compared with the excellent and good groups, the students in the middle group have a higher proportion of "thinking ideas". It is presumed that the students in the excellent and good groups have good enough thinking ability, while the virtual reality has a better effect on the students in the middle group with relatively poor thinking ability. due to a strong auxiliary effect.
Figure 3 The percentage of reasons for using virtual reality among students of different genders

Figure 4 The percentage of reasons for students with different abilities to use virtual reality

VR applicable stage

As shown in Figure 5, teachers and students have the same order of importance of each stage. In order to improve expression, design evaluation, idea creation and preliminary research, the difference lies in the role of teachers in virtual reality in the other three stages except the perfect expression stage. Recognition is higher than that of students.
As shown in Figure 6, students of different genders rank the importance of virtual reality in different design stages in the same order. The order from strong to weak is perfect expression, design evaluation, idea creation and preliminary research. The difference is that girls have less confidence in the role of virtual reality in the perfect expression stage, but they are more confident than boys in the preliminary research and report and display links. The stage of conception, creation and perfect expression pays more attention to rational analysis, which is consistent with the rational way of thinking of men; women's perceptual thinking characteristics pay more attention to visual experience, so the attention of virtual reality in the stage of perfect expression is transferred to the virtual environment that can provide the venue and virtual environment. The preliminary investigation stage of the case and A presentation stage that facilitates design and expression.

As shown in Figure 7, the ranking of the importance of virtual reality in different design stages of students with different abilities is consistent with the gender classification. The difference is that there are large or small differences in the proportions of each stage. It is speculated that learners with different abilities have different emphasis on the functions of virtual reality. The students in the excellent group are excellent enough in their own abilities, and only need the three-dimensional performance ability of virtual reality to assist in the deliberation of space design, so they are higher than other groups in the stage of concept creation and perfect expression. Other stages are equal to or lower than other groups; students in the good group have a higher proportion in the early stage of investigation due to lack of design ideas and need to conduct relevant research through virtual reality; students in the middle group pay more attention to design performance, so they have a higher proportion in the presentation stage.
This chapter draws the following two conclusions through teaching experiments and questionnaire surveys:

(1) Through teaching experiments and data analysis, it is proved that virtual reality does have an impact on architectural design teaching, and the impact on students of different genders and abilities is different. The experimental results show that virtual reality has a positive effect on women but no significant effect on men; it has a significant effect on the students in the good group and the middle group, but the positive and negative effects coexist. Weak positive effect. Different types of learners also have subtle differences in the selection of questions in questionnaires, but there are also commonalities. In the "reasons for using VR" question, everyone believed that "first-person perspective (real experience)", "understanding space", and "convenient communication with teachers and classmates" were the main reasons for use; in the "VR application stage" question, they all believed that the order of importance of VR application stages from large to small is perfect expression, report display, idea creation and preliminary research.

(2) Comparing the results of the teaching experiment and the questionnaire survey, it is found that the reason why virtual reality has both positive and negative effects on the students in the Liangzhong group may be caused by the differences in the students' own attention to virtual reality.

The teaching experiment data shows that virtual reality has a significant impact on the students of the good and middle groups, but it has both positive and negative effects, and it has a positive impact on students with other ability levels; students with these two abilities in the questionnaire are in the "reasons for using VR". The choice tendency in the question is also often different from that of students with other abilities. It is speculated that the negative impact of VR on these two types of students is caused by the difference in the students' focus. Virtual reality may have a positive impact on learners; when there is a significant difference in the focus of students of a certain ability level with students of other abilities, virtual reality may have a negative impact on the group of students. And this difference in focus most often occurs in the Liang and Zhong groups, so the impact of virtual reality on such students is the most unstable (both positive and negative).

According to the above data and conclusions, it can provide support for the following determination of the impact path of virtual reality and the comparative analysis of virtual reality teaching and traditional teaching.

**Conclusion**

Virtual reality technology can make the interaction between users and computers more natural, just like the interaction between humans and nature in reality, users are completely immersed in the virtual environment generated by the computer, resulting in an immersive interactive look and feel. Teachers use virtual reality technology to make the teaching courseware of "Landscape Architecture Design Course", which enables students to feel the design method of garden space more intuitively and improves the teaching efficiency. At the same time, virtual reality technology brings immersive experience to students. Students seem to be in a real garden space, constantly scrutinizing their own design, and judging whether the scale of the space they design is reasonable. If there are any deficiencies, they can adjust the design plan in time, improve the learning efficiency of students. The operation technology of virtual reality is relatively simple and easy to master, and students can proficiently generate virtual reality garden models, so as to scrutinize the scheme repeatedly in the design process, feel the design effect, and improve students' interest in learning. When students communicate and display their homework results, the new display mode will be more easily accepted by the public. In terms
of teaching costs, the existing virtual reality technology can be combined with the Internet to generate links to the garden space, and display them in the computer and mobile app. Teachers and students can use simple VR glasses or hand-touch models to scrutinize, greatly reducing the cost of traditional teaching. The cost input of wood, plaster, concrete, plastic, metal and other materials in model making also saves students' time.

Data availability
The figures used to support the findings of this study are included in the article.

Conflicts of interest
The authors declare that they have no conflicts of interest.

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Reference