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Research on the Training Method for Involving VR Technology in Interior Design*

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Abstract—The research in this paper originates from a rethinking of interior design training method after involving new technology in it. Due to the extensive application of VR technology, the spatial logic, morphological composition, texture organization, and furniture styles of interior design are displayed intuitively by virtue of its three characteristics such as immersion, interactivity and imagination. This technology can help designers forming good spatial perception ability and solve the problem of insufficient expressiveness of traditional design aids freehand sketching and models. But students pay more attention to the perception of specific information, such as the choice of materials, furniture styles, lighting effects, etc. Such interior design often has good local decoration effects, but the overall order and effect of the entire interior design is not so ideal, such as the inconsistent styles, chaotic lighting effects, and unreasonable material mix. How to deal with the new contradictions brought by using VR technology to resolve interior design perception problem becomes the focus of consideration.

The idea of kit-of-parts was born from the unremitting exploration of space topics by the modernist architecture movement. This training method has been passed down from the 1950s to the present. In a series of exploration made by Chinese and foreign universities, a set of mature, stable and unique teaching system was gradually formed. As an effective space design exercise, kit-of-parts training method has been successfully applied in the basic teaching of architectural design. Its characteristics of abstraction, preset elements, and component operation make the study of spatial forms concerned in more targeted way and help to complete a complicated design process in clearer and more intuitive way and can effectively assist in cultivating logical design thinking and rational design decision making ability. In view of this, this paper attempts to transplant the kit-of-parts training method into interior design, and proposes corresponding improvement strategies for solving a series of problems that the interior design faces in space research and guiding the design practice.

The first part of this paper focuses on the problem of contradiction between specific perception and overall order when VR technology is involved in interior design; the second part analyzes the reasons for the contradiction through literature review and case studies, whether it is available to solve this problem in the existing interior design method and explores new methods for solving the problem; the third part analyzes the feasibility of applying kit-of-parts training method to interior design, and discusses the specific method for transplanting kit-of-parts training method in the VR technology involved interior design; the fourth part makes exploration and practice on specific project on the basis of the strategy proposed on the basis of the kit-of-parts training method and taking VR technology as the main means to deliberate the design scheme.

Keywords: VR technology, interior design, training method

I. INTRODUCTION

In the previous interior design teaching, work model and electronic modeling were important tools for perceiving and grasping the overall design in the design process. In recent years, VR technology has been more and more widely used in interior design. With its three characteristics of immersion, interactivity, and imagination, the technology can be used for intuitively showing the spatial logic, morphological composition, texture organization, and furniture style of an interior design. It well compensates for the deficiency of two-dimensional representation of drawings, and helps designers to form good spatial perception ability. It is a powerful technique currently to solve the problem in perceptual design of students and practitioners. But after VR technology is involved in interior design, more attention is paid to the perception of specific information such as the choice of materials, furniture styles, lighting effects, and so on. Such interior design often has good concrete materials, but the formal order effect of the entire interior design is not so ideal. So how to deal with the new contradictions between the concrete perception and formal order brought by using VR technology to resolve interior design perception problem becomes the focus to be researched.

At present, the focus of theoretical and applied research is generally on helping designer to practically feel the proportion of space layout, understand the interior materials, lighting and other factors, refine those elements and adjust the design scheme after involving VR technology in the design. Marxent's latest research achievement, Holoroom application, combines VR technology with interior decoration of kitchen. It is available to use this application in combination with VR technology and HMD to show customers the interior decoration, decoration details,

removable furnishings and so on as well as a preview of the decoration effect [1]. Prof. Wu Junting from Central South University once issued a paper named "Exploration of Virtual Reality Technology in the Teaching of Residential Interior Design". In his research, MARS virtual simulation technology was used for experiencing and designing the special notes in residential interior design such as lighting arrangement, furniture style, color configuration, and movable decoration configuration. In real three-dimensional environment, the new technology is used in interior design at the perceptual and rational levels. In Zhou Yong's master's thesis "Application of VR & AR Technology in Interior Design" [2], VR technology was used for previewing the changes in the interior scene, floor, furniture and sanitary fittings and walls of the Bank of Chongqing in advance and various problems that may be encountered in interior design was solved.

According to the above researches, it can be found that the current VR technology has been widely used in the design field. It is commonly used to turn design ideas into visible virtual objects and environment, enhance the observation and perception experience, realize "what you see is what you get", and improve the quality and efficiency of the design and planning. However, there is lack of further exploration on the contradiction between concrete perception and formal order as brought about by involving the new technology in interior design; the current interior design cannot solve the problems brought about after the involvement of VR technology, resulting in an awkward situation that it cannot adapt to the new technology.

II. PROBLEM ANALYSIS

A. Reasons for the contradiction generated between concrete perception and abstract order

Semper used original shanty to trace the original motive of the building. This shows that building is never an abstract being, but requires to be constructed by specific physical materials and technological procedures [3]. Vitruvius also discussed the important impact of the characteristics of bricks, sand, stone, wood and other materials and the processing procedures on the final construction in detail in the second volume of the Ten Volumes of Architecture. He believed that the characteristics of materials are related to the form they are presented, and the architect's creativity lies in discovering the "potential similarities" between them. This attention to materials and craftsmanship further illustrates the materiality and specificity of architecture [4]. Design of the interior of building is a process of materialization and materialization. All the functions and comfort provided to people are based on material conditions. All walls, floors, and rooms are subject to constraints of objective construction. Professor Zheng Shuyang mentioned that since the construction of building, decoration has been changed in styles with the change of the architectural style, so the concept of decoration inside building is deep-rooted and easy to be understood [5]. In a long history, materials and structure are the main contents of the interior of building, and decoration design has become the pronoun of interior design.

If the main driving force for building development is construction technology, the study of materials and processes is the main driving force for the development of interior design. The concrete elements have also become the focus of attention.

Similar to the discussions in architecture circle, the confusion of understanding and cognition in interior design is mainly on the ambiguity and abstraction of the space concept and mainly comes from two aspects: on the one hand, the concept that usually takes decoration as the design content puts the work focus on the concrete treatment of solid surface, and compared with the style or material and technology, space is an abstract topic not mentioned in interior design; on the other hand, for beginners of design, "space" is an abstract term. The word itself is a concept between existence and non-existence. It is neither visible nor touchable, but it is closely related to people's daily life in the building. Physical entities can always catch our eyes visually. How to make hidden space issues stand out and help us focusing on the design and research of interior space is a serious difficulty faced in the current interior design practice field. In the early development stage of interior design in China, art research was the main content, and basic research related to interior space was lacking, leading to a large number of designers' understanding of the concept of "interior space". Because space itself is void, people are easily attracted by tangible physical entities. People often subconsciously think that the "space" in the space environment has no special practical meaning, and only the "environment" is meaningful. To some extent, the misunderstanding of "interior space" seriously hinders the advancement of space design research.

Frampton compared the contradiction between construction and form to the ideological conflict in Mies's architectural career. His works painfully struggled between the technology of the times, the classical tradition and the abstract aesthetics, which seems to show that abstraction and concreteness are like fish and bear's paw that you cannot have both of them. Concrete materials and technologies are the focus of people's attention at present, and are also the original motive of construction that cannot be ignored. As a key topic in current architectural circle, space has its own characteristics of void, vagueness and abstraction, so that designer ignores the attention to spatial order and form when designing and is attracted by tangible architectural components or internal facilities. As a result, the rich spatial experience is greatly weakened and replaced by sculpture and refining of concrete materials. At this time, there is a contradiction between concrete perception and formal order. How to focus on the abstract formal order when designing is the problem to be solved at present.

B. Analyzing availability to solve this problem in the existing interior design method

As a part of architectural field, interior design has undergone many iterative changes since it entered China in the 1950s. Finally, it gradually became stable in design techniques and teaching content. By reading, investigating and comparing the interior design textbooks of several

universities in recent years, it can be found that there are certain generality in interior design training methods.

Zhang Shuyang from Tsinghua University mentioned in the "Interior Design Procedures" the basic methods and steps of interior design: the first is graphic thinking; functions are gone over through investigation, common sense of life, and site investigation; this step has abstract logic, and will eventually present a functional analysis diagram. The second step is function adjustment. Through trials and comparison, the relationship between various functions is grasped and adjusted as a whole. The third step is to implement the above function analysis on the plan and effect sketch. The "Basics of Interior Design" [6] prepared by the Department of Environmental Art of the China Academy of Art and the "Interior Design Principles" prepared by Lai Zengxiang of Tongji University also show similar methods: the first step is to make a functional analysis according to the design requirements and design tasks; the second step is to study the function zoning and traffic flow lines; the final step is to deliberate the above functions and get it expressed in the plan drawing, and analyze the perspective drawing. The design method followed by the above textbooks has two significant features: emphasis on functional analysis and emphasis on hand-drawn technical drawings [7]. This training method focuses on the functional logic in space, and the content expressed will also be reflected at concrete levels such as the graphic effects, specific functional forms, styles, and decorations. The result often shows good graphic effect, lies in form and with outstanding local decoration effect; but the practical spatial experience and abstract order are not as expected. Such a training method cannot resolve new contradictions after involving VR technology in. It may even intensify the generation of contradiction between concrete perception and abstract order because of the intuitive feeling of 1:1.

C. Exploring new methods for solving the problem

The moving from material technology to spatial awareness is actually a process of transformation from concrete perception to abstract order. After involving VR technology in interior design, this contradiction has not been resolved but be even intensified. The materiality of interior design determines that the behavior of interior design is necessarily based on specific materials, but the process of making and using materials inevitably causes the designer to keep an eye on the concrete perception because material has the meaning of concreteness-abstraction. This research hopes to use VR technology as a medium to find a method transition path for moving from concreteness to abstraction and from specific material to spatial awareness.

III. METHOD REFERENCE: THE CHARACTERISTICS AND TRANSPLANTATION OF THE KIT-OF-PARTS TRAINING METHOD

The kit-of-parts training method is derived from the nine-grid practice proposed by Hejduk and Slutsky, members of the Texas Mounted Police in the 1950s. They combined a sculptural training similar to "three-dimensional composition" with structural content such as beams and columns of the building and formed into a new architectural

design method which became the prototype of the later "Zurich system". The research focus of the kit-of-parts training method is on the space form, and the rest decoration, climate, materials, and craftsmanship are not the primary considerations. This design method has two characteristics in teaching: first, parts are abstracted. In nine-grid practice, a 3 $\times$ 3 grid frame is set as the basic structural system. Students can use abstract parts for design practice. For example, a pole, an undecorated slab and a pure block can be placed in the grid frame and be respectively corresponding to the beams and columns, walls and rooms of a building. These abstract parts weaken the decoration and materials, helping designer to focus on the spatial form. Second, this method emphasizes the organization of parts. Students can directly use models as tools to intuitively perform spatial operations and exercises, and then make data models.

The classic part of the kit-of-parts training method is that in the form of abstraction, it avoids the interference of all visual decorative factors. The abstracted component and the intuitive operation of parts help to focus researches on the space problem itself. This provides a key methodological inspiration to the improvement of traditional interior design teaching. The kit-of-parts training method has been successfully applied in the teaching of basics of architectural design in theory and application practice. In the abstract form, it avoids the interference of visual decoration factors, and focuses on the design of overall order itself. This provides a key inspiration to the improvement of traditional interior design training method.

In terms of basic theoretical research, the book "Texas Mounted Police" written by Alexander Caragonne systematically discusses the historical background of the birth of the first kit-of-parts training method: nine-grid exercise. In the "Concept of Kit of Parts", Timothy Raff analyzes the ideological basis and research prospects of kit-of-parts training method. In "Harvard Bauhaus to Texas Mounted Police: Colin Rowe's Legacy", Zeng Yin in School of Architecture and Urban Planning of Chongqing University discusses in detail how Colin Rowe, the important founder of the kit-of-parts training method, gave birth to this important idea changing the development path of modern architecture step by step against the background of architectural researches at that time in the United States.

In terms of applied research, the "Space Operation: The Foundation and Rethinking of Modern Architectural Space Design and Teaching Research" written by Professor Zhu Lei in the Southeast University makes a research on architectural space from three aspects (the space design operation mode, analysis of space operation, teaching practice of space operation) and determines the value of space design and teaching research. The construction experiment of the Chinese University of Hong Kong was developed by Professor Gu Daqing. He also wrote the book "Space, Construction and Design". In this book, he clearly and completely describes the research on space dominated by "pole, slab and block" taking the kit-of-parts training method as the prototype, and well demonstrates and explains the way

to do design practice by taking the kit-of-parts training method.

The kit-of-parts training method was born from the unremitting exploration of space topics by the modernist architecture movement. After decades of practice and continuous reform, this method has formed a relatively mature and stable ideological system with its own characteristics in the successive explorations of a series of Chinese and foreign institutions. It interprets an objective and rational design method with a new attitude and is worthy of exploration and reference in theory and practice. Discussing it in combination with the problems encountered in space research by interior design can help solving the problem of transformation from concrete perception to formal order as brought about by involving VR technology in interior design.

IV. SOLUTION

A. Method: abstraction and organization of parts

In view of the macro perspective and integrity principles of architectural design and the interpretation of the kit-of-parts training method, it can be understood that the differentiation and abstraction of spatial elements are the basic concepts of spatial awareness, and the organization and operation of abstract elements are the process of transforming from "concrete perception" to "abstract order". This concept is of great significance to inspire resolving the contradictions brought about by involving VR technology in interior design.

In the kit-of-parts method, the form of elements is preset as rod, slab and block. The preset design conditions on the one hand weaken the concrete stylistic features and focus on the research of abstract form of space itself; on the other hand, the conditions adapt to the processing methods of building materials in the industrial era. How do the three elements come about? The feature of block is the clear occupation of space ("Fig. 1"). Block is a void being enclosed by the shape of a square box; the internal space is void and plays its role. Therefore, block corresponds to a room with a certain function, and the blank space between blocks forms an open space. Slab has a delimiting effect ("Fig. 2"), so that the space forms two separate areas and the slab becomes the boundary between the two spaces. Their connection or dislocation or bending can be treated as building components such as walls, ceilings, and floor slabs. The feature of pole is to adjust a space ("Fig. 3"), so that the space and the surrounding environment retain visual and spatial continuity.
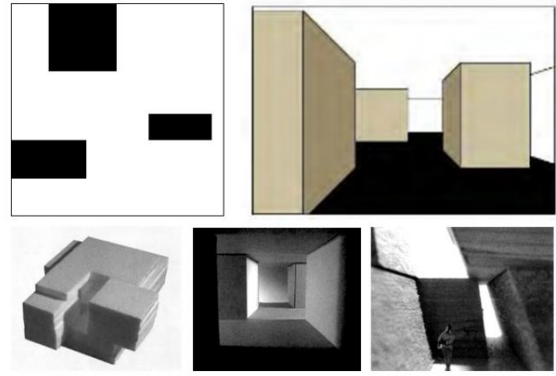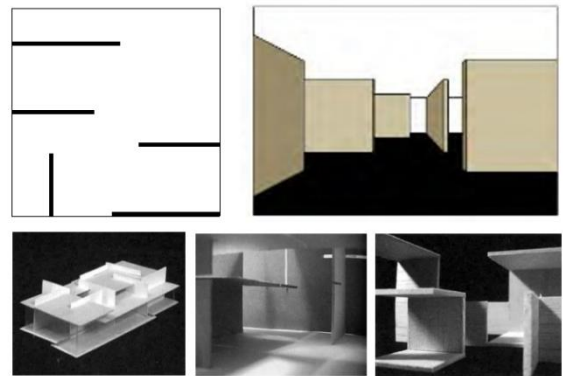

Fig. 1. Block- occupy (Pictures from the Internet).

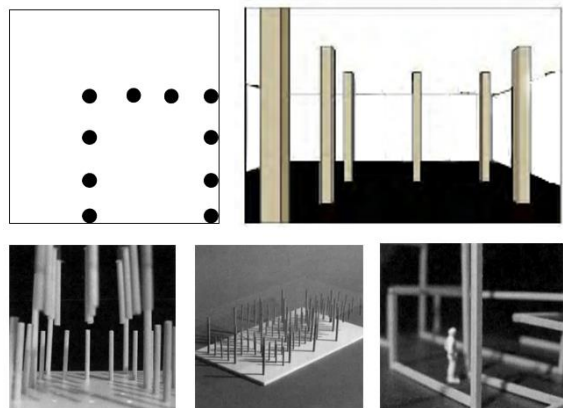Fig. 2. Slab – define (Pictures from the Internet).

Fig. 3. Rod – adjust (Pictures from the Internet).

After abstracting the real and concrete building components, how to organize these complex and diverse components is the key point in transplanting the above method. For the design of internal space, clear abstraction of concrete components only provides the basic formal language. The generation of spatial form also requires further operation and organization: as for the operation of block, by operating an introverted block, it is possible to form a private space while maintaining the continuity and graphics of the "empty" area. As for the operation of slab, slab can be used for defining and dividing a space, forming a flowing and continuous space while still having a space form. Regarding

the operation of pole, the density of a space can be adjusted by adjusting the spacing arrangement of poles in the space. Different spatial experience and form can be formed by adjusting the density of poles.

B. Practice

In this research, the transplantation of the said method was tested on the interior design class of junior students majored in environment art design of South China University of Technology. The topic of the course is the design for renovation of a family hotel. The functional logic of the hotel is the foundation and the generation logic of the space form is the training goal. After the site survey and question summary, students need to generate some spatial form in the model operation to deal with the questions acquired from the survey. The first step in the course design is to abstract the interior furniture, building components, etc. into poles, slabs and blocks. For example, a bed can be represented by slab or block, and the partition wall can be abstracted into slab or pole as required. Abstract and simplified components make students ignore the decorative and surface styles and focus on the organization of space. The second step is to directly use a model to observe the combination effect of the components, and consider the impact of changing the size and position of components on the spatial form. Solid model plays a more intuitive and efficient role than drawing, and students' operation of the spatial form is more clear. In the training process, abstraction processing makes the focus of design practice fallen on space, rather than complex solid components and furniture, so that it is possible to truly understand the spatial relationships, spatial forms, and spatial scales. And functions and decoration can be added in the further deepening of the subsequent plan step by step. In this way, the design achievement is right a design with good space experience and not monotonous.

The third step is to model the abstract model in SU, and then lay the data model into Mars software for VR observation. In the virtual reality environment provided by Mars software, students can perceive rich spaces by 1: 1, and observe the contrast and changes between spaces from the spatial sequence, such as the space size, shape, proportion, direction, and displacement of sight, changes in the amount of light entering the space, etc. Through VR observation, the form and spatial language of the designer can be clearer when designing, and the spatial operation is clearer. This way can avoid the clutter and blindness of operation and help distinguishing the operation methods used in the design, and verifying the design result from the experience of the space. At the same time, after using VR technology, a distinction can be made between the elements of the original single material. The distinction means difference and contrast, and means to establish a new order between elements and space on the basis of the original order and to seek richer expression content based on the abstract form and expression of space. Three characteristics of materials mainly considered in VR are texture of materials (such as the contrast between wood and metal materials), color and light and shade (such as the contrast of walls of various colors) and material transparency (such as the contrast between

transparent materials, translucent materials and opaque materials). The impact of the distinction of materials on spatial perception can be perceived through immersive observation (see "Fig. 4" for the results).

Fig. 4. Scheme model and effect diagram (Image source: Self-painted by the author).

V.   CONCLUSION

VR technology has already been widely used. It has three characteristics such as immersion, interactivity and imagination. On this basis, it can be used for intuitively showing the spatial logic, morphological composition, texture organization, and furniture styles of an interior design, helping the designer forming good spatial perception ability and solving the problem of insufficient expressiveness of traditional design aids based freehand sketching and models. However, students often pay more attention to concrete perception, such as the processing of materials, furniture

styles, lighting effects, and so on. Such interior design often has good concrete effect but not that ideal in abstract space order. So after involving VR technology in interior design, how to realize the transformation from concrete perception to abstract order becomes a difficult problem. The kit-of-parts method as an effective space design exercise has been successfully applied in the teaching of basics of architectural design. Its characteristics of abstraction, presetting elements, and parts operation attracted more attention from the study of space form in more targeted way. This method is conducive to completing complex design process in more intuitive way and effectively assisting in cultivating logic design thinking and rational design decision-making ability. In view of this, this research tries to transplant the kit-of-parts method into interior design, and puts forward corresponding improvement strategies for solving a series of problems in space research of interior design and guiding the design practice.

The abstraction of building components can be realized in the training process and restore the most authentic form of space composition. Abstraction processing makes the focus of design research fallen on the treatment of the problem of spatial abstract order. What is perceived by intuition is no longer a concrete element, but the problems of spatial relationship, spatial form, and spatial order. In the deepening of the design plan, it is possible to add functional factors gradually and further discuss the strategy for organizing the functional spaces so as to establishing a correspondence between specific operation logic and practical purpose. The transplantation of kit-of-parts training method solves the difficult problem in transforming the concrete perception to abstract order after involving VR technology in interior design, and also attracts targeted concern from researchers of interior design.

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