

Application of Multidisciplinary Approach Based on Innovative Thinking Training in Design Education

—— Taking Environmental Design as an Example

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Abstract: In recent years, the design discipline has gradually developed into an interdisciplinary discipline. Under the social background of the parallel development of contemporary art and science and technology, the discussion of design methodology has gradually turned into a multidisciplinary direction, thus reflecting the scientific and practical nature of the design discipline. Starting from the logical composition of axiomatic design, design affairology and service design, this paper discusses its application in this discipline through related cases, studies the use of the above-mentioned design methods in related fields, and expounds their methods and promoting effects on the cultivation of innovative thinking. Finally, combined with the classroom teaching of environmental design, the above design method is applied to teaching practice, and its influence on students' innovative thinking training is analyzed. Moreover the logic and feasibility of students' innovative thinking is improved by using multidisciplinary approach.

1. Introduction

In recent ten years, China's design education has an obvious tendency of internationalization, which is closely related to the emphasis on innovative thinking in design education. With the increasing influence of Chinese manufacturing in the world, China has attached more attention to the cultivation of innovative ability and innovative thinking.

The understanding of innovation in the design field is relatively fixed. Namely, a kind of design activity between "improved design" and "conceptual design" is called innovative design. It is called innovative design because "it improves the quality of our work, consolidates the competitive position of enterprises, and has a fundamental impact on our economy, society and technology. So, we call it innovative design instead of calling any new design an innovative design."^[1] It can be seen that the definition of innovation in the design field is closely related to its actual benefits and social and economic values. In China, design belongs to the art category as a hole, but the environmental design under the overall design framework has a special interdisciplinary attribute compared with other disciplines. Environmental design includes external environment and internal environment in definition. The design of external environment is closely related to urban planning and landscape, and the internal environment is inseparable from architecture. As a result, environmental design educators not only discuss formal innovation from the artistic point of view, but also pay attention to the interdisciplinary nature of environmental design. Therefore, this paper proposes to learn from the design methods and innovative methods of other disciplines to cultivate students' innovative thinking.

2. Application of multidisciplinary approach in design education

Some design powers lay great emphasis on the discussion of design methods and thinking in design education, and they also attach great importance to the cultivation of students' innovative thinking, which is closely related to their scientific and perfect discussion of design methods and long-term

scientific practice. These are also the contents lacking in design education in China at present. In addition, although there are related courses with design methods in design education in China, students often fail to recognize the method to link the contents of methodology study with the actual design work in design. As a result, they despise design methods, pay less attention to design thinking and more attention to drawing expression, neglect the engineering properties of environmental design and overemphasize its artistry. Therefore, the introduction of engineering-related design methods into design education and the use of innovative methods and design composition models in its methodology will help students to give full play to the interdisciplinary nature of design discipline based on their own disciplines.

2.1 Axiomatic design

Axiomatic design was put forward by Professor Nam Pyo Suh of Massachusetts Institute of Technology in 1990. It was mainly used in the field of mechanical design and design decision at first. With continuous improvement and renewal, axiomatic design has gradually become a scientific criterion in the field of design. It divides the design process into four domains: user domain, functional domain, structural domain and process domain. The domains keep mutual linkage relationship (as shown in Figure 1). "The domain on the left relative to the domain on the right represents 'what we want to achieve,' where as the domain on the right represents the design solution, "how we propose to satisfy the requirements specified in the left domain."^[2] After years of practice, axiomatic design has been widely used in engineering design, mechanical design and other fields. Based on the process of axiomatic design, many improved design schemes and innovative design methods have been developed. Concurrent design and robust design have been developed for mechanical and engineering fields. At the same time, the software AACLARO-DFSS has been designed in combination with relevant mathematical models, and the design process is expressed in the form of mathematical matrix, thus quantifying each link of the design. Based on the application of axiomatic design in system design, engineering management, intelligent control and other fields, it is introduced into the teaching of environmental design. The process of environmental design is divided into four parts (as shown in Figure 2), including user demand analysis, material design, construction technology requirements and management system design of the whole space. The relationship between various design processes in the process of environmental design is discussed from different fields, so as to achieve the purpose of effective use of space and artistic expression. axiomatic design makes use of the expression form of design matrix to model the relationship between domains in the design process, and makes mathematical analysis for the overall design logic to help designers find out contents needing improvement and innovation in the overall design.

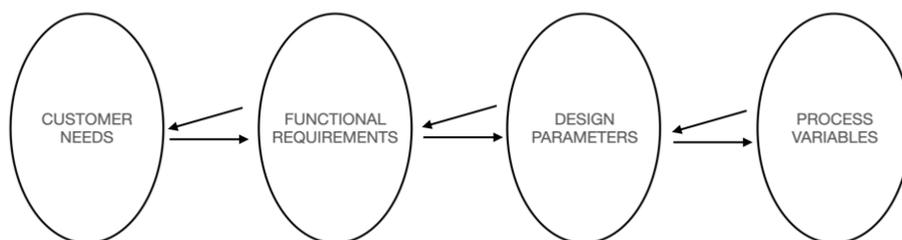


Figure 1 The process of axiomatic design

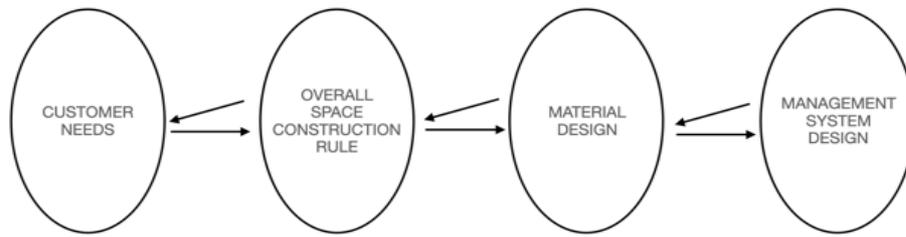


Figure 2 Transformation of axiomatic design method in environmental

In addition, from the perspective of BIM and building industrialization, space design is also developing towards prefabrication and modularization. Using axiomatic design method to build module library and basic model management mode can also effectively solve the composition of space function. The application of axiomatic design method in the teaching and practice of environmental design is in line with the interdisciplinary attribute of design, which can promote the development of the combination of art and science and technology, and is also beneficial to the expression of engineering attribute in design discipline.

2.2 Design affairology

Design affairology is a design theory put forward by Professor Liu Guanzhong in 2006. It is a design methodology put forward from the perspective of industrial design under the background of green design, information design, experience design and sustainable design, based on the social and historical background and design development of China. He summarized design from "things" to "affair" and from "feelings" to "substance", and understood design behavior as a process of coordinating the relationship between internal and external factors, and optimizing the utilization and creativity of external resources. Artificial design products projected people's ideas and purposes, and condensed people's strength, labor, production and creation (Figure 3). Professor Liu Guanzhong stated in the book 'Science of Human Affairs' that "using scientific methods and means to design is called design science and creating and expressing emotions and beauty in an artistic way is called design art. Artistic imagination and scientific methods are integrated in design, artistic creation and scientific analysis."^[3] That is to say, design draws knowledge from science to explore a reasonable way of life for human beings; design chooses technical means to realize itself; design obtains the expression of beauty, value and emotion from art. In sum, the concept of design should be the combination of science, art and technology.

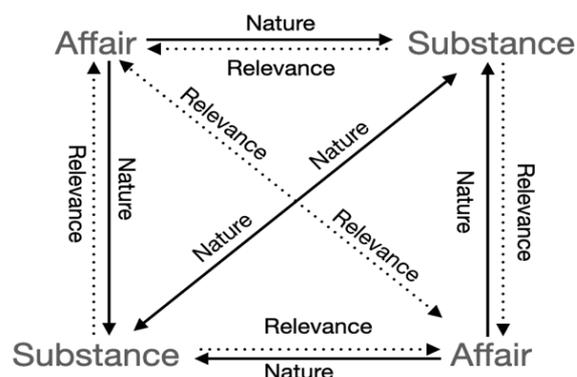


Figure 3 The relationship between "affair" and "substance" in design affairology

Seen from environmental design, particularly the external factors of design, the external factors affecting environmental design are immutable, which include various design specifications, limited spaces, various construction methods and materials. The designer can not change these existing external conditions, but can only use resources to create reasonably to the maximum extent, while the designer's ability is reflected in his/her coordination ability and creative activities in the reorganization of various resources. From the perspective of education, many of the above fixed factors come from the basic knowledge provided by design educators for students, and every design behavior means the organization and creative use of controllable resources. The creativity includes the understanding of "affairs" and the "feelings" expressed by designers in their works. Design affairology regards the space of environmental design as the product of target system, and the process of establishing target system is the process of "designing and positioning" things. Generally speaking, the purpose of design affairology is to understand users' needs, define design goals and external factors. The theories of design affairology are "dynamic, relational and pluralistic".

2.3 Service design

Service design is a method of design work, which usually refers to the design of systems and processes, aiming at providing users with all-round services.^[4] Service design method refers to the design process, and service design education is a briefing and counseling process. Service design has been widely used in product design, graphic design, social design, interactive design and other fields. Introducing service design thinking into the education of environmental design can help designers get users' needs quickly. In addition, service design also provides a variety of ways to obtain information and logical combing methods. The main methods are:

2.3.1 Stakeholder diagram

The purpose is to draw an easy-to-understand summary, point out the existing problems and analyze the potential improvement opportunities, so as to concretize the complex situation that designers need to face.^[5] The stakeholder diagrams can help students quickly understand the needs to be met by space, so as to refine the design and complete the design scheme from the perspective of multiple users.

2.3.2 Service travel

Service travel with emphasis on experience design, it explores good and bad design contents from existing cases, which can be regarded as students' early research on projects and students' understanding and analysis of cases in the design classroom. Through service travel, the customer experience process diagram and service design flow chart are completed, and through the contact point between users and services, students can better understand that the key of environmental design is to create continuity for space instead of dividing space into independent functional spaces. In addition, in the past design teaching, design thinking has always been emphasized to focus on "problems", which refer to the relationship or contradiction produced when many elements of design are intertwined. A good design must organize the problems as a whole.^[6] The manifestations of problems are usually expressed through the relationship between phenomena and phenomena, and between phenomena and external factors. Service travel can quickly help us find out where the problems lie and the parties involved in the problems.

According to the design method provided by service design, the design process in the service design methodology system is considered to be linear, but in actual design projects, the design process is usually non-linear. Whereas its composition adopts iterative method. That is, in the whole design work implementation, each step may go back to the previous step or even start from scratch.

Therefore, starting from the thinking of service design, the first step of design should be the design of the whole design process, that is, the iterative process of exploration, creation, thinking and implementation. The advantage of being able to express the design process clearly is that it can stimulate the designer to further think about the impact of the results. In the exploration part of the design process, the service design puts forward a double diamond model (Figure 4) to help designers constantly think and improve the design process and key points in the overall design and detailed design. The creation stage is the concept formation stage of the whole design process, which is closely related to the thinking stage, and is a process of constantly revising ideas and concepts. In this process, the characteristics of service design thinking is also reflected- namely not avoiding mistakes, but finding as many mistakes as possible and drawing lessons from them. This method also encourages students to dialectically look at the problems in the design stage, thus reducing the cost loss caused by mistakes in production. The rethinking stage is to verify the ideas put forward in the exploration and creation stage and collect feedback to improve the design. The focus of the rethinking stage is to test the design subject under approximate real conditions, so as to get real feedback information. The implementation stage is the final stage of service design for design, and it is also the embryonic stage of a new design. The implementation process includes the initial stage of design process, that is, exploring the innovative direction of design. There will never be an optimal design, only a better design than the previous one.

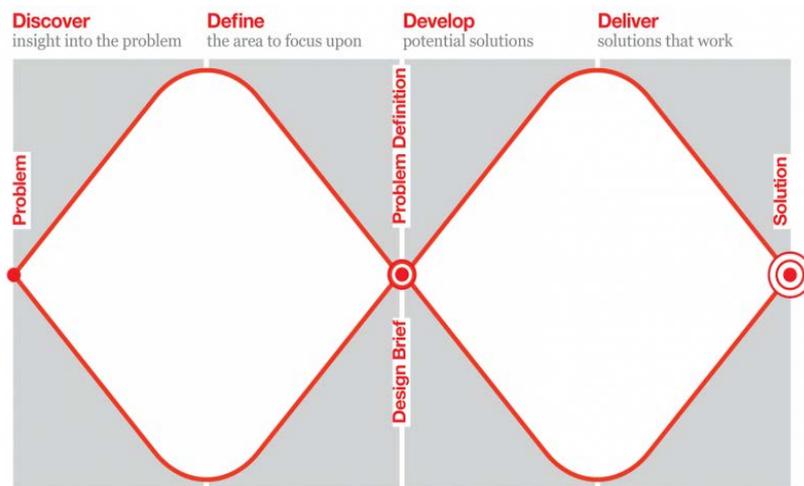


Figure 4 Double Diamond Model of Service Design

Figure source: <https://www.designcouncil.org.uk/news-opinion/design-process-what-double-diamond>

3. Reform methods

3.1 Curriculum evaluation system focuses on the expression of design process and the performance of design thinking

The existing curriculum evaluation system in China mostly adopts the method of combining the usual performance with the final performance. The usual performance includes students' attendance, classroom performance, homework, class discussion, etc. The final performance is judged by homework after the course. The usual performance contains few contents that can reflect students' design thinking and design methodology, which also makes students often ignore the expression of design methods in peacetime. Therefore, adopting OBE curriculum evaluation system to make students' scores correspond to the teaching objectives and emphasizing students' expression of design thinking in teaching objectives can effectively improve students' understanding of design thinking

and help them pay attention to design process in design, thus cultivating their application of design thinking and design methodology.

3.2 Focusing on interpretation of practical application

In the teaching of design methodology, environmental design lays less than other design majors. The theoretical courses offered by design majors often emphasize the theory of environmental design history, engineering materials and budget, introduction to interior design, ergonomics and related theoretical contents in engineering fields. The explanation of design methods is usually completed by teachers in the teaching of professional courses, and students do not fully understand them. Therefore, in the teaching of environmental design methodology, students should be guided not only to learn design methods from the perspective of professional methodology, but also learn from other related design fields. In the training of professional courses, students should be made aware of the importance of methodology to design and the expression of design thinking in professional fields, so that they can master design methods and design purposes and have a deeper understanding of design work.

The discussion and study of design method is characterized by "people-centered" method, which is manifested by designers' cooperation mode and participation mode of co-creation. At the same time, people's access to information is diversified and complicated, which makes users of design products expect to join in the design. As a result, the design problems faced by designers are changing from "aiming for users" to "co-designing with users".^[7] In the completion of the whole design practice project, we should not only contact with colleagues (other designers, engineers, marketing specialists), but also consider the stakeholder team of the project to cooperate to solve problems. That is, we should train students' ability to solve problems and their ability to solve various problems at the same time. The training of students in this field mainly includes the training of problem analysis ability and communication ability, which requires students to have relatively perfect project elaboration ability and communication ability, and be able to clearly explain their own thinking and the content to be expressed. The students need to have a complete logical expression and logical thinking mode for the problems they think in the design process. Therefore, helping students understand the scientific nature of design through the design methods of other discipline, can effectively train their innovative ability.

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