

## Research on the Innovative Application of Diagram to the Cultivation of Environmental design Professionals

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**Keywords:** Diagram; Environmental design major; Personnel training; Creativity; innovative ability

**Abstract:** In a society where information and urbanization develop at an accelerating speed, culture and innovation have become the core competitiveness of every country. Universities in China have also shifted their emphasis from skills training, to the cultivation of academic thinking, and independent thinking ability to cope with social change and scientific and technological progress. As an emerging design discipline, environmental design major, boasts a short history with a high-speed development rate. Based on such situations, this paper illustrates the significance of diagrams to the cultivation of creative and innovative ability of environmental design professionals, and enumerates some implementation methods through expounding the diagram characteristics, creative function and its role in the cultivation of environmental design professionals.

### 1. Introduction

In an era with rapid development of information and fragmentation of network information, the ever-changing digital media and diverse design trends, are gradually moving towards self-growing design thoughts, such as ecological, regional, and constructional design ideas. Besides, the great progress made by computer technology, and the application of nonlinear scientific theory, they have formed the nonlinear design theory, and led to the exploration of nonlinear environment design under its guidance. Threatened by the growing popularity of 3D computer model drawings, as opposed to the hand-drawn design sketch, especially the graphical analysis chart, will this be gradually replaced? Does the use of diagram still have an effect on the training of design talents? How will the use of diagrams help to cultivate and improve students' innovation and creativity in the environmental design professional training model?

In the 1980s, China achieved great advances in economic development, which also gave birth to, and prompted, the rapid development of the environmental design discipline. In the current information age, culture and innovation have become the core competitiveness of the country. The major concerns with design in higher education, have received much attention due to the direct transformation relationship between culture and artistic creation. As the main branch of art design, environmental design majors share teaching resources with architectural design, landscape design and environmental art design, directly serving social development and project construction. Although keeping pace with the era, it's still accused of imperfect theory system and teaching structure system, lack of creative teaching model, and individualized teaching thought. At present, the education concept of universities has shifted from focusing on skills training to the cultivation of academic thinking and independent thinking ability. This has become the top priority of concern with institutes of higher education. They are working out how to improve and promote the innovative spirit and creativity of environmental design students, guide and mentor students' thinking patterns, and cultivate and enhance students' logical analysis.

The diagram refers to “the process of interpreting, analyzing or calculating for the purpose of demonstrating or interpreting things” [1]. In architectural design, it is “a colloquial language used to express sketches and promote thinking” [2]. It closely links thinking with design and fully reveals the development process of the design. In this process, various graphic sets will be produced, such

as the mind diagram, the architectural sketch, and the final architectural rendering (Fig. 1)

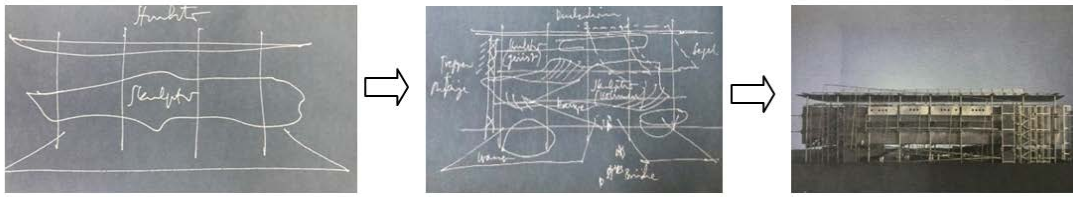


Fig.1 Conceptual expression process of the German Pavilion at the 1992 World Expo in Seville

During the second half of the 20th century, the basic techniques and procedures of international architectural knowledge shifted from drawing to diagram. This with form, language, representation, program, force and performance has gradually evolved into one of the core tools of architectural creation. In the 1950s, the combination of diagram and cubism, liberalism, gestalt psychology, neo-criticism, and tactical ways, contributed to the logical expressions for the higher modern (or modernist) architectural design and teaching [3]; and the expressions range from the central and peripheral language, vertical and horizontal language, internal and external language, positive and rotating language, virtual and real language, point and face and other languages. This set of language expression, is not only an important part of Western architectural theory exploration, but also is frequently applied to the design practice of many world-renowned architects. However, China's understanding of diagrams remains at the initial stage, and its understanding of the application of diagrams in design thinking still awaits further improvement.

## 2. Developing history of diagrams

From the floor plan of the St. Gall Abbey drawn from 819 to 826 AD, the manuscript by Leonardo da Vinci in the 16th century, to the architectural sketch by Le Corbusier in the 20th century, the history of illustration concept is as long as the building itself. It is generally believed that the Villa Palladio presented in the form of squared up by Rudolf Wittkower in 1940s was the initial manifestation of diagram. Robert Venturi summed up his master thesis written in 1950 as “a great illustration”. While Peter Eisenman further promoted the diagram nature in his doctoral thesis 《The Formal Basis of Modern Architecture》 in 1963 which was firstly put forward by Christopher Alexander 《Notes on the Synthesis of Form》. He also proposed 24 graphic deformation tools such as rotation and extension and 6 concept tools such as montage and layering (Fig. 2) based on 3D modeling and simulation software.

From the late 1950s to the early 1960s, the diagram pedigree was inherited in the form of the Sudoku problem in the practice of the American Academy of Architecture [5]. Greg Lynn, a student of Eisenman, introduced diagram technology to the “dynamic diagram” field led by teachers, which stirred the potential of dynamics, and decided the final design formed by the overlapping of the effects (Fig. 3).

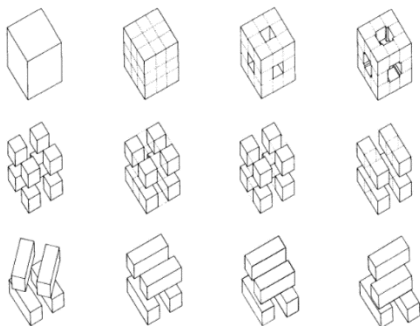


Fig.2 Peter Eisenman's Residential 4# rotating layering

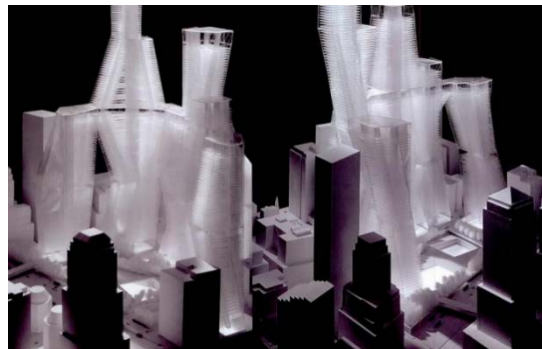


Fig.3 the Strand(left) and form(right) of Greg Lynn

Historically, there are two tools for buildings illustration: an interpretive or analytical tool, and a

generative tool. The former is the diagram of information carrier, also known as endogenetic diagram, while the latter is called exdogenetic diagram. Endogenetic diagrams refer to analysis diagrams of real information based on the design background, and architectural forms are generated directly from these diagrams. MVRDV diagrams from the noise analysis of the project site is a vivid example, and NO·MAD diagrams are generated from the strip morphology and functional layout of the site. Exdogenetic diagram mainly makes use of external illustration that has a complete form and meaning while still have certain elements of common with the base, such as the human body structure diagram used by Corbusier in Chandigarh planning, and the application of mobius ring to the mobius house project design (fig.4) by Ben van Burke from UNStudio.

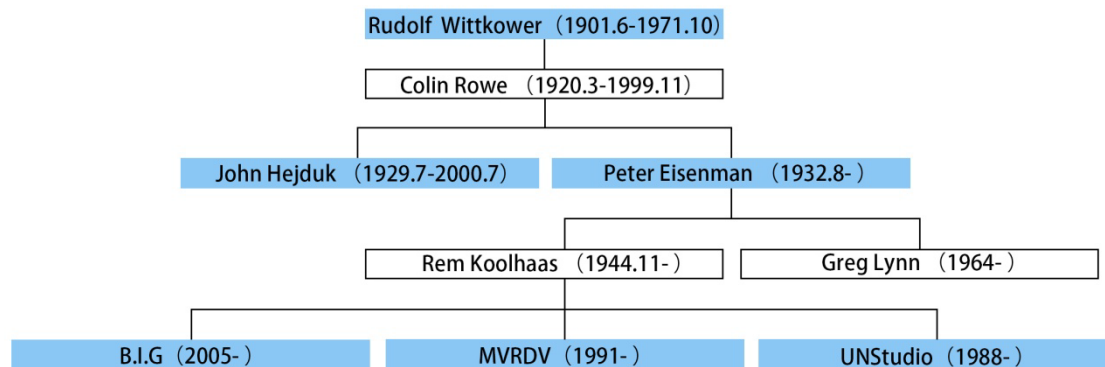


Fig.4 Diagram researcher's inheritance relationship Table

Currently, the related books that are widely read in China are as follows: (Diagram Diaries》 by Peter Eisenman, (After images) by Ben van Burkle, and (Graphical Thinking for Architects & Designers(The 3<sup>rd</sup> Edition) by American architect Paul Laseau. They provide flexible design activities, creative solutions, and present more diverse and easy-to-learn sketches; (Architecture: the Power of Painting) by Peter Cook elaborates on the creative role of painting in the field of architecture, which is a model of graphic design. Greg Lynn Form combines time, motion, and multiple forces to create large buildings for illustration. Among Chinese works, Latent Image of Space by Dr. Wang Yun collects 49 sketches of architectural design and creation process, which completely transforms the design idea from nothing to project realization, further elaborating on that “the sketch is an idea rather than a sketch” [4].

Compared with the number of diagram related researches in western countries, there are only 328 articles concerned with architectural “diagram” in the Chinese online index, among which 169 papers were published between 2001 and 2018, with less attention paid to. Against the backdrop that China boasts the largest amount of construction practice in the world, the theoretical accumulation of illustrations cannot be matched in terms of both depth and breadth.

### 3. Characteristics of diagrams

Diagram is a process where thinking, creation and thinking activities happen. It will be produced when thinking is externalized in the form of sketching imagination. It can be divided into expression-oriented diagrams and analysis-oriented ones, and this paper mainly explores analysis-oriented endogenous diagrams, which boast the following four characteristics.

#### 3.1 Process of logical analysis

The origin of the design process is problem analysis, and designers present the problem by simplifying and extracting the essential elements of the problem which paves the way for Abstract sketch. In the design process, the transformation of all essential elements of block diagrams and diagrams from the specific to the extremely Abstract all centers around the need, context and form (Fig. 5) [5]; each structure has its corresponding boundaries and constraints, and the change of any one of the three structures, or the combination of the three, will lead to a design change . The design diagram is the embodiment of the new balance between the three structures . The process of design

thinking also mirrors that of logical analysis.

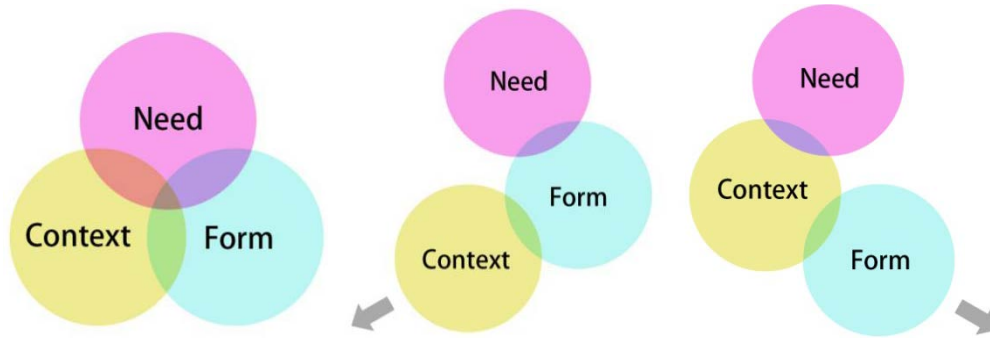


Fig. 5 The balance relation of need, context and form

### 3.2 Process of open thinking

The process of diagram thinking adopts diagram language and grammar. The diagram language includes images, marks, numbers, and vocabulary with coherent and shared meanings, such as international road signs, traffic signs, notes, mathematical symbols and so on. All symbols and intricate interrelationships can be taken into consideration and described simultaneously. The syntax of the diagram refers to “bubble map”, network diagram, matrix diagram and squared-up diagram, which is based on time and order and can be sorted by convention or by arrows. Other types of syntax can also be introduced in the grammar, whose features are specified by row or column. Therefore, graphic language and grammar play an important role in expanding the realm of thinking.

### 3.3 Process of effective communication

Each phase of the design process is basically a process of communication. It passes from one type of drawing to another type of drawing in the next phase. Designers use diagrams to deal with large amounts of information, apply concise graphical language coding to cope with changes, and find conceptual solutions from them. After the information processing, it will be translated into appropriate diagrams and passed on to the next design phase.

The diagram process is actually a process of self-communication and communication with the public: Through a closed network formed by sketching images, eyes, brain, hands and paper, something that has not existed comes into being, step by step on the paper. Friendly cooperation and mutual support are necessary for creating an appropriate atmosphere for the development of diagramming thinking. The design sketch always arouses the attention and interest of the recipient.

### 3.4 Process of continuing exploration

Diagram is a form of visual communication. is a process of exploration that is continuous and interactive. During the artistic creation of three-dimensional space, the brain, eyes and hands of designers work cooperatively, with the hands, crystallizing the thought, the eyes observing, and evaluating what has been observed, which will stir further thought and inspiration. Flexible visual thinkers continually try to uncover the hidden structures in the organization between Abstract and figurative images, and attempt to explore and dig out more possibilities by replacing internal thinking with visual thinking.

After the completion of a design project, the experience accumulated from it, and its existing problems, will continually be explored in the next project, thus forming the designer's design style.

## 4. Functions of diagram thinking

### 4.1 Connecting fragmented information

The information age is characterized by infinite potential information request, and information transformation function. Faced with massive information, individuals' mastery and operation of information has become one of the main criteria to measure their talent. Diagrams are Abstract

representations of the new balance achieved by need, context and form, which can adapt to the infinite changes of ideas, and provide designers with new views on separation or circulation, strengthening the structural connection between various information. An appropriate example of endogenous diagrams is the application of terrain analysis diagram, venue function utilization diagram, and spatial distribution diagram to the Olympic multi-functional sports center competition plan by NO.MAD, while that of exogenous diagrams is the application of the three-leaf diagram used in the Mercedes-Benz Museum project by UNStudio's Ben van der Burkle.

#### **4.2 Developing open image**

The “function bubble diagram” created by Gropius and Bauhaus is adopted to analyze and sort out the functional composition of buildings and the relationship between functions. In contrast to the static diagram, Wright applied the cross-plane diagram to generate Ullman House [6]. From Eisenman's dynamic illustration, to Lynn's dynamic overlay illustration, it can be concluded, from the development history of illustration, that illustration has been cultivating a creative and open image.

The sketches expressing ideas are usually fragmentary and casual, allowing a variety of possibilities open to different ideas. It is “the growing and complex interaction of the nature of various problems”, which reflects the development of thinking, with “sketch and thinking compulsory always opening the door for further development” [5].

#### **4.3 Effective communication**

The effective communication of diagram lies in the designers' self-communication, the communication between group members and the one with the public. Around 70% to 80% of the knowledge people get is obtained through vision. Diagram is a form of visual communication. One characteristic of its expression is that all kinds of information can be simultaneously transmitted, received and fed back at multiple levels. Intricate information such as the composition, detailing, and brushwork of the diagram can be showed collectively to owners, consultants, contractors, and other people concerned with the project, which can promote shared thinking and resonance. It is an inclusive process which aims not to illustrate the results but to convey a unique thinking ability. Compared to words and languages, it's relatively more effective. Meanwhile, the practice and the analysis of the communication system will motivate the design process, which in turn encourages many application methods for process processing.

#### **4.4 Transformation, consolidation and development.**

The attempt of designers to solve the problem is actually a creative process, which is open to new accessible methods from the very beginning to the end. In the process of diagram thinking, the designer adopts the diagram language to make thought and expression go back and forth between the Abstract and the concrete to reach a higher level. At the end, designers will enter a stage of repeated deliberation to expand the scope of the possibilities, and that is the transformation, consolidation and development of information.

### **5. Innovative application in the training of environmental design professionals**

Currently, there are over 1,000 universities offering environmental design majors in China [7] with each major under the support of institutes of higher education such as colleges and universities of fine arts, comprehensive universities of science and technology, standard universities, and comprehensive universities of finance and economics. Comparatively speaking, environmental design majors are most closely related to architecture and fine arts, but they fall into different subject catalogs of the Ministry of Education. For instance, “architecture” is a first-level discipline under the category of engineering, while “fine arts” belongs to second-level discipline under the category of art which is a branch of liberal arts, and “environmental design” is under the category of art, a second-level discipline in the category of liberal arts (fig.6). The difference in the same discipline produced in such a complex context is obvious.



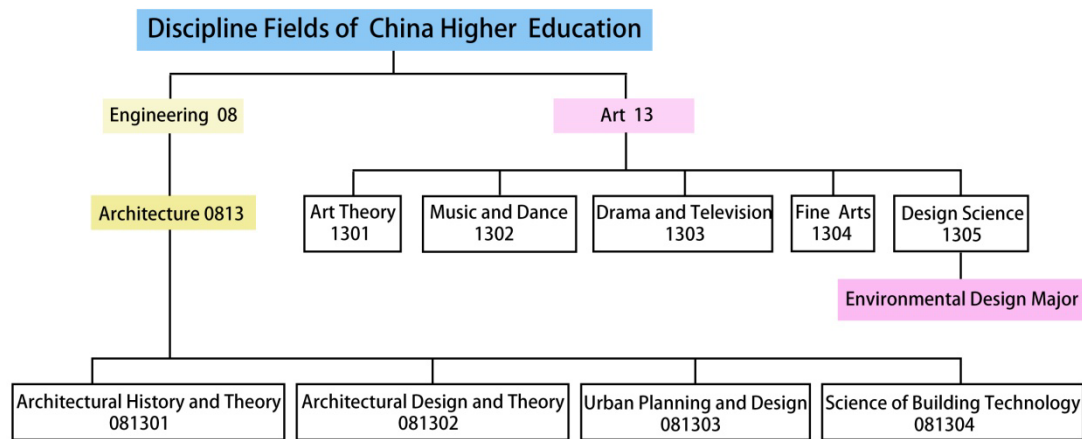


Fig. 6 Relationship between Environmental Design and Architecture and Art

Environmental design majors are a disciplined professional group with multi-disciplinary and multi-disciplinary interactions. Their teaching content can be mainly divided into the following categories: the architectural design, the interior design, the landscape design, the urban planning, the garden design, and the public environmental art, etc. The major itself is characterized by interdisciplinary enlightenment and mind change; meanwhile, it also boasts strong professional practicability and clear market orientation.

At present, the classified and feature development of national higher education has become an irresistible trend. To stand out, majors of colleges and universities must have their own characteristics. The establishment of characteristic specialty is a systematic project, ranging from concept to path, from team construction to construction condition. However, its bedrock still roots in talent cultivation. The starting point and destination of the establishment of feature specialty, are to improve the quality of talent cultivation. Therefore, specialty characteristics mirror the characteristics of talent cultivation in essence. In other words, a specialty that is distinctive and superior to others should be supported by the fact that the quality and ability of the students cultivated by the specialty are distinctive and superior to others [8]. Most students of environmental design majors are art students. Diagrams focus on analysis process, open thinking image, effective communication and continuous exploration, conducive to the cultivation of students' professional expertise in the following aspects (Fig.7).

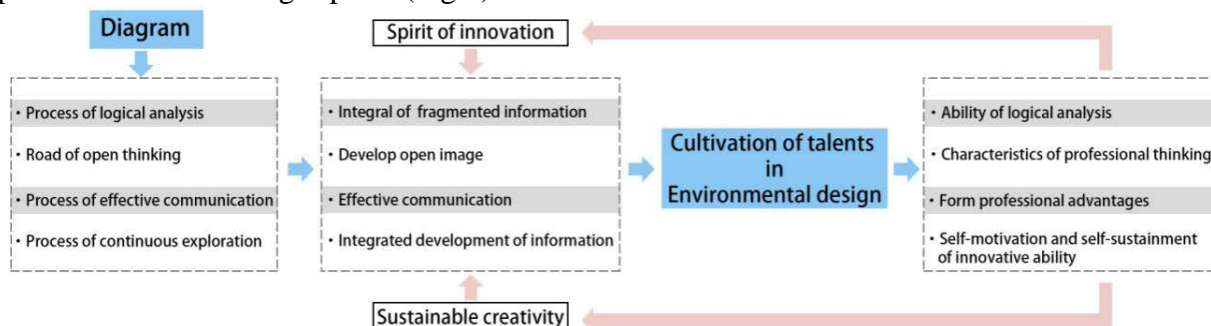


Fig.7the Innovative Application of Diagram to the Cultivation of Environmental design Professionals

### 5.1 Enhancing logic analysis ability

Diagram is a process of logical analysis, constantly obtaining new environmental solutions by balancing the needs of the design project, context and image. In this process, all types of information are categorized into corresponding variant forms to establish the connection relationship and form the system, during which a rational analysis process is established.

Students majoring in environmental design are mostly art students with good image thinking and weak Abstract thinking. Environmental design major comprises art and engineering technology, the application of which requires engineering, logical ability, but current domestic environmental

design majors lack a special course teaching “thinking method”; besides, teachers of each major will only preach design methods and thoughts based on a few specific project designs which further contributes to ambiguous design thought, and inadequate interactions between all types of information.

Diagram is in itself the intersection between the Abstract and the concrete, the sensual and the rational. Diagrams such as bubble diagram, grid diagram, network diagram and matrix diagram, are in themselves logical. Should teaching contents and practical training projects such as graphic analysis of classical architectural works and design schemes be added in professional teaching courses, the Abstract thinking ability of art students will be cultivated and a good design thinking mode will be formed through the interpretation, drawing and application of graphic analysis.

## **5.2 Developing characteristics of professional thinking**

Diagram is in itself a process of open thinking. It expands design ideas through increasing graphic language, and static, dynamic and dynamically superimposed design grammar. It explores all possibilities and is characterized by self-growth and self-opening. It can benefit the development of students from the levels of epistemology and methodology.

At present, the establishment of curriculum system of environmental design majors in Chinese colleges and universities, are all based on the curriculum system of architecture or fine arts. Architectural education rests on “drawing geometry” and “mapping and drawing” to perform visual thinking and spatial expression, which plays a role in cultivating the ability of graphic thinking. This process focuses on architectural space and engineering technology education. Fine arts aims to train students to grasp the relationship between form and space by “professional painting”, which focuses on space art modeling and decorative art education. As a developing discipline, environmental design still awaits a complete theoretical system for spatial expression.

Through the course of “mapping and drawing” and “professional painting”, relevant knowledge of perspectives, plans, elevations and sections is taught. However, students majoring in environmental design are only equipped with basic visual thinking and spatial expression ability in general.

During the course, excellent cases such as Villa Palladio diagram by Rudolf Wittkower, house series dynamic diagram by Peter Eisenman, particle shaping technology dynamic superposition diagram by Greg Lynn can be analyzed to help students cultivate understanding of graphic openness and growth, and form their own Design thinking and design methods.

## **5.3 Developing professional advantage**

Illustration is a process of self-communication, group communication and communication with the public, during which the communicator, and receiver of information, are equally important, and the communicator (designer) is required to be good at listening and expressing ideas.

The students majoring in environmental design are mainly art students, who show more concern for the final presentation of works and overlook the expression of the design process. They tend to think that the design process is a process of self-communication, lack confidence in their ability to sketch the design intention, and shy from sharing their own design ideas. To sum up the reasons, part of the students need to polish their language expression ability, and most of them should enhance their logic analysis ability during the design process.

To cope with the above-mentioned analysis, teachers can focus on students ‘ interpreting their designs based on their own work models and design sketches. The students can express their design ideas based on their own models and the shape, space and environment of their models and drawings from the perspectives of “why they did it”, “how to do it”, “what’s the design concept”, and “how to draw and interpret it”. In this way, students can be trained to “dig deep” in design, and be motivated to pay more attention to listener’s concern, receive feedback and develop their communication skills with others.

## **5.4 Enhancing creativity and innovation**

Diagram is a continuous iterative process of exploration. To grasp the method of diagram

thinking and expression is to master the main body of the design method. Therefore, the study and exploration of the schema thinking and design expression is of great significance to the formation and application of design methods.

Incorporating courses such as Diagram and Design Sketch or related lectures into the professional courses of Grades 1 to 4 should be an integral part of the entire subject education process. Diagram expression should also be emphasized in student's project training to stimulate students' understanding and exploration of the illustration. Students' creativity and innovative ability should also be improved.

## 6. Conclusion

“All the inner harmony of creation is expressed in the thinking picture” [9]. Guided by the national concept of culture rejuvenation, technological innovation, and influenced by the information age, illustration is of great value for the cultivation of the creativity and innovative ability of environmental-design talents, and Greg Lynn's introduction of digital technology into the field of dynamic graphics which promoted the infinite possibilities of design is a vivid example. Threatened by the impact of a large number of computer 3D model diagrams, hand-drawn design sketches, especially graphical analysis diagrams, will never be replaced for the time being and will absorb digital technology and multidisciplinary intervention to realize multidisciplinary in the information age. That will further reveal the logical relationship implicit in the space environment. Its own characteristics which range from logic analysis, development thinking, effective communication and sustainable exploration, all boast the function of cultivating the creativity and innovation of environmental-design students.

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