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Product Design Process and Methods

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Abstract

Suitable design procedures and methods will lead to twice the result with half the work. Hence, good products need a good beginning in the design process. The design procedure is the basis for guiding the steps of design process, while the design method is the guarantee for effectively developing the design process and improving its quality. A clear and reasonable process can lead to a simple and smooth way in design, while the proper use of creating techniques can let the designer find a better way to solve the problems in a wider range, so as to develop and design a good product.

Keywords: product design, design method, creating technology, design process, survey, evaluation

1. Introduction

“What is a process?” A process may be defined as “a series of steps, actions, or operations used in making something or bringing about a desired result: a manufacturing process” [1]. Similarly, a design process can be defined as a sequence of creative problem finding, analyzing, and solving steps used by the designer to develop an appropriate design solution for the given client, which is an organizational framework used by designers during the process of product design.

Design activities are complicated and interlocking. There must be clear steps to plan and integrate, and the whole process should be rationally arranged according to scientific laws, so as to achieve the final design goals clearly, as shown in **Figure 1**.

In these steps, series of problems, puzzles, and brand-new ideas will be brought in, to analyze to lead our future products. We need to find the key point to explore our product, know about

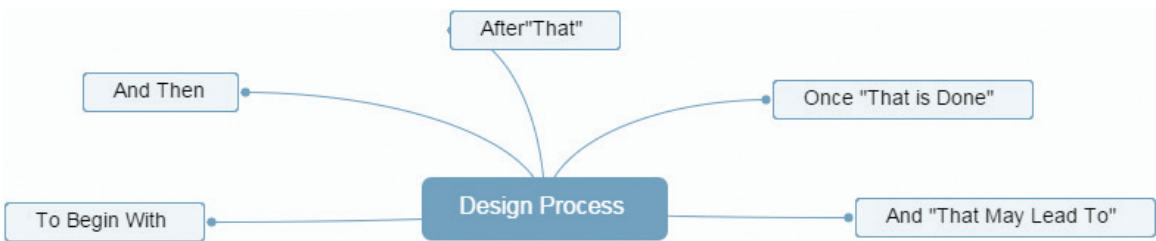


Figure 1. Design process.

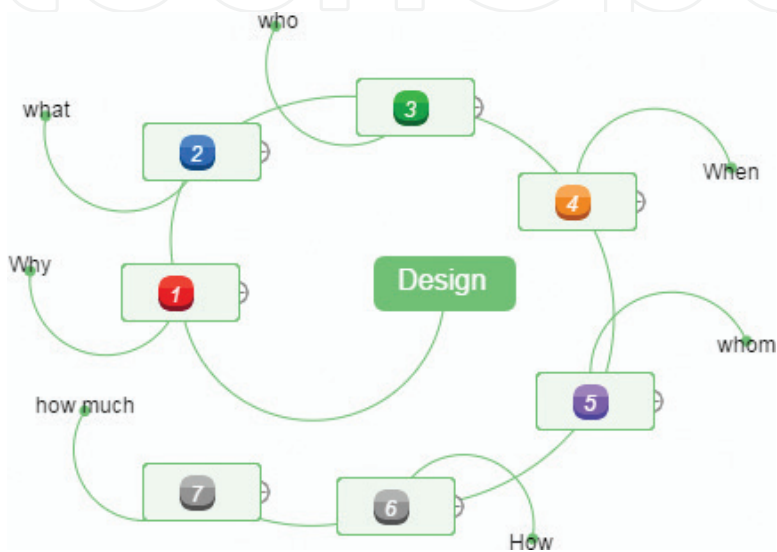


Figure 2. Design analyses.

the market and potential customers, and get important information about the variety of functions, what is more, we need to deal with the whole developing and design operations and have control on its correspond costs, as shown in **Figure 2**.

2. Definitions and relationship between product design process and methods

2.1. About product design process

The product described in this chapter refers to the concept in a broad sense, which refers to the sum of the products formed with a certain purpose and to meet the needs of targeted people as well as nonphysical services. Its general process is shown in **Figure 3**.

Modern product design is a planned, step-by-step, targeted, and directional creative activity. The design process refers to the development process of the design and the order in which the design tasks are completed. According to the arrangement of the process, it can be divided into linear programs, parallel programs, and complex programs. It is an organic combination of finding, analyzing, and solving problems.

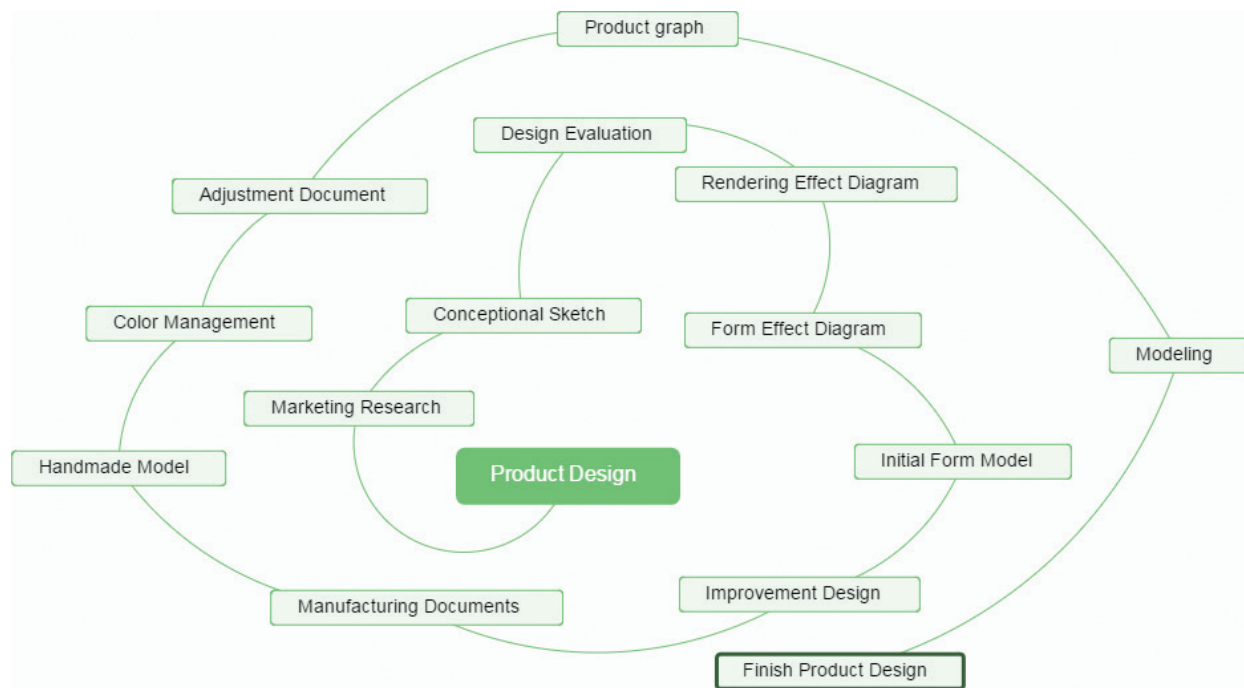


Figure 3. General product design process.

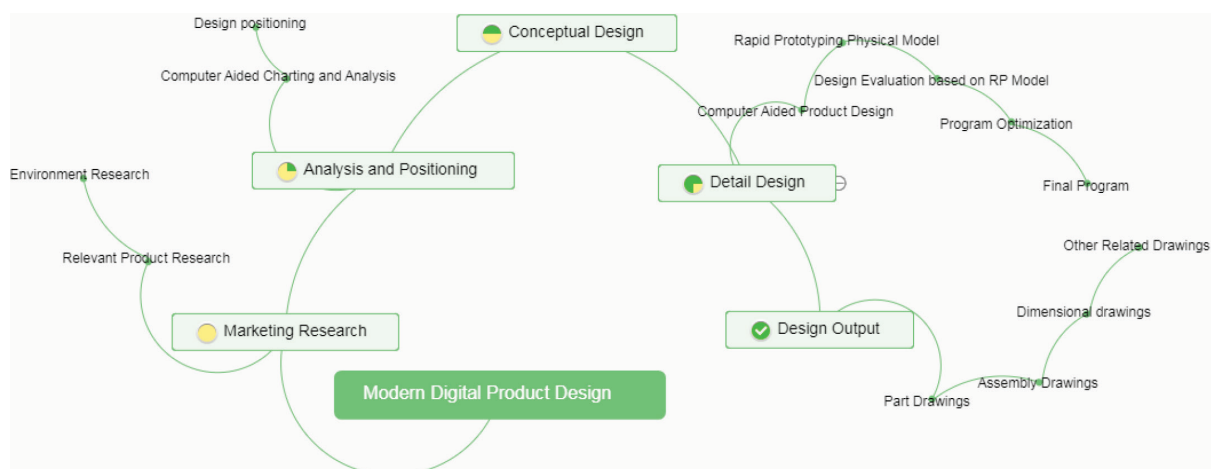


Figure 4. Modern digital product design process.

With the advancement of technology, computer-aided design and manufacturing have been widely used in the product design process. For example, in the market research stage, computer data analysis can be introduced; in the concept stage, product sketches, renderings, and even real physical models are created through rapid prototyping based on computer-aided design, as well as design evaluation, reversing, and optimization iterations. Thus, the design process of the above figure can be reduced to the following modern digital design process as shown in **Figure 4**.

2.2. About the design methods

Methods refer to the sum of the receipts that can be used to achieve certain purposes in any fields. When people want to know and transform the world, they must engage in a series of

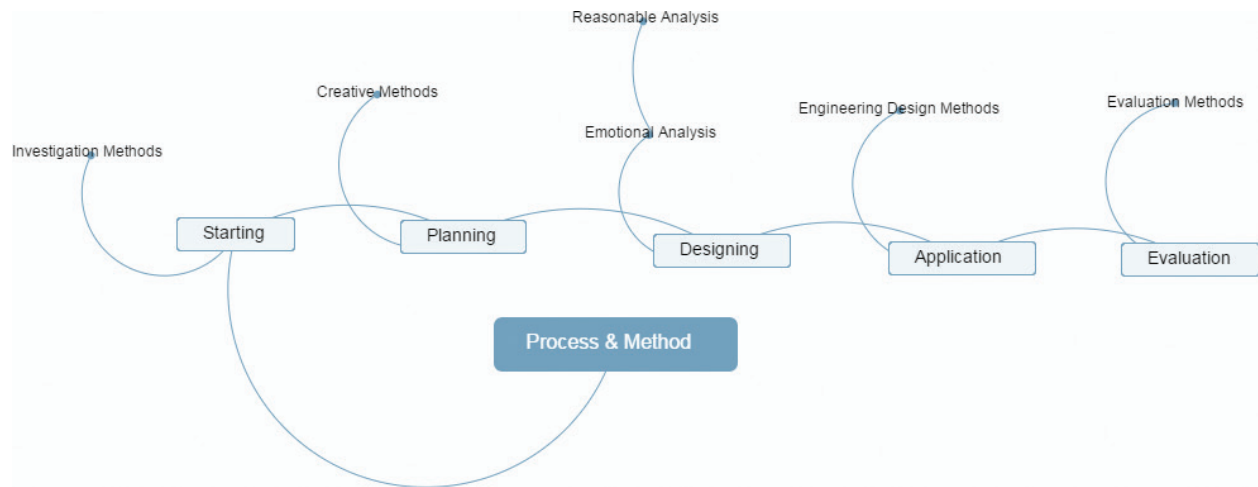


Figure 5. Relation between process and methods.

thinking and practical activities. Those various methods used in the activities are collectively referred to as methods. No matter what you do, you must have proper methods, and the correctness or inferiority of the methods directly affects the success or failure of the work.

The main features of modern design are optimization, dynamics, diversification, and computerization. Commonly used design methods mainly include catastrophe method, information theory method, system theory method, discrete theory method, intelligent theory method, cybernetic method, correspondence theory method, optimization method, fuzzy theory method, and art theory methods [2].

2.3. Relationship between process and methods

As for the relationship of product design process and methods, they complement and rely on each other, which is shown in **Figure 5**.

Firstly, the design process determines the steps of the design, while the method determines the design measures and effects.

Secondly, the design process itself requires specific methods and overall strategies to guide and support, and methods must be adapted and changed according to specific procedures. A clear and complete design process can guide in an orderly manner, simplify, and optimize the results in process. While designing, the appropriate method involved can solve the design problem efficiently and creatively.

Finally, a design program provides a platform for the application of the method, which ensures the smoothness and efficiency of the program.

3. Product design process

Generally speaking, product design involves four periods, namely, the research phase, the analysis and positioning phase, conceptual design phase, detailed design phase, and the

design output phase. According to different design objects, the specific matters of each stage are slightly different and complicated.

3.1. The research phase

Design and research are in the initial stage of the design process. Knowing what we have, what we want, and where to get as well as how to get required information from seeing the micro-knowledge to know the significance, using existing information as the starting point, by means of analysis and synthesis methods, etc., to integrate the important influencing factors of the products involved, so as to guide the follow-up design in a targeted manner.

Generally speaking, the research phase mainly focuses on people, machines, and environment, as shown in **Figure 6**. Among them, people include target users, potential users, producers, sellers, recyclers, etc., which are related to the product life cycle; gender, age, education background, income level, social status, family conditions, as well as other factors which reflects in status, lifestyle, and values all have a profound impact on the future direction of product design. The machine mainly refers to the various attributes involved in the design object and related products including the current status of the market products and various property expectations of the products involved such as function, form, structure, color, human-machine relationship, usage, carrying method, etc. The existing attributes of the product market have a certain reference and guiding role for future design. From the existing market survey, we can understand the distribution and gathering of market products, so as to find the opportunity of post-development positioning. At the same time, the investigation of the attributes of future products can further clarify the product characteristics, zero to thin, and gradually deepen the refinement of product concept until the entire product design process is completed. The environment mainly refers to the natural and human context in which

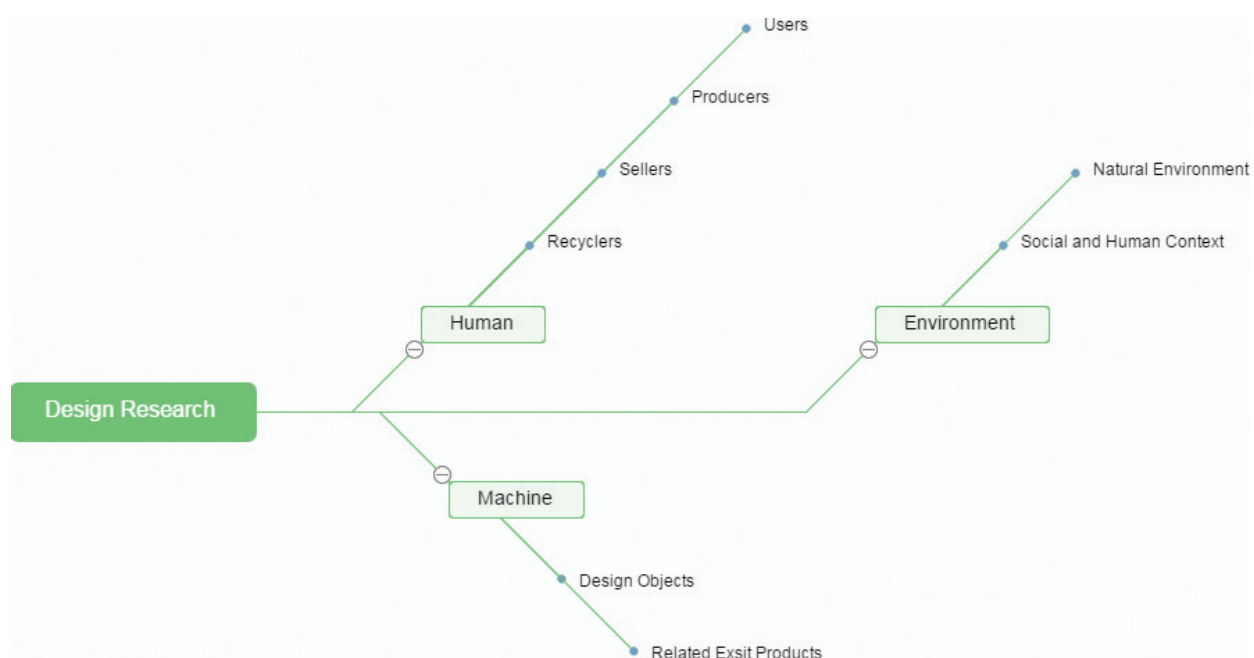


Figure 6. Design research.

the design object is located. Any product is used in a certain time and space and social environment, and the product status should match the current environment, which can highlight the design intent and the characteristics of the times.

3.2. The analysis and positioning stage

The analysis and positioning stage is mainly based on the abovementioned research information. Through the actual deep investigation of people, machines, and environment, we are firstly able to analyze the direct and potential needs of the users, so as to achieve design customization in a targeted manner. Secondly, the investigation of the machine can be intuitive and effective in discovering market development opportunities. In general, we can explore products from two aspects. On the one hand, in the state of market agglomeration, it means that the product status is very suitable for the current trend and can meet the needs of most users. It can be used as a follow-up product development, taking the advantages of popular goods and targeting the mainstream of the market. On the other hand, as to the market's unpopular performance, the challenge of the alternative way of solving problems with the mutant thinking and the use of unique strategies to creatively complete the development of brand-new products can be reversely considered, as shown in **Figure 7**. In terms of environment, in view of the indivisibility of product use and environment, the product environment is reversely inferred from the use environment, and the consideration and development of the support are beneficial to maintain the performance of the product for a long time, thereby ensuring the service life of the product and saving the human, material, and financial investment in the industrial chain.

On the basis of design analysis, the related aspects of the products involved are positioned to create a benchmark for subsequent series development and visual design, which lays the design direction and basis for the whole design process.

3.3. Conceptual design stage

Conceptual design is a series of organized and targeted concepts of concise design based on analysis of the previous market demand and user needs. It manifests itself as an evolving

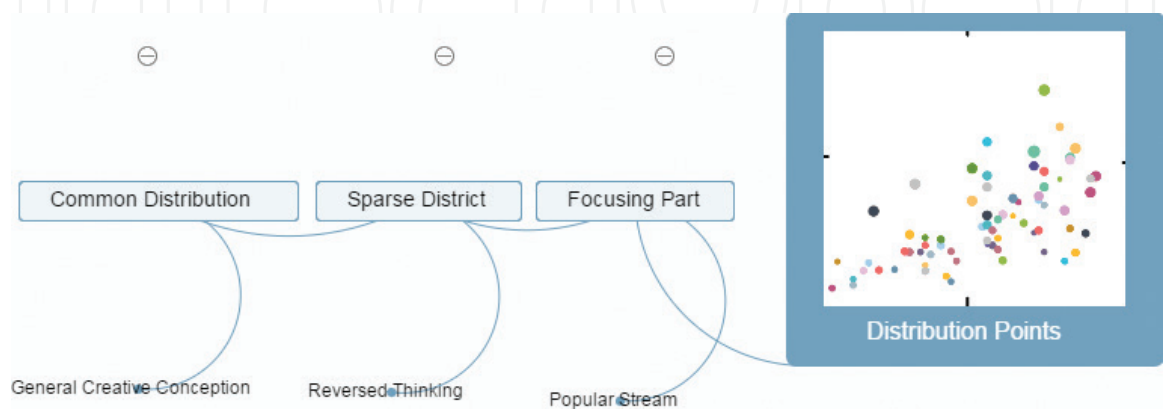


Figure 7. Distribution analysis.

process from coarse to fine, from fuzzy to clear, and from abstract to concrete, which is a preparation stage for the visualization of the design conceptions after the above design positioning is determined.

Conceptual design determines the main purpose and developing direction of the future product, through which we can save our resource input as much as possible, help the following production and sales, extend the profit margin, and effectively estimate and guide the late recycling issues. Thus, conceptual design in the initial stage of product is undoubtedly a crucial part of product life cycle.

3.4. Detailed design

Detailed design is a visualization process based on the previous design concepts. It is extending and diverging based on design concepts and gradually forms a visual clear plan, as

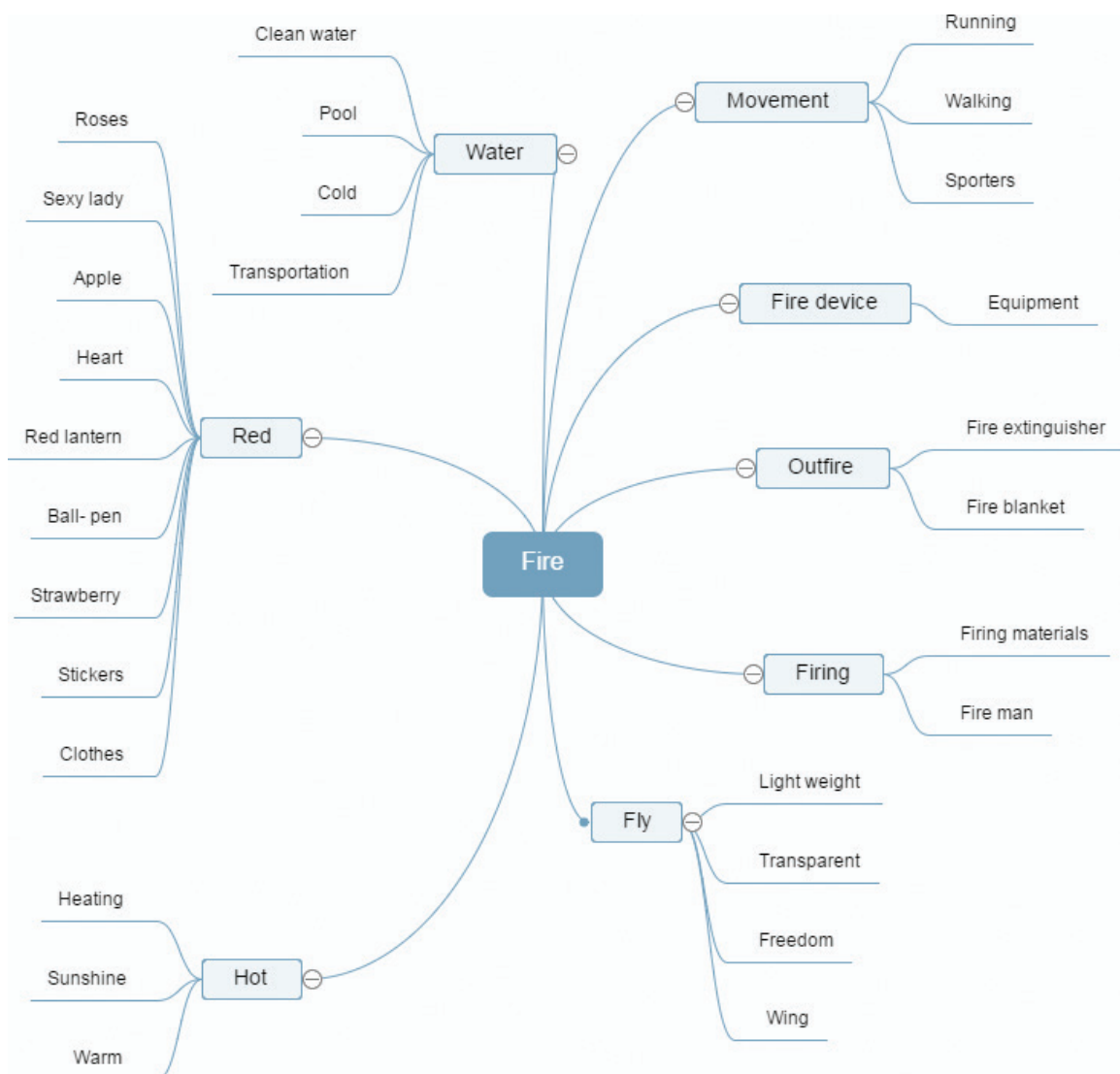


Figure 8. Divergent thinking.

shown in **Figure 8**. Based on this, the process of design evaluation, program selection, and optimization, as well as the product expressions, is carried out. With a same script, different interpretations produce different works. The same is true of the design concept. Focusing on the abstract design concept, divergent thinking, and extension, starting from different angles,

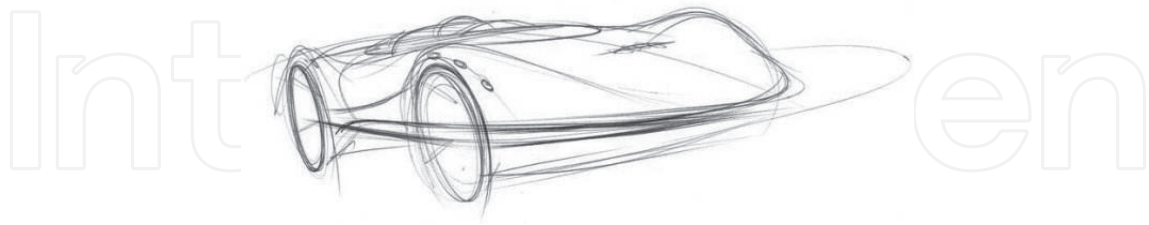


Figure 9. Original handmade sketch [3].

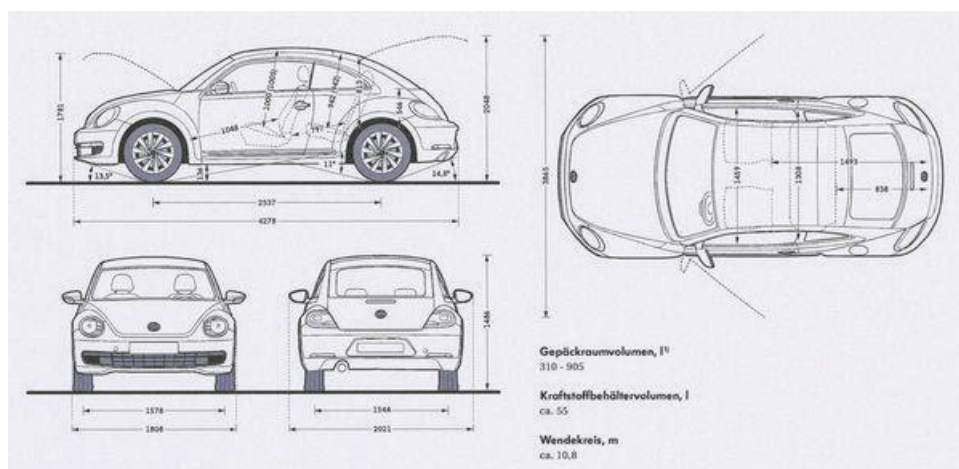


Figure 10. Computer-aided sketch [4].



Figure 11. Handmade model [5].

different characteristics, different ways, etc., the abstract concept is gradually associated with concrete objects, and the design process is gradually cleared and definitely expressed, as shown in **Figures 9** and **10**.

In terms of design evaluation, program selection, and optimization, based on the advancement and popularization of modern technology, computer-aided design and manufacturing technology can be fully utilized; digital models can be built with design sketches, and even 3D physical models can be obtained by using rapid prototyping technology, as shown in **Figures 11–13**. The model carries out product functional design, structural design, color design, human-machine interface design, etc. At the same time, according to the evaluation results, the digital model or physical model is optimized and improved through computer-aided design software and reverse engineering technology, as shown in **Figure 14**.

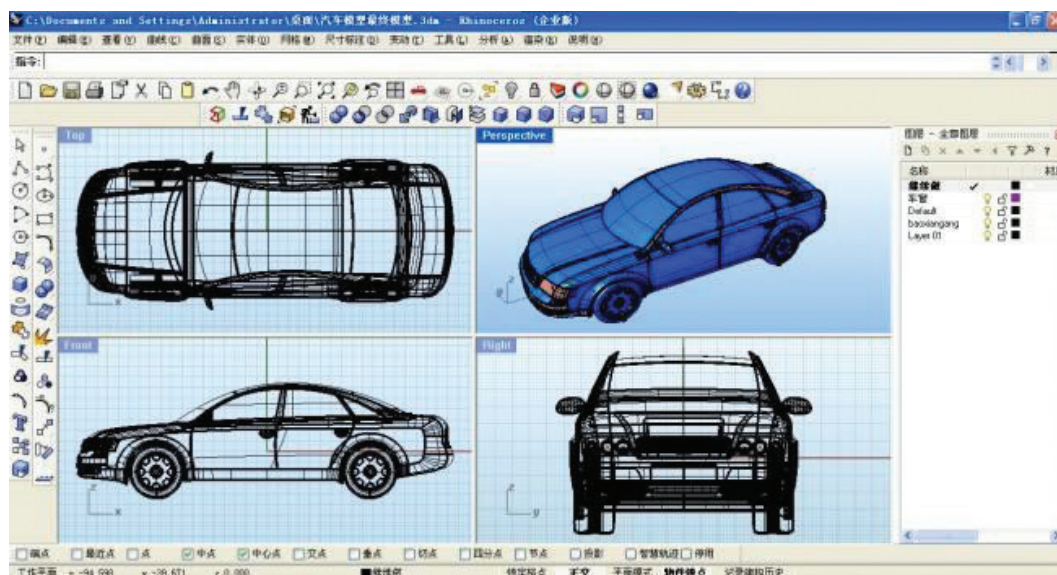


Figure 12. Computer-aided model [6].



Figure 13. Prototyping model [7].



Figure 14. Reverse scan [8].

3.5. The design output stage

The design output stage mainly refers to the expression of design results and the preliminary preparation for the following production. At this stage, through the design renderings, dimensional drawings, parts drawings, construction drawings, detail display drawings, structural drawings, etc., the design results are presented in a detailed and complete manner. Through this way, the above design work is closed and integrated on one the hand. On the other hand, these outputs also provide the basis for production and construction after the design phase.

4. Product design methods

In different design stages and target objects, the complexity of the steps is slightly different and so as the design methods involved. Generally spoken, blows are the common methods involved in the main four steps of product design.

4.1. Design survey

With the advent of the information age, the world has become smaller and smaller, and the acquisition of various information has become feasible and convenient. The factors that people choose products are increasingly influenced by the individual and the mainstream. At the same time, in the whole product design process, each step has a series of internal or external constraints. The design is just like “dancing with shackles.” Every involved part needs information intervention and guidance and gradually coordinates, optimizes, and iterates so as to initiate better ideas and works. This factor makes the investigation and research at the beginning of the design particularly important.

Common survey methods include comprehensive surveys, typical surveys, and sample surveys. The main difference is the coverage of survey samples. When carrying out the survey,

firstly, it is necessary to prepare for the whole investigation, determine its objectives, and clarify whether its form is inquiry, observation, experiment, or case, and based on preliminary analysis, formulate the basic ideas and problems of the investigation, and highlight the key points concisely as much as possible.

The second one is to conduct an investigation. This stage is the way to obtain information. Incorporate the survey objectives to determine the respondents, select appropriate survey techniques to determine the query items and design questionnaires, and then conduct a field survey in an orderly manner.

Finally, collate the survey results by analyses and research, draw into various forms, and then present analysis results of the survey, as shown in **Figure 15**.

At different stages of design, surveys are conducted around different surveyees, with different design goals and processes to make sure the final results are armed with comprehensive information feedback, so as to develop and create new products in a targeted manner.

4.2. Creating techniques

The creating technique is an important part to improve the design quality. It is a means to use the multi-directionality, the differentiation, the suddenness, the broadness, and the flexibility of creative thinking to propose new ideas. According to different classification criteria, creating techniques can be divided into different types. Such as according to the personality characteristics of the creative team members, the creating techniques can be divided into open speech and anonymous expression. The typical representative techniques are brainstorming

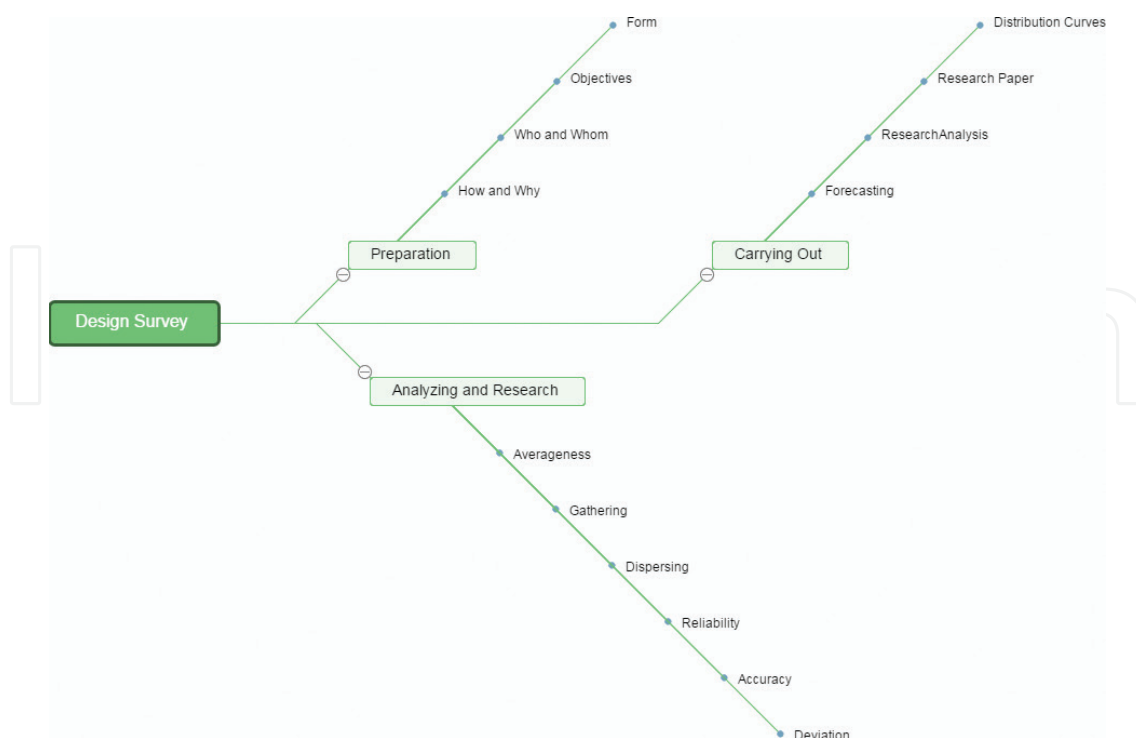


Figure 15. Design survey.

and 635 method. The former is free expression of team members, not bound to each other, and open to freedom. By this free style, the creativities of the group are stimulating, while the latter is to be silence in the whole previous period. Each one needs to avoid mutual interference and privately express their ideas in a recorded way. According to the nature of the creative proposal, it can be divided into active stimulating and passive stimulating. The typical representatives are the comprehensive method and enumeration method. The former uses abstract expressions to let the team members of different professional backgrounds associate with each other freely; the latter is based on existing objects, enumerate expressions and deep cognition one by one, and then use these expressions as sources of creativity. Flexible selection of different creative techniques at different stages of design is needed. As shown in **Figure 16**, it is a passive method by which we can make ourselves much more aware about the design purpose and processes after the relevant technique.

4.3. Product form design method

This stage of creating techniques is designed to complete the visualization process from design concept to product modeling. After completing the functional positioning of the product, the product structure and the later modeling design become the final platform for design creativity. Therefore, the product design method mainly includes the following three steps.

Firstly, decompose the product into individual parts according to the previous function and form positioning. Secondly, confirm the changeable parts of each shape. Thirdly, the changeable part is changed. Finally, recompose the relevant individual parts into a complete one, and select the best shape you evaluated. For example, a simple face will be a brand-new one

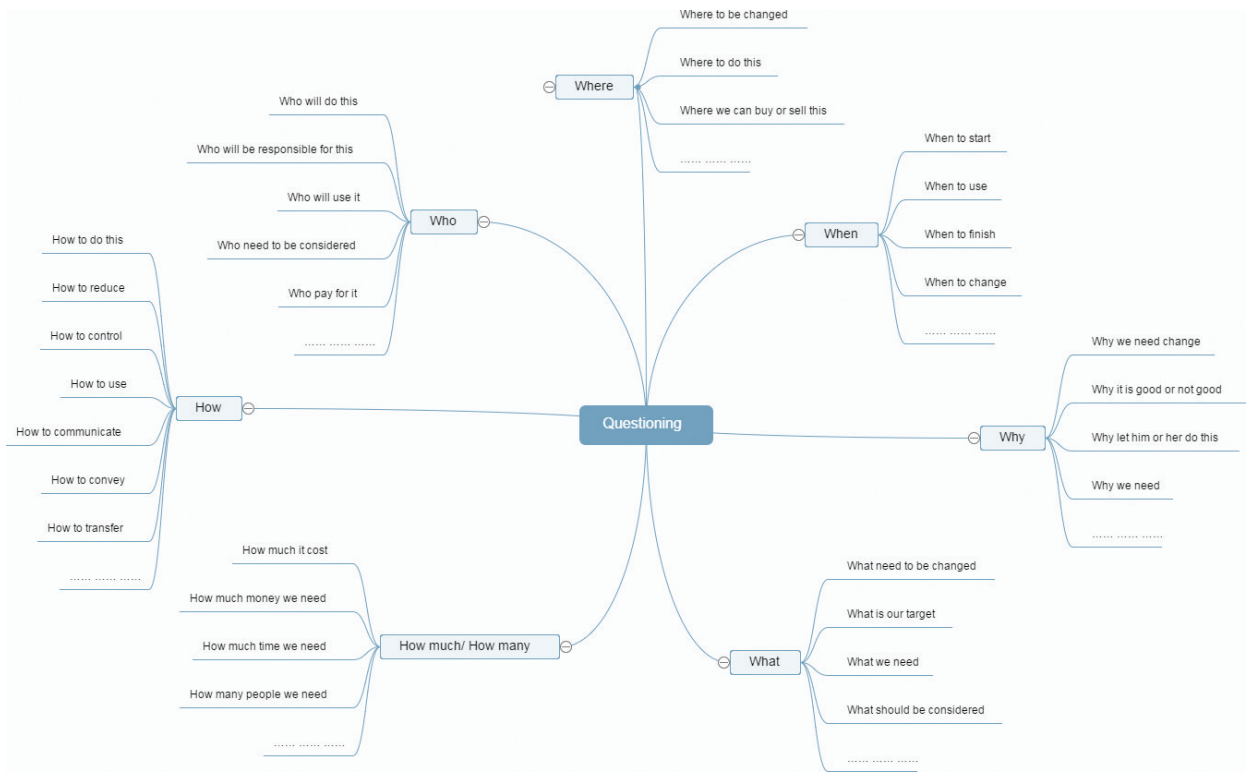


Figure 16. Questioning.

if we change parts of it, including face skin color and facial features and any other aspects. In principle, the number of new schemes is the same exponential power of the changeable part. As shown in **Figure 17**, the principle sum of the complete scheme is n^n .

4.4. Design evaluation method

Design evaluation is to compare and evaluate the solution to the problem in the design process, thereby determining the value of each program and judging its merits and demerits in order to screen out the best design. The meaning of “program” here is extensive and can be in various forms, such as principle program, structural program, modeling program, etc. From the perspective of its carrier, it can be a component or an overall drawing, or it can be a model, a prototype, a product, etc. In general, the “program” referred to in the evaluation is essentially the answer to the problems encountered in the design. The significance of design evaluation is to consciously control the design process, to target the direction of the design, and to assess the design plan with scientific analysis rather than subjective feeling, which provides designers with the basis for judging design ideas. Through design evaluation, the quality of design can be effectively guaranteed, and the best solution in which all aspects of performance meet the target requirements can be selected among many design programs. Secondly, proper design evaluation can reduce the blindness in the design and improve the efficiency of it. In addition, the applicative performance of evaluation can effectively verify the design plan, find out deficiencies during the process, and provide the basis for deeper design improvement.

In the actual evaluation process, due to the complexity of the design factors, the main influencing factors are generally selected. According to different design objects and different stages of the design, different evaluation objectives are determined, and the most appropriate content is selected to establish the evaluation target system. After selecting the evaluation items, the

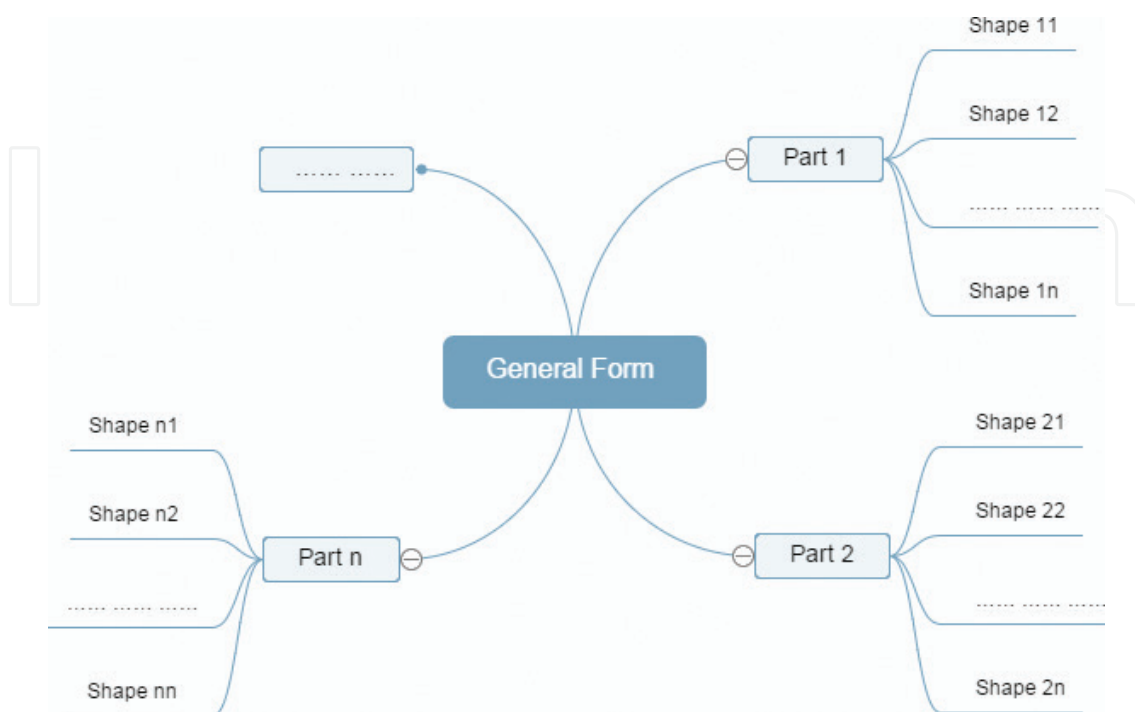


Figure 17. Questioning method in general form design.

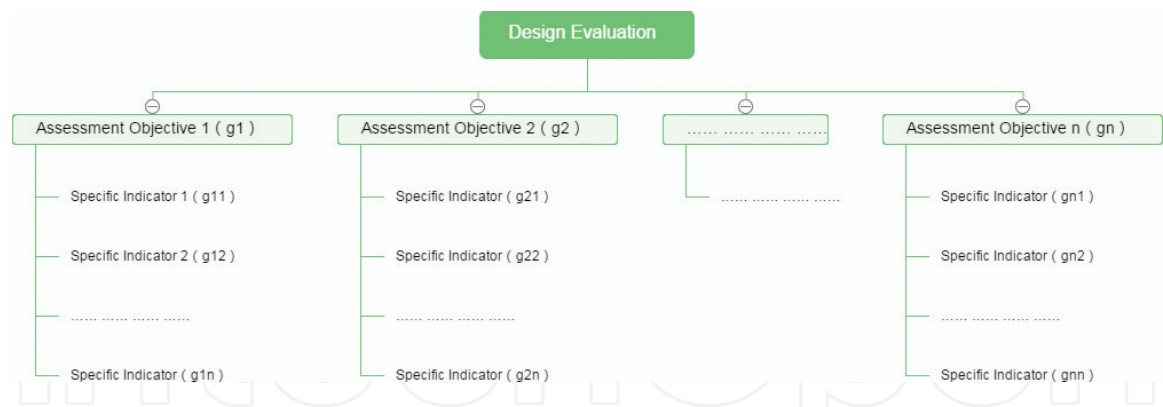


Figure 18. Design evaluation.

weighing coefficients are, respectively, set according to the importance of each evaluation item, and the entire project evaluation process is finally completed as shown in **Figure 18**.

5. Conclusion

The design procedure is the basis for guiding the steps of design process, and the design method is the guarantee for effectively developing the design process and improving its quality. A clear and reasonable process can lead to a simple and smooth way in the design, while the proper use of creating techniques can let the designer find a better way to solve the problems in a wider range, so as to develop and design a good product.

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