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Concurrent Design Strategy in Modeling and Structure of Electric Scooter for Young Disabilities

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Abstract

Disabled people often use the electric scooter as a means of transport. However, the electric scooter designed for disabilities is too bulky and not light in shape. It is not only awkward on the road but brings inconvenience to young people with disabilities. In the first phase of the study, first the electric scooter with a higher market share as a design reference was collected; then we use the image scale analysis to determine the market position of the electric scooter. Combine each major component and derive detail design of the product through Morphological chart method and Finite Structure Method (FSM). This study uses this method to complete the development of product modeling and analyze the configuration of the product as the main function in the structural and main function in space. Let function and appearance have the efficient combination. Then use Analytic Hierarchy Process (AHP) to obtain objective decision results. The use of Concurrent Design Strategy can effectively shorten the development process and increase the chance of product success.

Keywords: concurrent design, electric scooter, morphological chart method, finite structure method, analytical hierarchy process

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1. Introduction

The mental development and external social development for young disabilities often feel psychological discomfort due to secular vision. For young disabilities, they have the authority of Autonomy, choice, and control is important, they can live independently don't have different from ordinary people [1]. In recent years, the market for electric vehicles has risen year by year with the awareness of environmental protection. In Taiwan, the government considers zero-emission vehicles as a sustainable mode of transportation. Therefore, the development of zero-emission vehicles is an important strategy for the construction of a transportation network [2]. The electric scooter design for young disabilities needs to consider the appearance as well as the psychological and environmental factors. This study is based on the morphological chart method for the design of modeling, then use Analytic Hierarchy Process (AHP) to obtain the best decision through those methods can systematic analysis of details that are often overlooked. Using this method of Concurrent Design Strategy not only take into account the appearance, production feasibility, and market demand, but also improve the communication efficiency between different departments, as well as shorten the product production cycle, and greatly increase the success rate of product development.

2. Theoretical Background

2.1. Image scale method

According to the status of the existing products on the market for an objective evaluation, the evaluation results are marked on the X, Y axis of the coordinate system. The X and Y axis represent different image vocabularies. According to various requirements, the meaning of the axis can be set by yourself, and in the table to select the desired target product location, graphically and in proportion to clearly show the differences between products.

2.2. Objective tree analysis

Objective Tree Analysis is a hierarchical structure analysis, establish hierarchical relationships between issues and solutions.Once the problem is found, the problem will be solved as a second-level branch. To concretize the problem solved, a third layer can be formed by decomposing the solution into a sub-solution. In the general case, there is a difference in importance between design goals at the same level, so appropriate weights must be set for different design purposes, and different design goals can be distinguished by different weight settings [3].

2.3. Finite structure method (FSM)

The Finite Structure Method (FSM) first establishes the main function of the product, and then decomposes the secondary function from the main function. The secondary functions are changed in a certain amount such as configuration, arrangement of space, and size to obtain the desired shape. In order to achieve the main function of the purpose of the allocation of secondary functions, and then produce product modeling, the following steps are carried out [4],Step1: Identify all the main function of the target product.Step2: Decompose the main function which is the combination of several sub-functions, and limited with a certain number elements.Step3: Quantify the basic structure, which is the arrangements of limited sub-functions. Step4:Ensure the form of multiplicity, we consider the consistency of the original product design.Step5: Choose the best alternative. The main function of the product is divided into a combination of several secondary functions, and the elements that achieve the secondary function are referred as components. The combination of components also changes the shape of the product, so each product can use this concept to reorganize the sub-functional components and assist in the development of the design.

2.4. Morphological chart method

Morphological chart method include various parameters and components that describe the functional characteristics needed to produce a product. They point out the appearance and connotation of product; components are the characteristics that can be described in parameters or the means or methods that can be implemented [5].All in all, it is a form design method that dismantles the original product into various design elements by dismantling and regroups these design elements [6].

2.5. Analytical hierarchy process

The purpose of the development of hierarchical analysis is to systematize complex issues. Decomposing levels at different levels and using quantitative judgments to obtain a comprehensive assessment of the context can provide decision makers with the right choices and reduce the mistakes of decision-making [7]. The hierarchical analysis is a systematic process for solving hierarchical problems. It organizes problems after they have been dismantled layer by layer, allowing decision-makers to determine the order the weights of the problems through paired comparisons.

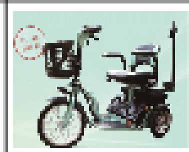
3. Case Study

Developing electric vehicles in Taiwan has become an indicator green industry, the development of the locomotive industry has even achieved large-scale integration. Therefore, the autonomy of Taiwan's locomotive industry is quite strong and it has a high degree of competitive advantage [8].Collect data from various pipelines and conduct surveys to obtain major design goals then list the detailed analysis of the functional structure, shape design, etc. of the various electric scooter, and you can clearly understand the main design features and minor features, as shown in Table I, Table II.

Table 1: Market Survey.

Brands	Sunpex	Sunpex	PIHSIANG	CTM MINI	FREE RIDER
image					
weight	78KG	22.4KG	33.7KG	40.1KG	23.5KG
Maximum load	90KG	110KG	110KG	116KG	115KG
Endurance	35-40KM	12-18KM	10-12KM	11KM	15KM
Maximum speed	17KM/HR	5KM/HR	6KM/HR	8KM/HR	6.4KM/HR
Front wheel size	13inch	7inch	7inch	8KM/HR	6.4KM/HR
Rear wheel size	13inch	6inch	7.5inch	8KM/HR	6.4KM/HR
Body size	380(L)*630(W)*1280 (H)	375(L)*830(W)*910 (H)	490(L)*950(W)* 840(H)	500(L)*890(W)* 1020(H)	500(L)*860(W)* 1000(H)

Table 2: Market Survey.

Brands	PIHSIANG	PIHSIANG	Merits	Merits
image				
weight	27KG	150KG	64KG	110KG
Maximum load	90KG	140KG	100KG	159KG
Endurance	14-15.5KM	27KM	10-12KM	40KM
Maximum speed	6KM/HR	10KM/HR	6KM/HR	6.4KM/HR
Front wheel size	12inch	26inch	7inch	8KM/HR
Rear wheel size	16inch	26inch	7.5inch	8KM/HR
Body size	445(L)*755(W)*1010 (H)	730(L)*910(W)* 1600(H)	570(L)*1050(W)* 1190(H)	640(L)*1150(W)* 1300(H)

Simultaneously, the collected products will be related to the image scale analysis.

1. The meaning of horizontal axis coordinates is: large volume → small volume
2. The meaning of vertical axis coordinates is: Modeling Conservative → Modeling Modern

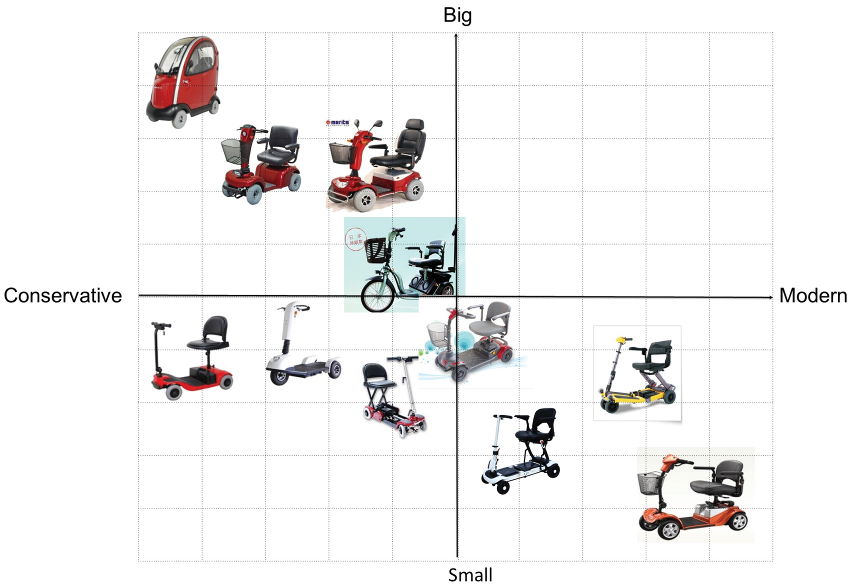


Figure 1: Image Scale of Existing Products.

According to the product of the image scale position, the difference of the existing product can be understood. During the process, the integrity of the retained image is used as a reference for subsequent design, and the image scale analysis is used as a model. On image scale, modern and conservative are the horizontal axes of the coordinates, and the large and small coordinate axes are shown in Figure 1. This shows that there is a lack of modern and small-sized electric scooter designs in the market. The follow-up of this paper will be the focus of development.

3.1. Black box Diagram

Analyze the procedure hidden between the input and output of the electric car with a black box analysis, and predict the potential problems and difficulties in using, and each link to design thinking as Figure 2.

3.2. Establish design criteria

It is very important to determine the elements of the design in the early stages of the design. Through the analysis of the target tree, as shown in Figure 3, the design goals

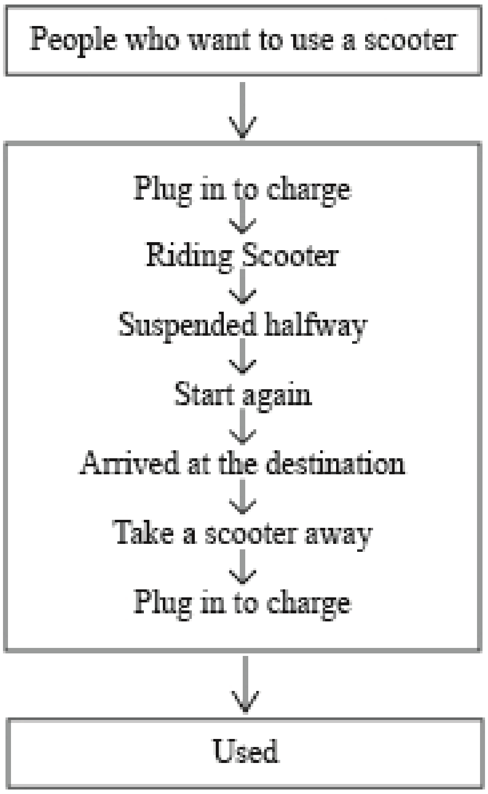


Figure 2: Black box analysis.

are divided into four categories, including convenience, safety, comfort, and modernity, then list design elements to provide more detail to achieve the goal. D and W, as shown in the figure, represent the necessity of "need" and "expect" elements.

3.3. Design process

In order to optimize the design, this study first analyzes the functional features of existing products. Use the image scale to determine the product's development direction, and cooperate with the Morphological chart method, FSM, and AHP to assist the electric scooter concept development and select the best design solution, this design process is shown in Figure 4.

3.4. Concept develope

The development of the electric mobility scooter in this study is divided into three phases. The detailed steps are as follows:

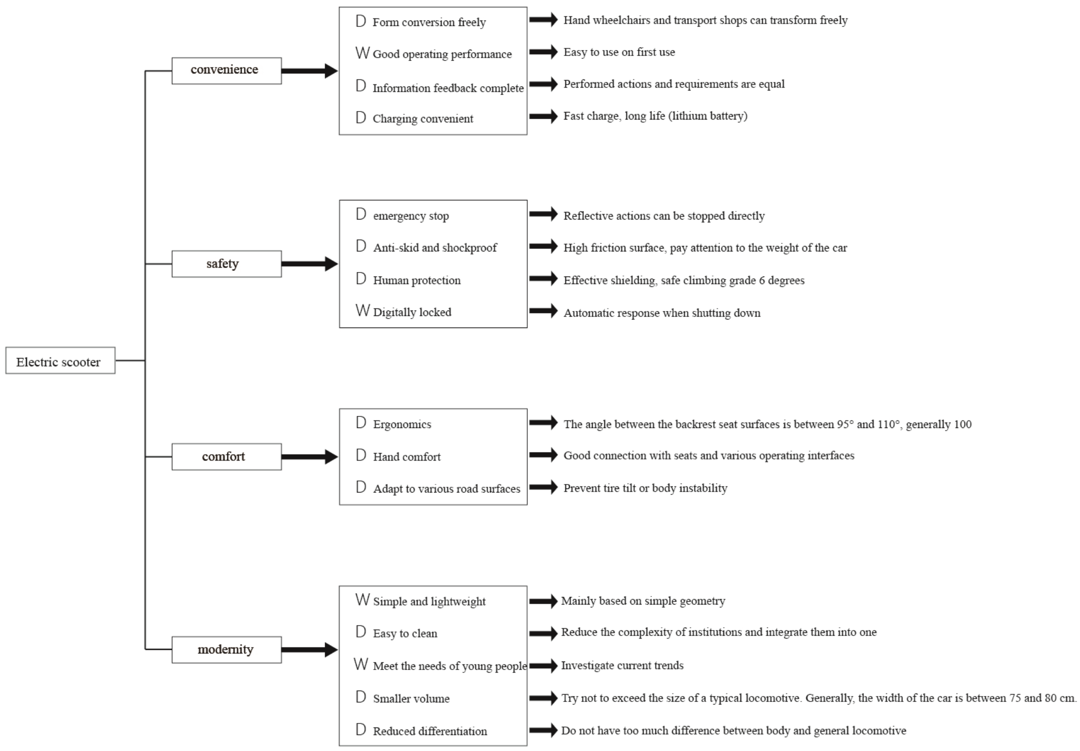


Figure 3: Target tree item.

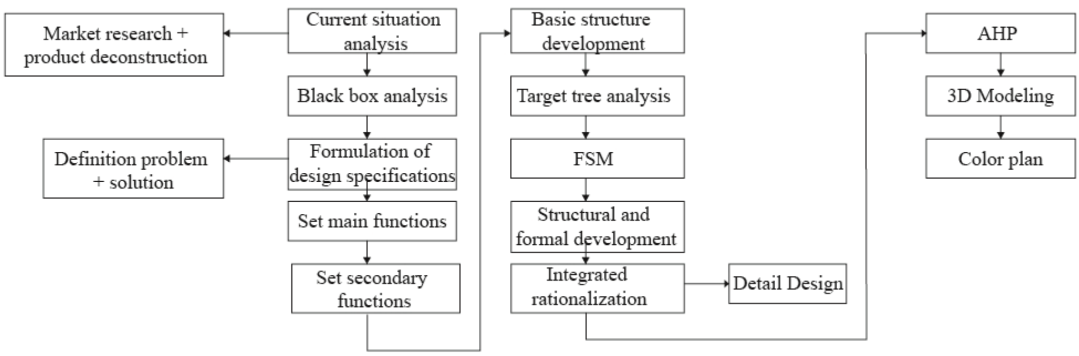
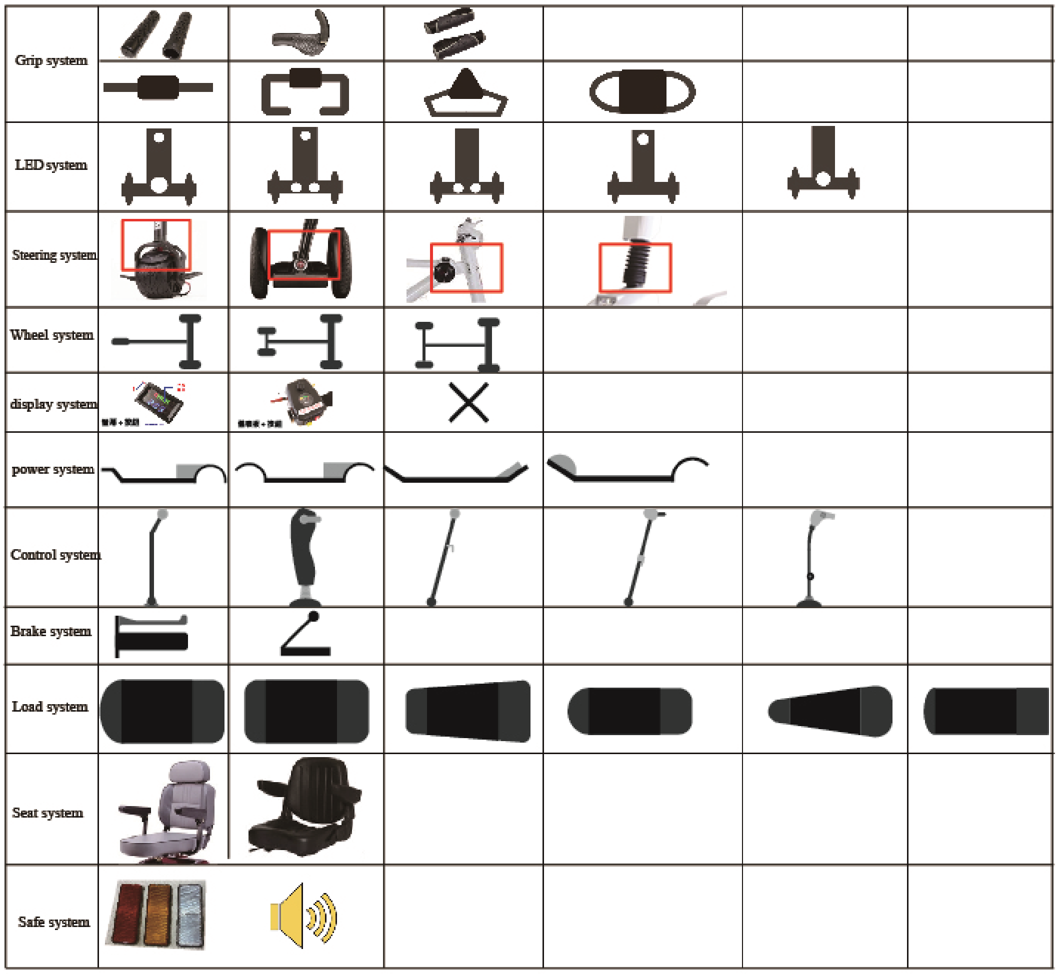


Figure 4: Design process.

3.4.1. Morphological chart method

The concept of electric mobility scooter re-design is introduced according to the Morphological chart method, as shown in Table III.

Table 3: Morphological chart of electric scooter.



3.4.2. Finite structure method (FSM)

Figure 5 shows the configuration development of the battery and motor in the structural variables and space through the morphological chart method then compare various programs. The battery will affect the weight of the car body and the size of the car body. The motor is divided into front and rear wheel drive, affecting the maneuverability and direction stability of the car body. This article places the motor in the rear wheel and the rear wheel drive is the most commonly used drive type. It has good stability and good handling at low speeds [9]. The battery is also configured at the back end, in order to increase the front-end space and the stability of gravity, the result is shown in Figure 5(L).

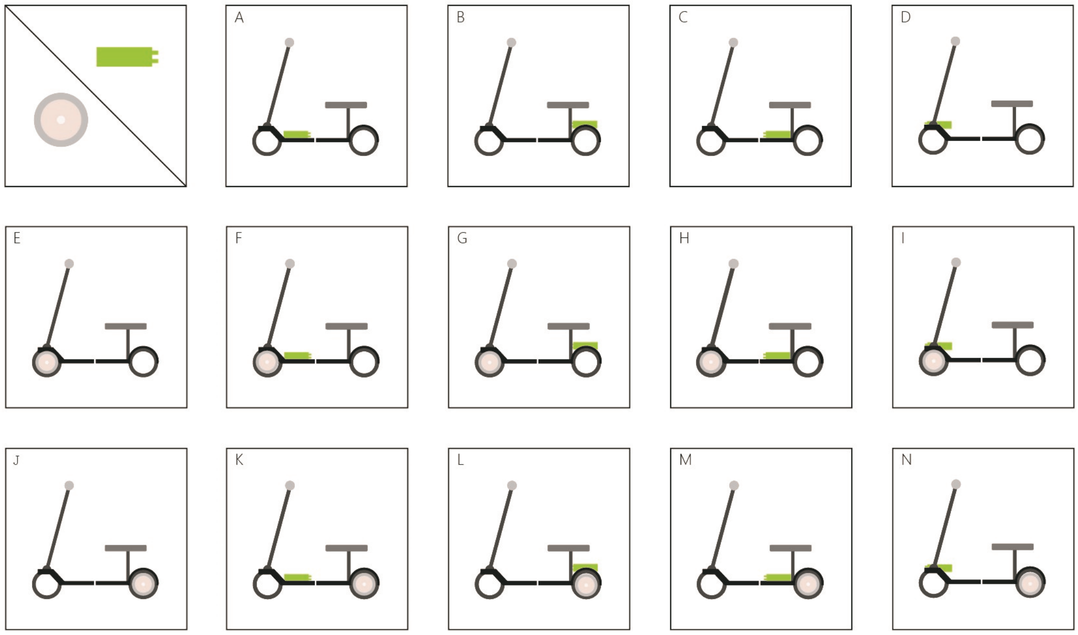


Figure 5: Analysis of Configuration of Main Functions (Battery, Motor) on Structural Variables.

3.4.3. Conceptual sketching

Integrate the analysis of electric scooter functions of the above morphological chart analysis method and Finite Structure method, and re-design the analysis result into multiple ideas and sketch development, as shown in Figure 6.7 below.

Figure 6: Sketch of electric scooter.

3.5. Concept assessment

Based on the development of the concept sketch above, three design options A, B, and C are selected. These three options are mainly based on three-wheeled vehicles.

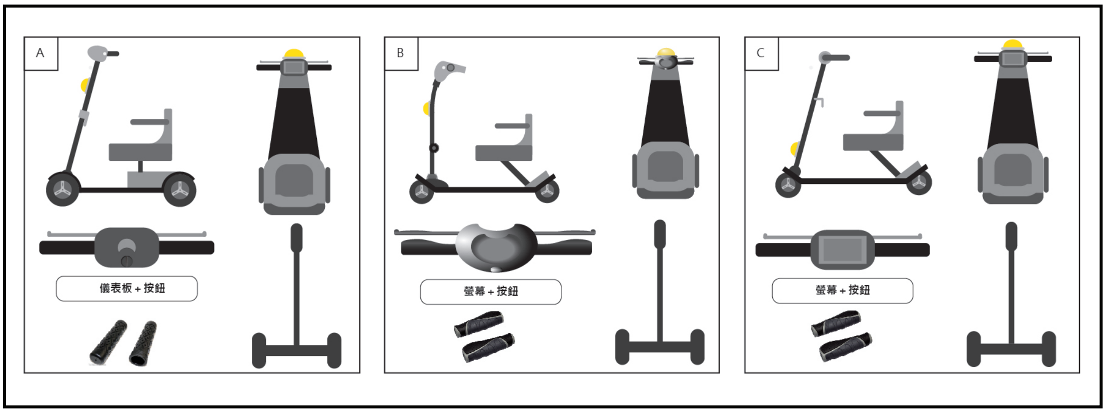


Figure 7: Conception Detail Design.

In the future, the business opportunities of electric tricycles may be higher than that of electric four-wheeled vehicles. There are tens thousands of four-wheelers electric scooter are needed, but one hundred thousands of three-wheelers electric scooter, so three-wheelers electric scooter has rich business opportunities [10], and the form is light and simple to meet the current trend of the times. Then perform the AHP method to calculate the best plan and use Table IV as the selection criteria, and base on AHP analysis and weight addition calculation, the weight values are shown in Table V. Finally, the AHP matrix operation is performed on the design scheme. The operation result is shown in equation (1).

Table 4: Selection criteria.

	Convenience	Safety	Comfort	Modernity	Geometric average	Weights
Convenience	1	1/3	3	1/3	0.933	0.221
Safety	3	1	3	3	1.228	0.292
Comfort	1/3	1/3	1	1/3	0.813	0.292
Modernity	3	1/3	3	1	1.071	0.193
total					3.991	

3.6. 3D Modeling

Through the above AHP method to evaluate the A, B, C three programs, the final calculation result is that the best design for the B, the B program to 3D software construction product appearance shown in Figure 8-9.

Table 5: Scheme weight value Selection criteria.

Convenience	A	B	C	Geometric average	Weights
A	1	1/3	1/2	0. 799	0. 261
B	3	1	2	1. 251	0. 41
C	2	1/2	1	1	0. 327
total				3. 05	

Safety	A	B	C	Geometric average	Weights
A	1	1/3	1	0. 871	0. 286
B	3	1	2	1. 251	0. 411
C	1	1/2	1	0. 917	0. 301
total				3. 039	

Comfort	A	B	C	Geometric average	Weights
A	1	1/5	1/3	0. 712	0. 229
B	5	1	2	1. 333	0. 43
C	3	1/2	1	1. 051	0. 339
total				3. 096	

Modernity	A	B	C	Geometric average	Weights
A	1	1/5	1/2	0. 749	0. 239
B	3	1	3	1. 316	0. 42
C	5	1/3	1	1. 065	0. 34
total				3. 13	

3.7. Color planning

The color scheme takes PANTONE 2018's annual representative color as one of considerations, then refers to the 2018 spring fashion color collocation, and finally makes a series of developments in black and white, as shown in Figure 9 - Figure 11.

4. Results and Discussion

The final design of electric scooter is mainly for young disabilities. In addition to adding new technologies, the body adopts a minimalist design concept, which emphasizes lightweight, simple appearance and modern feel. The final design feature is:

1. Telescopic folding provides users with more features for selective use.
2. With rear-wheel drive, driving is better at low speeds.

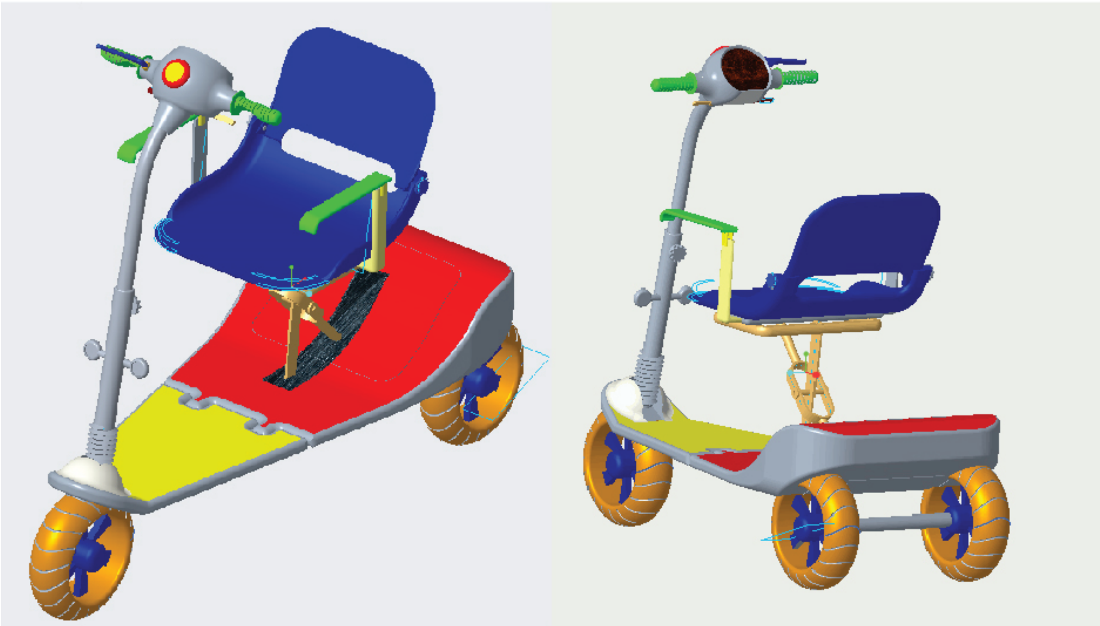


Figure 8: 3D Modeling with Equal view and rear view.

	PANTONE 18-3838 Ultra violet		PANTONE 19-4053 Turkish Sea
	PANTONE 17-3930 Jacaranda		PANTONE 17-43288 Blue Moon
	PANTONE 13-0940 Sunset Gold		PANTONE 15-1516 Peach Beige
	PANTONE 15-1242 Must melon		PANTONE 13-1012 Frosted Almond
	PANTONE 18-4538 Hawailan Surf		PANTONE 14-4506 Ether
	PANTONE 17-3420 Bodacious		PANTONE 14-3949 Xenon Blue
	PANTONE 11-0622 Yellow Iris		PANTONE 17-3924 Lavender Violet
	PANTONE 13-0324 Lettuce Green		PANTONE 15-0525 Wipping Willow

Figure 9: PANTONE released 2018 spring fashion color.

3. The use of three-wheeled scooter to reduce the outside of the vehicle is also full of future market demand.

Figure 10: Electric scooter modeling series color plan.

Figure 11: Electric scooter detail design.

4. Retractable seats, which are lighter and lighter in appearance and less bulky in appearance.

5. Lithium-based batteries can be quickly charged and have a long service life [11].

5. Conclusion

Designers often develop products based on personal perception. When making decisions, there is no objective data to design. Product success depends on good luck or the designer's own rich experience. The entire design process used traditional industry black box operations, causing unexpected ills. This study mainly discusses that concurrent design strategies can effectively save product development and design time. Through image scale analysis and black box design methods, market positioning and design specifications can be clearly defined, then morphological chart methods, FSM, and AHP hierarchical analysis methods can be integrated. The model supplemented by the color plan refers to the development of the electric scooter and the results of computer-aided design simulation design case studies. These methods not only satisfy the consumer's functional, aesthetic needs and design specifications but also accelerate the design process. Significantly increase the success rate of product commercialization.

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