Research on Wheelchair Design for the Disabled Elderly Based on QFD/TRIZ

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Abstract. Objective This research proposes a wheelchair design method for the elderly with disabilities based on the combination of QFD theory and TRIZ theory to improve the satisfaction of the needs of elderly users and the feasibility of implementing related product technologies.

Methods Starting from the needs of disabled elderly people, this research analyzes the shortcomings of QFD theory and TRIZ theory, and builds a framework model that combines TRIZ and QFD theory. Conclusion Through the redesign of the wheelchair, the various problems encountered by the disabled elderly in the process of using the wheelchair are solved, and their needs in the wheelchair are met. At the same time, through the analysis of the design process and results, the QFD/TRIZ integrated model is proposed and verified. The feasibility of functional product design that can be applied to disabled elderly people.

1. Related theoretical applications

1.1. Formatting the title Theory of QFD
QFD is a quality development theory designed to meet user needs. Its core is based on user needs and runs through the entire process from product feasibility analysis to product production. Using QFD theory can effectively transform user requirements into design requirements. HQO is the core tool of QFD. It combines user needs with product characteristics. Through integration, analysis, and calculation, the priority of user needs and the importance of product characteristics are obtained.

1.2. Formatting the title Theory of TRIZ
Designers will have three contradictions when designing, namely, physical contradiction, technical contradiction and management contradiction. TRIZ theory is to study the physical contradictions and technical contradictions. Designers will have three contradictions when designing, namely, physical contradiction, technical contradiction and management contradiction. TRIZ theory is to study the physical contradictions and technical contradictions.

2. Integrated model of QFD and TRIZ
The theory of QFD provides the direction of design by meeting the needs of users, and the theory of TRIZ provides direction for solving problems through professional matrix analysis. The combination of the two overcomes the shortcomings of the designer's experience. The integrated model of QFD and TRIZ establishes an integrated application example of "user requirements-house of quality-conflict resolution matrix-product", which can better guide product design and production. Taking the wheelchair of the disabled elderly as an example, the integrated application example of QFD and TRIZ integrated model is shown in Figure 1.
The integration model of QFD and TRIZ is mainly developed in three steps. First, describe the needs of disabled elderly people in wheelchairs, conduct demand acquisition, and sort and classify the needs to determine the weight of needs; secondly, establish HQO to obtain the correlation between the needs of disabled elderly people and product characteristics. Draw the priority order of product features; finally, use the principles contained in TRIZ’s theory to eliminate product feature conflicts. By completing the complete steps of the integrated model of QFD and TRIZ, a wheelchair design that meets the needs of the elderly with disabilities can be carried out.

3. Wheelchair design practice for disabled elderly

3.1. Construction of HQO
First, the needs of disabled elderly people are screened and classified. The needs of disabled elderly in the process of using wheelchairs mainly include three aspects: physical needs, psychological needs and economic needs. Among them, the physiological needs are simple operation, diverse functions, simple structure, safety and hygiene; the psychological needs are beautiful in appearance; the economic needs are durable, practical, and affordable. In addition, according to the quality requirements and the wheelchair product design method, the required technical indicators are to maintain balance, structure, material and colour. First, according to the characteristics of the wheelchair and the physical characteristics of the elderly, the product characteristics of the elderly wheelchair products are summarized as: structural complexity, material and shape, overall comfort, user customization, convenient use, stability, lightweight, modularization, Size, internal structure, versatility, functional configuration. Then, within the theoretical framework of QFD, the comprehensive needs of user experience such as physiology, psychology, economy and design technical demand index matrix are developed to complete the HQO construction of wheelchair products for the elderly, as shown in Figure 2.
3.2. Model transformation of TRIZ problem

Through the analysis of the relative relationship matrix between product characteristics and user demand, the negative correlation relationship between product characteristics can be obtained, and three main conflicts in the correlation matrix can be obtained from the top area of HQO. The resulting three sets of product characteristics and negative demand-related issues are translated into TRIZ problem models, as in Table 1.

### Tab 1 TRIZ Problem Transformation for Conflict Problems

| Negatively related characteristics | 39 general engineering parameters | The type of contradiction |
|-----------------------------------|----------------------------------|--------------------------|
| Modular                           | 8. The volume of a stationary object | Physical contradictions |
| size                              | 8. The volume of a stationary object | Physical contradictions |
| structure                         | 36. The complexity of the system | Technical contradictions |
| Multi-use                         | 35. Adaptive and multi-use | Technical contradictions |
| The function configuration        | 35. Applicability | Technical contradictions |
| Cost of learning                  | 19. The consumption of moving objects | Physical contradictions |

![Diagram](image)

Fig.2 Wheelchair Quality House for Disabled Elderly

After transforming the TRIZ problem by transforming the conflict between product characteristics and requirements, the TRIZ theory is used to propose solutions, as seen in Table 2.

### Tab 2 TRIZ problem solution

| The corresponding TRIZ theory of the solution. | type |
|-----------------------------------------------|------|
| NO.1 Split                                    | Physical contradictions |
| NO.26. Copy                                   |      |
3.3. Analysis and solution of design problems

The designer uses the principles contained in TRIZ's theory to eliminate technical contradictions and physical contradictions, and then break through each issue to complete the innovative design of the product. The analysis is as follows:

(1) The component size of the safety modularization and the component size of individual requirements (physical contradiction). Current wheelchairs are used for daily activities of elderly people with disabilities. According to the description of conflicts, on the one hand, the size of the wheelchair needs to fit the human body, so that the disabled elderly can be more comfortable in the process of using the wheelchair; on the other hand, due to the rehabilitation needs of the disabled elderly, in the design of the wheelchair, the safety of their rehabilitation activities should be ensured, and the guarantee of safety comes from the relevant structural and functional components of the unified standard. At this time, the user's personality needs and the requirements of the security structure module produced a physical contradiction. As we can see above, the problem needs to be solved by using the principle of division under the theory of spatial separation, i.e. wheelchairs are divided into separate parts (subjects and wheelchair armrests). As shown in Figure 3, wheelchair handrails are designed to extend to a certain length of support crutches to help disabled elderly people walk during rehabilitation.

![Fig.3 The use of wheelchair handrails](image)

(2) Internal structure and multi-use (technical contradictions). The new wheelchair design is not only to meet the basic move, but should also have a variety of uses to help disabled elderly people with rehabilitation treatment, wheelchair versatility needs to make the structure of the wheelchair more complex, which is not consistent with the product design should be simple and practical product features. There is a technical contradiction between the multi-use of wheelchairs and the need to maintain the simple structure of wheelchairs. According to the 39 general engineering parameters in TRIZ theory, simple structure and multi-use can correspond to the complexity and applicability and versatility of the system respectively, and then the design principle of solving the contradiction can be obtained through the contradiction matrix -- using air pressure and hydraulic structure to solve this contradiction. As shown in Figure 4, in the design of the wheelchair, the use of hydraulic rod as the wheelchair's deformable power support, not only to maintain the original simple structure of the wheelchair, but also to meet the multi-functional needs of the wheelchair itself.
(3) Functional configuration and learning costs (technical contradictions). Wheelchairs are designed to meet the needs of older people with disabilities, and increasing the functionality of wheelchairs themselves is one of the ways. But the addition of features also makes learning higher for older people with disabilities. Therefore, the development of new functions and reduce the cost of learning formed a technical. By looking for common functional parameters corresponding to functional configuration and learning cost, the principle of using reverse action can be determined in the contradiction matrix to solve this contradiction. In the design, change the form of the function, make a previously immovable part movable, as shown in Figure 5, so that the wheelchair seat and back can be moved, you can help the user move. This transfer process does not need to rely on other objects, just sit in a wheelchair, press the switch to put down the backrest, rely on the electric support bar to move the body to the destination point, the function of the process is simple to use at the same time, reducing the cost of learning.

4. summary
The purpose of this study is to provide a method for the design of wheelchairs for the elderly with disabilities through the models of QFD and TRIZ collection, to import the needs of the elderly with disabilities into the product design. Designers must accurately position the design and positioning of wheelchairs for the disabled, and finally design a multifunctional wheelchair. In the case of realizing lifting and walking assistance, simple toileting, easy getting in and out of bed and other functions, a simple use process is guaranteed. In the product design analysis stage, through the survey of disabled elderly, medical product designers and manufacturers, the demand with higher frequency is selected as the final user demand. These have greatly guaranteed the authenticity and objectivity of user needs. Over time, the design system of products for the elderly will become more and more perfect. This study aims at the wheelchair of the elderly, hoping to solve the practical problems of the aging society through the relevant design practice, and also hopes to provide a new design concept and research idea for the relevant design research.

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