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A Study of Design Demand of Applying Quality Function Deployment in Plastic Folding Chairs

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Abstract. The design of folding chairs has long been focused on the low-price market targeting at mass gathering with high demand. Following the changes in society, a number of public have accustomed to use the folding chairs as household use, whereas the household folding chair with mid to high price range also emerge from the market eventually. Nonetheless, the rise of consumer awareness and enhanced demand for product quality from the public have shifted the design of plastic folding chair from general folding chair to the designers perception oriented chairs. Hence, the study applied quality function deployment to establish user demand for plastic folding chairs, inducing the five expectations for plastic folding chair through the procedures in quality function deployment, namely into "aesthetics," "convenience," "structural safety," "comfort," and "environmental protection." These five demands are placed into the House of Quality and transformed into the design elements and benchmark.

The research results show that the first three projects and weights for customer requirements are sorted in the order of "parts unlikely to fall off (6.8%)," "non-pinching during use (6.7%)" and "ergonomic considerations (6.5%)." Among the parameter characteristics of design, the first three projects and weights are sorted in order of "use sliders or pullers to prevent pinching (10%)," "no screws used (9.4%)" and "holistic design of structure and form (8.5%)." The designers can fully understand customer demand through this transformation and the designers can add the above demand quality into the design of plastic folding chair during the conceptual design, attempt to assure the new product design can solve the existing inconvenience. The study analysis and results can be proposed as specific reference for the relevant design developers in designing plastic folding chairs.

Introduction

Folding chair has long been widely used in our daily life. It is one indispensable chair that is used in general families, large gathering or halls of graduation ceremonies, and even outdoor gathering on grasslands. In recent years, the consumption pattern of folding chair has somewhat changed as a number of public are treating folding chair as part of the household chairs and the increasing popularity in household plastic folding chairs with mid to high prices. The design of folding chair in the past focused on public gathering and low-priced market with larger demand, whereas the consumers were not necessarily the end users. The choice of purchasers did not necessarily reflect the mindset of the users. As the society changes and the consumer awareness rises, people's demand for product quality climbs and the design and manufacturing of folding chairs are no longer carried out through old methods but completely rely on the perception of designers. Additionally, few suppliers have developed plastic folding chair and even less designers on the design and development of plastic folding chairs. The designers must probe into user demand in the design of plastic folding chairs. Hence, the study applied Quality Function Deployment (QFD) to systematically explore the user demand for plastic folding chairs and transform the demand projects as the basis for auxiliary design policies, thereby to enhance the user satisfaction towards new products and improve existing problems occurring to user daily.

Literature Review

Research Process and Analysis

The study acquired knowledge on the characteristics of folding chairs and quality function deployment in addition to the applications through literature review and data collection. The study further applied questionnaire survey to understand the projects of consumer demand and related quality elements to consumers. The acquisition of samples for the study comprised users who have used folding chairs, aged between 20~55 years old. The study has released questionnaire survey in 2 stages as shown in (Table 3-1). The first stage investigated on 50 users with semi-open questionnaire for the demand projects in the design of plastic folding chair. A total of 50 respondents were interviewed in this stage, grouped and categorized according to KJ methods. The consumers were analyzed with project weights to conduct closed questionnaire survey at the second stage. In this stage, the survey emphasized on general consumers (same respondents as last time), whose evaluation on the importance of requirement projects for the folding chair design.

Table 3-1 Quality Function Deployment Questionnaire Survey Description

Stage	First Stage	Second Stage
Questionnaire Type	User demand questionnaire survey (Semi-open)	Questionnaire survey on demand weights (Closed)
Purpose	Collecting user demand	Investigating quality weights of demand
Survey Targets	The general public who have used household folding chair	Same as first stage
Number of Questionnaires	50 copies	50 copies

User demand survey

A total of 50 respondents have been interviewed in this survey, with male and female accounting for 25 each. The number of valid questionnaires was 46, 4 invalid questionnaires and the effective recovery rate was 92%. The data show that most public using folding chair at home emphasize more on the coordination between the folding chair and the environment. Most users even treat the folding chairs as the dining chairs or study chairs, and therefore they focus more on the comfort of chairs. Additionally, due to the frequent use for folding and unfolding chair, some spare parts are likely to fall off which could lead to accidents. The rise of environmental protection leads a small number of users, urging the design of folding chair with consideration of recycling. Most users in outdoor gathering and dining room believe that the chairs could easily be rusted on the iron pipes due to the outdoor climate or humidity of the restaurants. Most users believe that the shape and comfort of folding chairs fall below expectation and still have room for improvement.

Importance analysis of demand quality

The importance of demand quality was analyzed from the results of questionnaire survey. The results from the first-stage questionnaire allowed users to conduct evaluation on the various demand projects according to differences in individual demand, giving scores according to five evaluation standards, namely highly important, important, no comments, not important, and highly unimportant. Each point of score (1~5) was multiplied by the number of scores received and summed up with the scores received from various demand quality to yield the weighted coincidence of the benchmark project. The numbers after computation and sorting became the importance of various demand quality. The weight coincidences sorted out were divided by 46, in other words the importance of demand quality. The greater the weighted points, the greater the importance and hence the higher the importance. The data were summarized into the importance analysis of demand quality as shown in (Table 3-2).

Table 3-2 Importance Analysis of Demand quality

Dimension	Demand quality	Evaluation 1 2 3 4 5	Weighted Coincidence	Importance	Weight %	Order
Aesthetics	Color coordinating with the environment	0 1 8 24 13	187	4.07	6.01%	10
	Form integrity	0 1 8 17 20	194	4.22	6.23%	6
	Surface finish	0 2 5 24 15	190	4.13	6.1%	8
Convenience	Easy moving	0 0 8 24 14	190	4.13	6.1%	8
	Compact	0 0 8 18 20	196	4.26	6.29%	5
	Easy folding and unfolding	0 0 5 20 21	201	4.37	6.42%	4
	Convenient stacking	0 2 6 18 20	194	4.22	6.23%	6
Structural Safety	Unlikely to fall off when standing on top of the chair	0 1 7 18 20	195	4.24	6.26%	5
	Non-pinching to hands during use	0 0 4 12 30	210	4.57	6.74%	2
	Parts not easily falling off	0 0 3 13 30	211	4.59	6.78%	1
	Resistant to weather, wind and rain	0 1 10 22 13	185	4.02	5.94%	11
Comfort	Taking consideration of ergonomics	0 0 7 15 24	201	4.37	6.45%	3
	Material use	0 1 6 22 17	193	4.2	6.2%	7
Environmental Protection	Recycling and reuse	0 1 9 22 14	187	4.07	6.01%	10
	Reducing use of materials	0 1 8 22 15	189	4.11	6.07%	9
Sum				67.7	100%	

Preparing Quality Function Deployment Table

The quality projects have been converted from demand and sorted into quality deployment table, the quality analysis will be yielded according to the quality table. The researchers converted demand quality projects into demand quality elements and prepare quality element deployment table. The quality elements were first prepared into quality element label table based on the real demand of users when developing quality elements, according to the principles of simple and clear quality characteristics without excessive abstraction. The study then applied KJ method to sort and group the elements and eventually prepared the quality element deployment table. The study concluded 22 quality elements into 16 quality elements, and eventually arranged into six groups “aesthetics,” “easy assembly,” “convenience,” “safety,” “comfort,” and “environmental protection.” This dimension was the first layer of quality element deployment. The second layer consisted of “structural and form integrity design,” “new color conversion and use,” “aesthetics in chair reinforcement,” “No screws used,” “use plastic elasticity for assembly,” “handle design,” “latch for easy stacking,” “flat surface required after folding,” “Sufficient seat reinforcement,” “Use sliders or pullers to prevent pinching,” “appropriate arch and angle of chair back,” “dimension of seat,” “appropriate angle and contour,” “appropriate height of seat,” “appropriate back height,” “parts can be dissembled and recycled,” and “part reduction.”

Establish Relation Matrix

A relation matrix between demand quality and quality elements according to demand quality and quality element deployment diagram a, followed by filling out the relevant symbols for demand quality and quality elements inside the matrix. Such symbols indicate the strength of correlation for each demand quality on quality elements. A blank can be left without marking if there is no relationship between the two. The correlation symbols and strength are described below: ◎ Strong correlation : 9points, ○ intermediate correlation: 5 points and △ weak correlation: 1 point. Finally, the independent point allocation is applied to calculate quality element weights. The method calculates the demand quality weights and relevant matrices acquired from quality planning: The score is calculated by the weights of demand quality multiplied by the correlation symbols of relevant

matrices, which are summed to become the absolute weight of quality elements. The percentage is calculated to yield the quality element weights, thereby completing the "demand quality-quality elements" matrix deployment table, as shown in (Table 3-3).

Table 3-3 Demand Quality- Quality Element Matrix Expanding Table

◎ Strong Correlation : 9 points ○ Intermediate Correlation : 5 points △ Weak Correlation : 1point		First Layer	Aesthetics			Easy Assembly		Convenien-ce		Safety		Comfort				Environ-mental Protection		Planning Quality		
		Second Layer	Structural and form integrity design	New color conversion and use	Aesthetic appeals in seat reinforcement	No screws used	Use plastic elasticity for assembly	Handle design	Latch for easy stacking	Sufficient seat reinforcement	Use sliders or pullers to prevent pinching	Appropriate arc and angle of chair back	Appropriate seat dimension, angle and contour	Appropriate seat height	Appropriate height of chair back	Parts can be dissembled and recycled	Parts reduction	Importance	Weight%	Order
First Layer	Second Layer	No	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15			
Aesthetics	Colors coordinating with environment	1	△	◎														**4.07**	6	**10**
	Form integrity	2	◎	○	◎	○	○	△	△		○	○	○	△	△		△	**4.22**	6.23	**6**
	Surface finish	3	△	△														**4.13**	**6.1**	**8**
Conveni-ence	Convenient moving	4						◎										**4.13**	**6.1**	**8**
	Compact	5	△				△		○		△							**4.26**	**6.29**	**5**
	Easy folding	6						○			◎							**4.37**	**6.42**	**4**
	Convenient stacking	7						△	◎									**4.22**	**6.23**	**6**
Structural Safety	On top of the seat not easily falling off when standing	8			○					◎	△							**4.24**	**6.26**	**5**
	Non-pinching during use	9									◎							**4.57**	**6.74**	**2**
	Parts unlikely to fall off	10			△	○	○			○	△						△	**4.59**	**6.78**	**1**
	Resistant to weather, wind and rain	11				△				△							△	**4.02**	**5.94**	**11**
Comfort	Taking consideration of ergonomics	12						△		△		◎	◎	◎	◎			**4.37**	**6.45**	**3**
	Material use	13	△	△	○	△	△			◎	△	△	○			○	△	**4.2**	**6.2**	**7**
Environ-mental Protection	Recycling and reuse	14	○			○	△									◎	○	**4.07**	**6**	**10**
	Material reduction	15	○			◎	○									○	◎	**4.11**	**6.07**	**9**
Quality Weights	Absolute weights		**9.55**	**66.1**	**85**	**110**	**77**	**71.8**	**64**	**91**	**119**	**65**	**81**	**43.6**	**43.6**	**78.2**	**74.4**	**1163.5**		
	Quality element weights%		**8.21**	**5.68**	**7.3**	**9.4**	**6.6**	**6.17**	**5.5**	**7.8**	**10**	**5.6**	**7**	**3.74**	**3.74**	**6.72**	**6.39**			

RESULTS AND DISCUSSION

(Table 3-3)shows that there is a number of design factors for plastic folding chairs, which demand elements mainly include "aesthetic," "convenience," "structural safety," "comfort," and "environmental production. In terms of aesthetics, consumers emphasize more on the overall form of folding chair, which could result from the folding chair being a functional-shape product (structure is also part of product appearance). Hence, the design of seat should pay attention to aesthetics in reinforcement beams. In addition to focusing on the compact size after folding the plastic folding chair, the convenience dimension emphasizes more on the convenience of folding for the chair. In terms of structural safety, the consumers not only stress on whether if the chair pinches the hand during the folding process but also whether if the product parts can easily fall of and cause accidents. Additionally, consumers particularly place importance on the comfort of chairs, as a good chair allows users to sit over long period of time without feeling tired. Therefore, whether the chair applies

ergonomics in the design is one project which the consumers highly value. Finally in terms of environmental protection, although the rise of green awareness in recent years have urged people to enhance their concepts of environmental product, the survey in contrast did not discover consumers emphasizing more on the reduction of materials and recycling materials for reuse as expected.
The quality elements are divided into "aesthetics," "easy assembly," "convenience," "safety," "comfort," and "environmental protection." In terms of aesthetics, the folding chairs often require reinforcement beams on the seat to support the weight of human body, whereas these reinforcement beams are visible from outside. Hence, the designers must pay attention to aesthetics in the reinforcement beams for the seats in attempt to maintain the structural and form integrity. In terms of easy assembly, the combination of using plastic elasticity and no use of screws not only educes assembly time but also simplifies the overall assembly process, making materials more easily recycled and reused. In terms of convenience, adding handle to the back provides convenience in moving the chair. In terms of safety, the average folding chairs apply four-bar linkage as the linking mechanism and consumers could face with pinching problems due to parts and parts movement shaping into scissors type during the folding/unfolding or moving of products. Hence, the designers may apply sliders or pullers to prevent product pinching when designing the folding chair. In terms of comfort, whether if the art and angled of the back are appropriate and whether if the dimension, angle and contour of the seats contain comfort, are all critical elements of consideration. In terms of environmental protection, parts that can be easily dissembled and recycled is one of the factors taken into consideration for design.

CONCLUSIONS

The study applies quality function deployment to emphasize on the design deployment procedures for plastic folding chair to acquire objective user demand through user analysis. In the process of product design, user demand was fully converted into design parameters for product development. The study results showed that: Five major dimensions and the framework for the 15 customer demand based property projects are built with the top three projects and weights sorted in the order of "parts unlikely to fall off (6.8%)," "non-pinching during use (6.7%)" and "taking consideration of ergonomics (6.5%)." Among the characteristics of design parameters, 6 major dimension and 15 elements of plastic folding chair product design characteristics have been established, in which the top three projects and weights are sorted in the order of "use sliders or pullers to prevent pinching (10%)," "no screws used (6.7%)" and "structural and form integrity design (6.5%)." The above results can be provided to designers to add the above required quality during the conceptual design into plastic folding chairs, in attempt to assure the design of new products can solve current inconvenience and increase user satisfaction. The study results can be proposed as specific reference for future designers and developers in the design of plastic folding chair.

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