

QFD Phases I and II on Walking Aid Case Study

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ABSTRACT

The development of the product is currently necessary in order for the product to be successful in the market. This article discusses the redesign of walking aid items as a response to the concerns and issues that users have with these products. Its goal is to supply tools that are both secure and suitable for the requirements of the consumer. Enhancements are made by the utilization of the integration of the Quality Function Deployment Phase 1 and Phase 2 techniques. During the first phase of QFD, client needs will be translated into technical qualities in order to optimize tool design, whereas QFD Phase II will generate priority part qualities for the purpose of accelerating the process of tool design improvement. As a consequence of this, the technical qualities that need to be fixed immediately are the design mobility and the convenience of use, and the features of the part that need to be enhanced almost immediately are the multifunction and the safety of the tool. It was possible to achieve improvements in the design of the foot therapy device by reducing the fundamental framework. After that, a foam armrest was installed, and rubber was used to replace the handrails. Wheel retention components, including as brakes and user seats, are also included in the new design of the vehicle.

Keywords:

QFD; Phase 1; Phase 2; Walking Aid

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1. Introduction

Companies need to continue to develop products by understanding product functionality as well as consumer needs or interests in an increasingly competitive business environment. This is necessary in order to obtain products that are competitive and of high quality while still generating high levels of profitability (Prasad, Subbaiah, & Rao, 2011).

A walking aid is a therapeutic item that can help patients recover from injuries or bone and muscle abnormalities in the lower body. There are various difficulties or complaints from physiotherapists and patients who use these foot therapy devices, such as uncomfortable grips and the risk of patients falling during the treatment procedure, creating concern and discomfort to patients. The customer survey was conducted on the entire population of 50 people (patients). According to consumer surveys, there are issues with the usage of walking aids, which are customer needs that must be considered while developing product enhancement concepts (Ginting & Silalahi, 2023)

Table 1. Complaints about Walking Aid

No	Problem
1	The size is too big, so it is difficult to use every day
2	Complaints of callus on the palms caused by an uncomfortable grip
3	The design complicates user mobility
4	There is a risk of the user falling

According to the study "Designing an Innovative Walking Aid Kit; A Case Study of Design in Inclusive Healthcare Products" conducted by [_\(Taukobong, Myezwa, Pengpid, & Van Geertruyden, 2014\)](#). The use of an improper walker may aggravate the user's condition, impede healing, or raise the chance of an accident or injury. According to Nickpour's research, users of walking aids require walking aids that can adapt to their users.

The objective of this research is to develop qualities of walking aid items that are adapted to the demands of consumers in order to identify the best option in order to lessen the danger of patients falling and to meet user needs. As a result, the Quality Function Deployment approach is employed. Quality Deployment Function (QFD) is one of the quality tools that can help to translate customer needs into a product, either a new product, an improvement of an existing product, or combining the function of existing products. The research was carried out using the QFD method, and the existing problems were printed so that the most critical problems could be found ([Ginting et al., 2021](#)).

Mitsubishi's Shipyard in Kobe, Japan, pioneered Quality Function Deployment (QFD) in 1972. Toyota and its suppliers have since developed the approach, which is now used in car design ([Ginting, Perancangan dan Pengembangan Produk, 2018](#)). Quality Function Deployment (QFD) is a method of improving the quality of goods or services by first understanding consumer needs and then connecting them with technical provisions to manufacture goods or services at each level of production ([Ginting, Malik, Silalahi, & Shelvira, 2021](#)). QFD (Quality Function Deployment) is a technique for planning and converting client needs into measurable engineering specifications ([Erdil & Arani, 2019](#)).

Dias et al.'s study "Quality Function Deployment in Healthcare: Systematic Literature Review" concludes that the QFD approach can provide output based on consumer preferences and aspirations. QFD has evolved into a powerful tool for improving service quality by concentrating on the demands of the client. HoQ makes QFD implementation more structured and valuable, ensuring that the desired goals are met ([Sukma, Setiawan, Kurnia, Atikno, & Purba, 2022](#)). Customer requirements are translated into measurable goals. QFD is a customer-centric strategy that serves as a direct tool for gathering client requirements and incorporating them into product features ([Rampal, et al., 2022](#)).

According to the findings of Radoslaw's research paper titled "The use of QFD method advantages and limitations," the QFD method is most commonly employed in Sweden to improve the product development process and customer quality. QFD also has advantages such as taking consumer wants into account, improved quality cost planning, and a favorable impact on the company's creativity and productivity ([Wolniak, 2018](#)).

QFD Phase I will create product attributes based on consumer complaints and translate customer needs into technical characteristics; these technical characteristics will then be used in QFD Phase II to create component priorities in products based on consumer desires ([Rahmayanti, Meilani, Zadry, & Saputra, 2018](#)).

2. Literature Review

2.1. Quality Function Deployment Phase 1

The methodology section should describe in detail the approaches/techniques used in the study so it can be replicated and developed by other researchers. Unless there are well-established methods, it can be briefly explained. If the study uses equipment or instruments, it is also necessary to mention the specifications. Be specific and provide all necessary detail ([Eshan, 2012](#)).

2.1.1. Analysis of Customer Needs

Customer voice is something that becomes their need for product attributes. Customer needs can be obtained through literature studies, brainstorming with experts, and distributing questionnaires to consumers. According to Akao (1990) an assessment of customer needs needs to be done to see the priority and level of importance of product attributes ([Thomas, 2017](#)). In this paper, the assessment is carried out by distributing closed questionnaires, by looking at the mode value or the majority of respondents' responses to product.

2.1.2. Analysis of Technical Characteristic

The key in QFD Phase 1 is the process of translating customer requirements into technical characteristics. Technical characteristics are ways to meet customer requirements. These technical characteristics are used as the basis for making or developing a product. Technical characteristics are obtained through literature study and brainstorming with experts. Assessment of technical characteristics is determined by looking at the relationship

between technical characteristics and the relationship between technical characteristics and customer needs. This assessment aims to determine priority improvements to the product (Irem, M., & Semiha, 2005).

The level of relationship between technical characteristics is determined by the rules of the roof ranking method (eg V = strong positive, v = moderate positive, x = moderate negative, X = strong negative, – = no relationship). The level of relationship between consumer desires and the technical characteristic of the product is determined based on the rules of the body ranking scale (eg 0 = none, 1 = weak, 3 = moderate, 9 = strong). Ranking of technical characteristics is done by looking at the level of difficulty, degree of importance, and estimated costs (Ginting, Tarigan, & Panjaitan, 2020)

Determination of Difficulty Level is determined from the relationship of technical characteristics. The calculation is done by translating all relationship weight values and dividing the weight of each TR by the total weight. Furthermore, the difficulty level (scale 1 - 5) is given based on the percentage range, where 0-5% (Scale 1), 6-11% (Scale 2), 12-17% (Scale 3), 18-23% (Scale 4), and >24% (Scale 5). The difficulty level of TR can be calculated by formula (1).

$$\text{Difficulty Level} = \frac{\text{Technical characteristics weight}}{\text{The total weight of the technical characteristics}} \times 100 \quad (1)$$

Determination of the Degree of Importance is calculated by first calculating the total weight for each relationship between the attributes of consumer desires and technical characteristics.

$$\text{Degree of Importance} = \frac{\text{Technical characteristics with attribute weight}}{\text{The total weight of the technical characteristics with attribute}} \times 100 \quad (2)$$

Cost estimates are calculated based on the difficulty level factor:

$$\text{Cost estimation} = \frac{\text{Technical characteristics difficulty level}}{\text{Total difficulty level}} \times 100 \quad (3)$$

2.2. Quality Function Deployment Phase 2

The Phase 2 QFD Matrix represents a systematic approach to translating engineering requirements (or product functions) into product parts. It provides an understanding of the correlation between functions and product parts.

2.2.1. Identification of Design Characteristics

The critical part is the most important component in the design improvement process. The stage of determining this critical part is an analysis of the parts that are considered important to the product. Determination of critical parts can be done by studying literature, interviews, and discussions with experts (Irem, M., & Semiha, 2005)

2.2.2. Analysis of Design Characteristics

Then identify the relationship between the technical requirements from phase 1 with the critical parts and the relationship between the critical parts themselves. The degree of relationship between each critical part is described using the roof ranking method. While the relationship between critical parts and technical requirements uses a body ranking scale. Furthermore, the same as QFD Phase 1, priority determination of critical parts is also carried out. The ranking of critical parts is done by looking at the level of difficulty, degree of importance, and estimated costs using equations (4), (5), and (6).

$$\text{Difficulty Level} = \frac{\text{The critical part weight}}{\text{The total weight of the critical part}} \times 100 \quad (4)$$

$$\text{Degree of Importance} = \frac{\text{Critical part with technical characteristics weight}}{\text{The total weight of the critical part with technical characteristics}} \times 100 \quad (5)$$

$$\text{Cost estimation} = \frac{\text{Critical part difficulty level}}{\text{Total difficulty level}} \times 100 \quad (6)$$

3. Methodology

Based on the explanation above, this paper is carried out according to the process flow diagram as shown in Figure 1, where work begins with an understanding of the terminology and principles of the QFD methodology that will be used in improving product design.

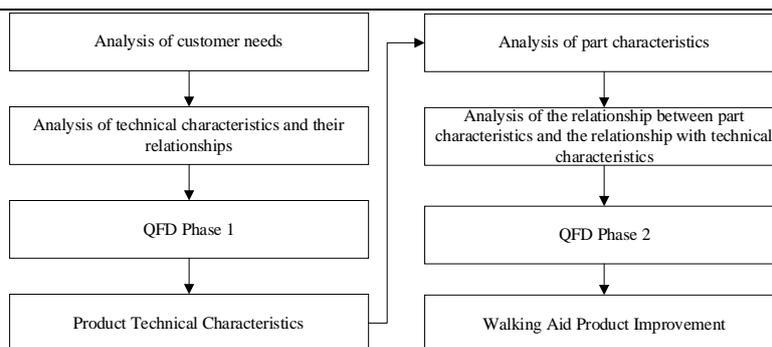


Figure 1. Research Methodology Flow

4. Results and Discussion

4.1 QFD Phase 1

The first phase is the product planning phase, which is better known as the first house (R1). Conducted excavation of information about consumer needs. After that, the process of translating the consumer's needs into a product characteristic is carried out. The translation process uses a matrix commonly called the house of quality (HOQ) (Ardani, Ginting, & Ishak, 2016).

4.1.1 Analysis of Customer Needs

Customer demands are identified by delivering open questionnaires to ten responders. According to [Kevin Otto and Kristin Wood \(2001\)](#), an open questionnaire was created as an early study to better comprehend the determination of qualities on foot therapy device items (Otto & Wood, 2001). The conclusions drawn from the open questionnaire responses generated the questions in the second stage of the questionnaire, namely the closed questionnaire, which was used to determine the level of interest (customer perceptions) and level of satisfaction (consumer expectations) in the product. The mode value on the closed questionnaire based on the frequency of the most respondents' answers to each characteristic was used to determine the level of relevance of the qualities. Each of customers needs' level of importance is shown on Table 2.

Table 2. Variable Customer Needs

No	Customer Needs	Level of Importance
1	Product handle material is Rubber	5
2	The product frame material is stainless	4
3	Product height can be adjusted	4
4	Product weight is 4.5 kg	3
5	The support width is 10 cm	4
6	An additional function of the foot therapy device is to have a seat	5
7	Foot therapy device has a function as a tool for walking and standing	5

4.1.2 Technical Characteristics Analysis

Determination of product technical characteristics is carried out by interviews and discussions with orthopedic specialists, medical technicians, and physiotherapists. The technical characteristics needed to meet consumer needs are Durability, Convenience of Use, Product Dimensions, Design's Mobility, Strong Power. In this step, the level of relationship between each of the existing technical characteristics to be analyzed is determined. The level of relationship could be strong, moderate, or weak relationship between these technical characteristics. Besides determining the level of relationship between each technical characteristic, the level of relationship between consumer desires and the technical characteristic of the product also needs to be determined. The relationship

between technical characteristics is shown in **Error! Reference source not found.**(a) and the relationship between technical characteristics and customer requirements is shown in **Error! Reference source not found.**(b).

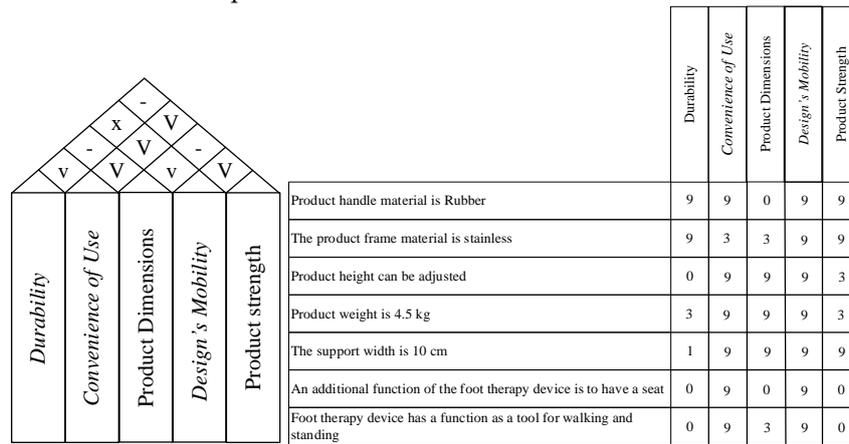


Figure 2. (a) Relationship between Technical Characteristics (b) Relationship between technical characteristics and customer requirements

Furthermore, the level of difficulty, the degree of importance, and the estimated cost of the technical characteristics. estimated using Eq. (1), (3), and equations. (2), and the results are shown in Table 2.

Table 3. Degree of Difficulty, Degree of Importance, and Estimated Cost of Technical Characteristics

Factor	TR 1	TR 2	TR 3	TR 4	TR 5
Degree of Difficulty	3	5	3	5	3
Degree of Importance	11	27	16	30	16
Estimated Cost	16	26	16	26	16

4.2 QFD Phase 2

Phase II of QFD is an attempt to translate technical qualities (Technical Requirements) into part characteristics (Design qualities). These design traits will be utilized as a guideline for redesigning later on.

4.2.1 Identification of Design Characteristics

The article may contain bulleted lists, as below: Determination of product critical parts based on interviews and discussions with orthopedic specialists, medical technicians, and physiotherapists. The critical parts of the product are multifunction, Main frame quality, Product Safety. The next step is to determine the relationship between each part characteristic. The level of relationship between technical characteristics and critical parts has the same rules as determining the level of relationship between technical characteristics and consumer needs in QFD Phase I.

4.2.2 Analysis of Design Characteristics

The next stage is to figure out how each part's characteristics relate to one another. The same procedures apply to identifying the level of relationship between technical characteristics and crucial parts as they do to assessing the level of link between technical characteristics and consumer wants in QFD Phase I.



Figure 3. Relationship between design characteristics

Furthermore, the level of difficulty, the degree of importance, and the estimated cost of the technical characteristics. estimated using Eq. (4), (5), and equations. (6), and the results are shown in Table 3.

Table 4. Degree of Difficulty, Degree of Importance, and Estimated Cost of Design Characteristics

Factor	DC 1	DC 2	DC 3
Degree of Difficulty	5	4	5
Degree of Importance	42	26	33
Estimated Cost	36	29	36

The QFD Phase 1 and Phase 2 matrices were created based on the data obtained in the previous steps. The QFD Phase 1 and Phase 2 matrices can be seen in Figure 4.

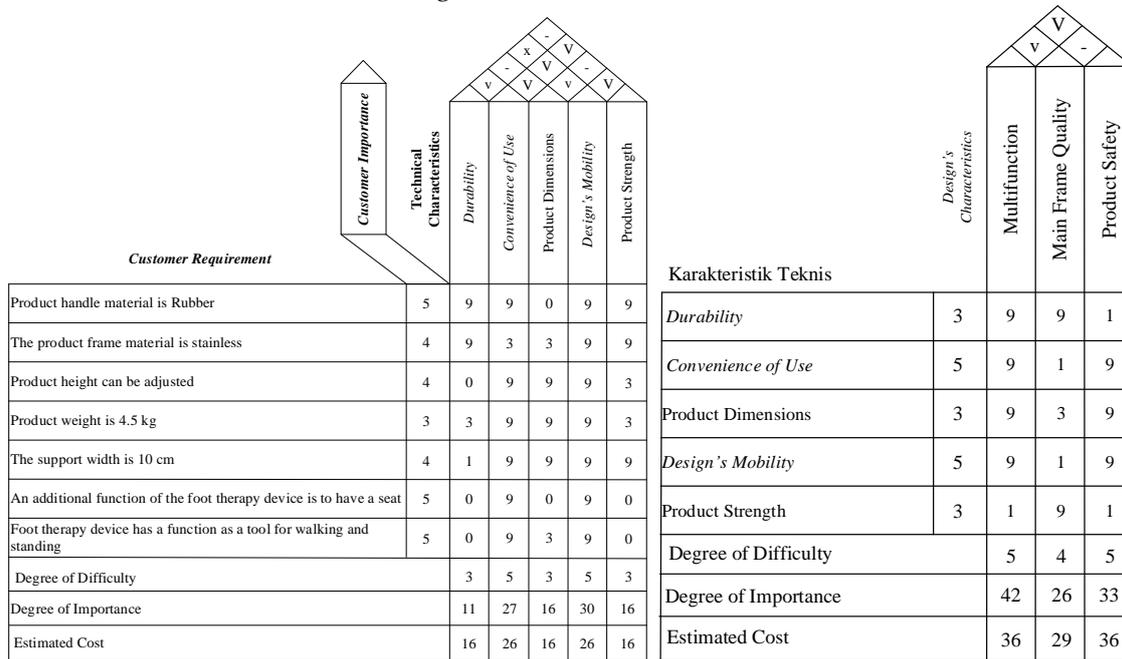


Figure 4. (a) QFD Phase 1 (b) QFD Phase 2

Walking Aid design improvements are focused on the priority of technical qualities and product part characteristics, as well as consumer needs (Murugan & Sankaran, 2022). QFD Phase 1 focuses on enhancing the mobility and use of foot therapy devices. Increased mobility of the foot therapy device design by altering walking aid's main frame.

Mobility can be achieved in a variety of ways. In many instances, for example, integrating wheels or rollers within a product is quite real. Compact items can also be more portable (AlGeddawy, Abbas, & ElMaraghy, 2014). By altering the primary frame of walking aid, the design of the foot therapy device was made more mobile. The walking aid's frame is a substrate that provides more space for the user and a wider reach when the gadget is utilized by the user. The size of the planned foot therapy equipment is also changed to fit the proper anthropometry. The use of anthropometry will be beneficial in dealing with design and workspace issues. Things connected to human body dimensions such as condition, frequency and difficulty, body posture, and conditions to aid movement (Wignjosoebroto, 2000). Foot therapy equipment is tailored to the anthropometric parameters of height, which include hips, hip breadth, and arm length. The dimensional anthropometric data were obtained from Indonesian Anthropometric data, as shown in Table 5.

Table 5. Anthropometric Data

Body Dimension	5 th	50 th	95 th
Height of Hip	55,33	87,30	119,27
Width of Hip	21,65	32,32	43,00
Hand Length	11,64	17,05	22,47

The height of the foot therapy equipment is set to the 50th percentile, which is 87.30 cm. The foot therapy equipment is set to the 95th percentile hip width, which is 43 cm. Meanwhile, the hand grasp diameter is set to the 50th percentile hand length, which is 17.05 cm. Convenience of use refers to the ease with which walking aid can be used. The tool's design has been improved to promote comfort for the user by including a foam arm support and altering the tool handle material from rubber to something less slippery. Rubber is also put into the handle pipe to make it more resistant to pressure (Alfadhliani, Meuthia, & Valent, 2013).

Meanwhile, based on the QFD Phase 2 depicted in Figure 3 (b). Walking Aid is expected to have a purpose other than assisting with walking and standing. Adding holding components such as wheel brakes improved the design. A seat is added to the foot therapy gadget to improve its safety. This is done to keep customers from tripping when using this tool. Figure 5 depicts proposed product design enhancements.

**Figure 5.** Design Improvement of Walking Aid Products

5. Conclusion

The technical characteristics produced in Phase 1 of QFD are durability, convenience of use, product dimensions, design's mobility, and strength. The most important technical characteristics to be improved immediately are the technical characteristics of convenience of use and design's mobility because they have a very difficult absolute difficulty level with a score of 5, have a very important degree of importance with scores of 27 and 30, and an estimated cost of 26%. Critical parts produced in QFD Phase 2 are multi-functional, main frame quality, and tool safety. The most important critical parts to be repaired immediately are the multi-function and safety of the tool, with a difficulty level of "absolutely very difficult" with a score of 5, having a degree of importance of "very important" with a score of 42 and 33, and an estimated cost with a value of 36. Improved tool design foot therapy is done by modifying the main framework to make it simpler. Then added a foam armrest and replaced the handrails with rubber. The new design also adds wheel retaining components such as brakes and seats for the user.

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