

Quality function deployment analysis of smartphones

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ABSTRACT

To utilize the concept of Quality Function Deployment (QFD) and apply it appropriately to address design decisions concerning the quality of cellular phones, a simplified version of the House of Quality (HoQ) will be built. Real customer requirements (CRs) are easier to collect when QFD is employed because it puts the emphasis on the customer and their demands where it should be. After gathering various users' opinions on different smartphone brands and conducting an online survey with mobile users in Taichung, Taiwan, the study highlights the items preferred by most users, such as long-lasting battery life, high-quality camera, reliability, wide screen, ease of use, and lightweight. This aids businesses in translating CRs into primary Design Requirements (DRs) so that they can create superior goods that align with consumer demands.

Keywords: Quality function deployment; House of quality; Smartphones; Primary design requirements

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1. INTRODUCTION

To succeed in today's market, a company must be able to anticipate and fulfill client wants and requirements more effectively than its rivals [1]. Companies aim to apply efficient management to speed up product creation in response to rising global competition and decreasing product life cycles. However, timetable overruns are a common problem in product development projects [2]. In 1966, it was determined for the first time that there was a need for essential points of Quality Assurance (QA) to be carried out through design and production [3]. 1978th saw the publication of studies that would eventually lead to a significant rise in the use of quality deployment across Japan. Through his research and consultation at Futaba and other companies in the early 1980s, Akao linked QFD with value engineering and other tools for cost deployment. These tools included others. In October 1983, the idea of QFD was first presented outside of Japan to the United States of America by way of an essay written by Dr. Yoji Akao titled "Quality function deployment and CWQC in Japan." This article was published in the USA. The purpose of Akao's creation of the target-means matrix was to assist in ensuring that the Japanese manufacturing sector would fulfill its quality, cost, and delivery objectives. The QFD approach is built on this matrix, which serves as its foundation.

The primary characteristics of QFD are its focus on the customer's point of view and its supply of a methodical way of ensuring that customer or marketplace expectations are accurately translated into correct technical requirements and actions throughout each stage of product development. Both characteristics are important for guaranteeing that a product meets the needs of its target market. This makes use of a series of matrices that are collectively referred to as the Quality Chart or the House of Quality.

In general, the process of developing a product is a complicated one that involves significant amounts of information processing and actions including decision making. Therefore, it is always a necessary responsibility to identify the genuine wants of consumers and then employ strategies of decision-making to translate these demands efficiently and successfully into new goods and services at lower costs and shorter

time to market. On the other hand, buyers and designers communicate in very different ways. As a result, gaining knowledge of the Voice of Consumers (VOCs) is not as simple as it may first seem [4].

By raising product quality and decreasing manufacturing time and cost, QFD is a potent instrument for increasing customer satisfaction. Using this method, businesses may learn exactly what features their consumers want to be included in their product [3]. Using surveys, QFD takes into consideration the wants and needs of consumers in relation to a product. These hankerings are dealt with as a collection of requirements from our clients (CNs). To achieve the highest possible level of customer satisfaction, several technical requirements (TRs) that are applicable to CNs have also been defined by domain experts. By prioritizing CNs and TRs via a procedure called a house of quality (HOQ), which ties CNs (known as 'WHATs' in QFD) to TRs (known as 'HOWs' in QFD), QFD makes decision-making in product development management easier. QFD does this by prioritizing CNs and TRs [5]. However, the QFD analysis may be a hard decision-making process since it requires the interpretation of hazy and subjective impressions that are sought from both consumers and engineers [6]. Establishing customer objectives or criteria and translating them into specific production plans using the QFD technique will result in products that meet those objectives.

These spoken and implicit client preferences or expectations are referred to as the "Voice of the Customer." A variety of methods are used to capture customer voices, such as direct conversation or interviews, surveys, focus groups, customer requirements, observation, warranty information, field reports, etc. A product planning matrix, often known as a "house of quality," is then used to synthesize this understanding of client expectations. These matrices are used to translate higher-level "WHATs" or wants into lower level "HOWs," such as product requirements or technical attributes, to satisfy these needs [7]. To produce a product, a team of people from many functional areas, such as marketing, design engineering, quality assurance, manufacturing/manufacturing engineering, test engineering, finance, product support, and so forth, must be involved. At each stage of this translation process, the active participation of these departments can lead to a balanced consideration of the requirements or "what's," as well as a mechanism to communicate hidden knowledge-knowledge that is held by one person or department but may not otherwise be shared throughout the organization [8].

The purpose of the HOQ is to identify client needs and product weights (WHATs), and to transform these needs into technical requirements (HOWs). HOQ provides significant advantages that blend client demands and technological requirements for designers. The manufacturers may then assist the organization in providing better products, increasing market competitiveness, and increasing customer happiness. Every stage of the process is represented by a matrix, and each matrix represents a phase [9]. The study is divided into five sections. Section 2 reflects on the past literature on the topic of QFD and smartphones. Section 3 illustrates the methodology adopted for carrying out the analysis. Section 4 presents the results and discussion of the study followed by the conclusions in section 5.

Research Gap

The feasibility of the suggested strategy is demonstrated by conducting a pilot investigation on the Millet phone. Millet phone research and development hinges on feedback from users, and the product is gaining popularity as a result. With an Internet-based open ecosystem allowing for the free expression of user needs, the Millet phone's critical requirements (CRs) are evaluated to determine how much weight each engineered characteristic should be given in the overall design. In the millet phone case study, various customer requirements and engineering characteristics were studied where big screen, long battery and high-quality camera were some of the customer requirements. As discussed, quality of a product in specific is a functional feature to carry out day to day businesses [10]. In the current changing world, with advancements in technology and awareness of all the products, customer requirements are changing. This study focuses on requirements which are in line with the engineering characteristics includes reliability, usability, and weight of the smartphone.

2. MATERIAL AND METHODS

2.1 Quality Function Deployment (QFD)

Technology is evolving quickly, and organizations must constantly adapt to remain competitive. Examining the many innovation processes that have led to the various forms of evolution that are already in place is essential when thinking about the function of new technologies. When it comes to innovations and how they evolved, closed innovation is at 1.0, collaborative innovation is at 2.0, open innovation is at 3.0, and co-innovation is at 4.0. The latter is the most emblematic example of industry 4.0 since it promotes growth through the collaborative analysis of shared data. QFD's purpose is to quantitatively realize consumer expectations and allow decision makers to steer them toward the desired product or service standards. Studies in fields as diverse as logistics and supply chain management, design and engineering, and marketing all

included QFD among their topics. QFD may help decision-makers in a system learn what makes customers happy and then find ways to improve on those things. Because of the limited prior research on QFD's potential use in the development of Smart Phones, the current study is driven to fill that void and meet the demands of consumers [11].

In QFD, correctly prioritizing needs is stressed more than any other task. Customers' expectations are prioritized since requirements' significance varies depending on the stakeholder group. This is often done through collaborative decision-making in which individuals assess the relevance of various needs and seek for weights that reflect their own values. Moreover, DMs often provide information about their preferences in a variety of ways, statistically or verbally, based on their cultural, educational, and moral systems. Given the wide range of opinions expressed by DMs, a group's preference must be derived from a variety of individual preference types [12].

As we discussed in the introduction, the QFD technique and the house of the quality matrix may be used to transform customer information into operational considerations. Typically, analysts (system administrators) collect such data using quantitative values for approximate computation; however, it is more common for analysts to collect qualitative or linguistic values when there is doubt about a customer's expectations. Multi-criteria decision-making procedures are powerful instruments for tackling such challenging decision-making issues since they consider not just consumer needs but also technical indications and alternative situations. "Design is a team effort but how do marketing and engineering communicate with each other? The answer is Quality Function Deployment (QFD)". The QFD management strategy was developed in 1972 at Mitsubishi's Kobe shipbuilding location. There are certain examples of product design and development techniques that have been tried and tested. Approaches like Taguchi, reverse engineering focus primarily on the features of the product, rather than the needs of the consumer. On the other hand, Quality Function Deployment (QFD) is a well-known approach to assessing the features and functions that have an impact on a product's quality to ensure it meets the needs of its customers [13]. In essence, QFD is a collection of planning and communication procedures that concentrates and coordinates abilities inside an organization, first for the design of, then for the manufacture of, and last for the marketing of things that customers want to buy and will continue to buy.

The House of Quality is a fundamental design tool used in the QFD approach. An inter-functional planning and communication tool, the House of Quality is a type of conceptual map. The core principle of the House of Quality is that from the moment a product is first imagined, marketing professionals, design engineers, and manufacturing personnel must all collaborate closely. Products should be developed to suit customers' preferences and needs. The most crucial input for the House of Quality is the preferences and tastes of the consumer, commonly known as the voice of the customer. Companies use a variety of marketing strategies to gauge, monitor, and compare consumer views of their offerings. Manufacturers can cut down on pre-launch time and post-launch tinkering by first focusing on consumer needs, then developing across corporate functions.

It is an integrated set of tools for identifying engineering features that meet user requirements, trade-offs that could be required between engineering features, and user demands. There have been many different definitions of QFD given, which is reflective of the fact that it has many different aspects. QFD, on the other hand, is essentially a people-based approach. Without humans, nothing at all can occur. It takes as its starting point what is known as the "voice of the consumer" (VOC). Additionally, it assembles cross-functional teams with the same goal of providing satisfactory service to the consumer. In addition to this, QFD assists in the formation of partnerships between customers and suppliers. Either a company is overly focused on its internal operations, in which case it creates products or provides services with only a hazy understanding of what its clients want, or it is overly focused on its external clients, in which case it strives to constantly satisfy its clients at the expense of its own ability to remain in business. The main trade-offs that need to be made between what the client wants and what the firm can afford to produce can be easier for businesses to make with the assistance of QFD. Spending less time on redesigning and modifying the product or process will be possible if efforts are focused on what will bring the greatest level of satisfaction to the company's clients and employees. As a result, it is an essential component of any total quality management (TQM) or continuous improvement program or deployment, as it enables businesses to transition away from an inspection-based strategy and toward the design of quality into goods. QFD does not do any actions that individuals did not perform in the past; nonetheless, it does replace erratic and intuitive decision-making processes with a more systematic method.

2.2 The QFD Process

The client requirements, which are sometimes referred to as the non-measurable aspects of a project, such as "how it appears, how it feels, durability, etc.," are the point of departure for any QFD endeavor. After these criteria have been analyzed, a set of technical parameters, such as "oven temperature, mold diameter, etc." will be developed. Measurables and engineering qualities are both terms that are used to refer to this step. The QFD procedure consists of the following four stages:

1. The product planning department is the quality control hub
2. Product design: components deployment
3. The planning of the process
4. Process control (quality control charts)

Each stage of the QFD process is depicted as a chart (or matrix) in the document. The whole QFD process includes the construction of at least four houses that stretch throughout the entirety of the system's development life cycle. Each of these houses is meant to represent a different phase of the QFD process. The most essential engineering qualities, as determined by the scoring at the bottom of the house, are the ones that move on to create the input for the succeeding step in the QFD process. This happens during the first part of the procedure. When it comes to QFD, there are some advantages. Applying QFD can lead to the creation of superior products at a cost that customers are ready to pay [14]. In addition, depending on its use in various businesses, the following advantages and benefits have been reported: reduced lead times for products [5], enhanced teamwork communications [15] and better designs. Practical advantages are frequently experienced when QFD is effectively applied: a reduction of 30–50% in the number of engineering changes, a reduction of 30–50% in the length of design cycles, a reduction of 20–60% in start-up costs, and a reduction of 20–50% in the number of warranty claims [16]. It ensures better coordination between marketing and engineering departments during the early stages of product development, and it is completely painless to correct an error in vision when one is in the brainstorming process. It is relatively inexpensive to correct a drawing or a calculation mistake when one is in the stage where all the work is still on paper.

QFD starts with the voice of customers as input. Hence several Marketing Research techniques are applied to identify, collect, and analyze the data from customers about what they want in a new product, and what improvements they would like to see in an existing product. After the customers' requirements have been collected and analyzed they are further refined and discussed with the technical department about how they can be met. QFD conveys the customer's voice to the manufacturing department through several houses.

These Houses are 1. House of Quality: Transforms engineering features into customer attributes. 2. House of Parts Deployment: This technique transforms engineering characteristics into component attributes. 3. House of Process Planning translates the properties of parts into crucial process steps. 4. The House of Production Planning transforms crucial process actions into production needs. Together these Houses not only transform the customer's requirements into product specifications.

The chart below is commonly referred to as the "house of quality". The QFD charts provide the team with assistance in the process of setting goals concerning matters that are of the highest value to the customer as well as the technical ways by which these goals may be accomplished. The ranking of the products that are on sale from competitors may also be accomplished via the use of benchmarking with consumers and users who are technically adept. The QFD chart is a flexible tool that may be used in a variety of different capacities all around the organization. It is a way for engineers to summarize key truths in a way that may be applied to various situations. General managers use client input, which is crucial to marketing, to find new company prospect [17]. A traditional QFD comprises four steps, including product planning, product design, process planning, and process control.

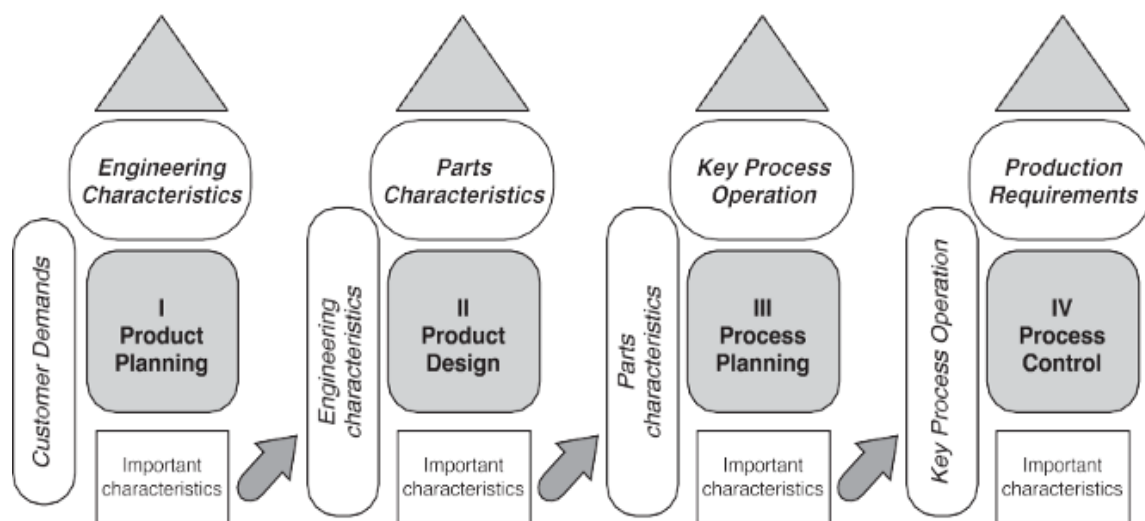


Figure 1: Four phases of a conventional QFD [18]

2.3 Method

Professors Shigeru Mizuno and Yoji Akao developed QFD in Japan in the late 1960s and early 1970s. It was developed by the Mitsubishi Corporation to define shipbuilding needs at the Kobe Shipyards [19]. The researchers focused on QFD as it seeks to transform clients' requirements into product specifications. Prioritize feasible offering specifications and develop market judgments based on weighted customer needs and ranked competitive evaluation. To translate client needs from the initial planning stages through production control, a matrix is employed in each of the four steps of a QFD process [20]. In the first phase, product planning the marketing team came up with the name "House of Quality" for this phase, which records customer requirements, warranty information, competitive opportunities, product measurements, product measure competition, and the organization's technical capacity to meet each customer request. Phase II, Parts Deployment, is started by the engineering division. Product ideas (goals and objectives) are formed during this phase, and some of the requirements are documented. (iii) Process planning is the responsibility of manufacturing engineering during Phase III. Process planning, manufacturing guidelines, flow diagrams, and process parameters (Target Values) are all documented at this time. (iv) in Phase IV, Production Planning: Performance indicators, maintenance plans, and operator skill development are all produced during this phase to track the production process [21].

The questionnaire was sent to 267 mobile users in Taichung city of Taiwan, preferred only young users. Researchers received only 231 responses. After editing, 187 responses were considered suitable and used in this study. 44 responses were rejected which were either inaccurate or insincerely responded to. The demographic information presented here that indicates the total 90 males (48.13%) and 97 females (51.87%). The sample is dominated by the respondents in the age of 15-20 years as is indicated by 21.39% of respondents, 20-25 years as is indicated by 44.38% of respondents, 25-30 years as is indicated by 27.28% of respondents, and more than 30 years as is indicated by 6.95% of respondents in the sample. The education level of all respondents as 101 respondents (54.01%) are graduated, 57 respondents (30.48%) are post-graduated and rest 29 respondents (15.51%) are PhDs. The demographic details are presented in Table 1.

Table 1: Demographic profile of respondents (N = 187)

Demographic Characteristics		Frequency	Percentage
Gender	Male	90	48.13%
	Female	97	51.87%
	Total	187	100%
Age-group	15-20 Years	40	21.39%
	20-25 Years	83	44.38%
	25-30 years	51	27.28%
	More than 30 Years	13	6.95%
	Total	187	100%
Education level	Graduation	101	54.01%
	Post Graduations	57	30.48%
	PhD	29	15.51%
	Total	187	100%

3. RESULTS AND DISCUSSION

We started by acquiring customers' opinions on various smartphone brands. We obtained the information through an online survey. We did some brainstorming among our group and conducted an online survey with mobile users in Taichung, Taiwan. Based on these responses and the group discussion, we finalized the following points that are preferred by most of the users. We ranked each item depending on the preferences of the interviewed users. Acquired data are as follows: Long-Lasting Battery, High Quality Camera, Reliable, Wide Screen, Easy to Use, and Lightweight.

Apple Inc. is a multinational technology firm based in the United States that specializes in internet services, computer software, and consumer devices [22]. With an estimated \$365.8 billion in revenue in 2021, Apple is the greatest information technology business by revenue and the most valuable company in the world as of that month [23]. Apple is the fourth-largest PC vendor and fourth-largest smartphone producer as of 2021, respectively. Along with Microsoft, Amazon, Alphabet (Google), Meta (Facebook), and Amazon, it is one of the Big Five US IT firms. The benefit for iPhone user is: (i) the iPhone is more user-friendly, (ii) iPhone have extreme security, (iii) iPhone works beautifully with macs, (iv) we can update iOS whenever we want, and (iv) apple pay for mobile payment [24].

One of the biggest manufacturers of electrical products worldwide is the South Korean firm Samsung [25]. Samsung focuses on producing a wide range of consumer and business electronics, including integrated

demonstrating how consumer expectations are closely related to the strategies and methods that businesses may employ to meet those criteria. (ii) Different consumers have diverse requirements. (iii) QFD Chart shows that the customers focus mostly on the battery life and camera quality. (iv) Decisions are heavily skewed in favor of the user's preferred brand.

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Author contribution

Akhil NSB and Vimal Kumar: Writing - Original Draft, Writing -Review & Editing, Conceptualization, Formal analysis, Investigation, Resources. Tanmoy De: Investigation, Supervision. Suriya Kalangrit: Investigation, Method verification.

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