

Product Development Process: A Comprehensive Literature Study

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Abstract: To stay competitive and lead the market, a company needs to be responsive to changing customer demands and moves from their competitors. The success of new products is determined particularly by the extent to which the producer succeeds in developing products that meet consumer demands. This implies that product development has to be fast in order to incorporate the latest trends in the product. Over the last few years an impressive body of research has accumulated on the topic of product development and the purpose of this article is to synthesize and analyze that literature in order to assess the research progress in the area and also to assess our understanding of involving users in the development process. This paper discusses as to what constitutes product development as a process; then it deals with the various available methods of product development currently employed within different genre of organizations; after that it elaborates and evaluate the various perspectives including user-involvement on product development through a literature review thus highlighting its major weaknesses; limitations; problem areas; and failures. The article in the end recognizes the need and attempts to link customer orientation with product development.

Keywords: Customer, User Requirements, Product Development, QFD.

1. INTRODUCTION

With the advent and advancement of technology, both the complexity of products and the number of functions they comprise have steadily increased. This leads to more opportunities focusing the products. Naturally, more complex products leads to increased intricacy of use, thus reflecting the difficulties of developing user-friendly products. Moreover, the product designers' distance with the user has increased, partly as an effect of growing organizations and expanding globalization. At the same time, there are continuously increase in demands from users, who expect not only excellent functionality and usability (Grudin, 1995), but also pleasure from product use and ownership (Jordan, 1998). Today, competition has taken another dimension and the product developing companies have to struggle hard to maintain their position in the market.

2. PRODUCT DEVELOPMENT PROCESS

Products are often referred to as anything e.g. an object or service that can be offered to a market in order to satisfy a customer's want or need (Kotler et al, 1996). The Product Development Process encompasses all the steps necessary to turn an initial idea into a final product. All companies apply either an implicit or explicit model of the product development process, and while the names of the steps may vary slightly, or the steps might be broken up differently, all processes contain basically the same stages. These seven steps are what must happen in order to produce a product. They are (Refer Fig. 1):

1. Ideas or concepts are created to satisfy some anticipated market demand

2. Specifications are developed to which the intended design should adhere.
3. Concepts are produced to satisfy these specifications
4. Concepts are differentiated and one is chosen
5. Chosen concept is developed into detailed design
6. Chosen design is proven to function as intended, i.e. it meets the specifications
7. Product is prepared for manufacture and sale

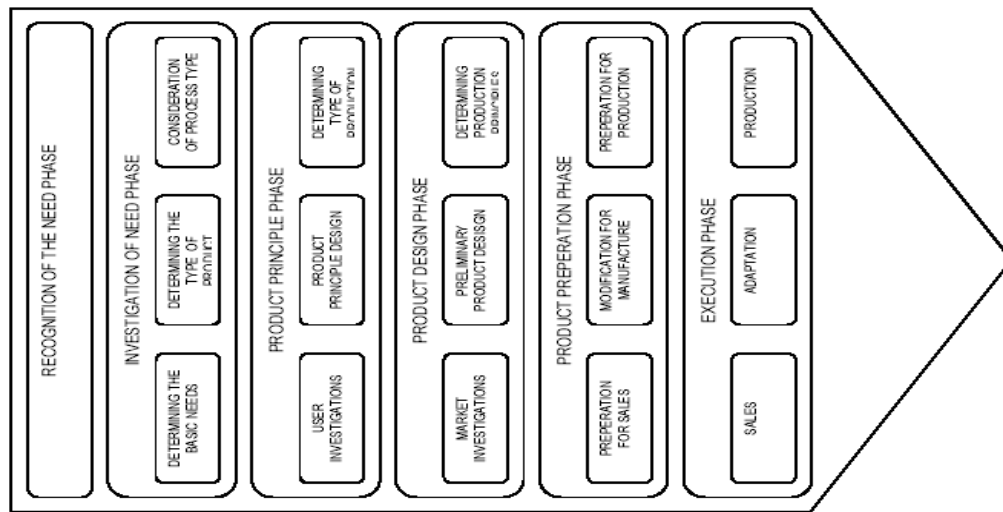


Figure. 1: Model of Integrated Product Development (Andreasen & Hein, 1987)

The product development process has also been described as a five to eight steps process including idea or concept generation and screening, research, development, product testing and marketing launch activities. Early models of product development implied that those companies who employed a stepwise new product development process were more successful. However, it is now generally accepted that a stepwise model of product development is over simplistic and that a concurrent or overlapping, flexible team oriented product development process is more advantageous than a sequential process (Ciccantelli et al 1993). More recently, product development has come to be perceived as a spiral process providing repeated feedback through every phase. In practice, these models emphasize the integration of the different stages and repeated evaluation throughout the process.

Product development comprises a broad spectrum of activities, which have to be correlated and unified in order to attain a satisfactory process. It spans the whole gamut of marketing, design, management, and other activities done between defining a market opportunity and starting production. The goal of the product development process is to create a model framework for producing a product (Reinertsen, 1998). The model must conform to the requirements stemming from customer or market needs. This includes the product, its manufacturing process; and its supply, distribution, and support systems. Ulrich & Eppinger (2003) declare it as the set of activities beginning with the perception of a market opportunity and ending in the production, sale, and delivery of a product. Apart from the activities, there are many elements, such as design engineers or other practitioners, management and goal system, working means, tools and equipment, information system and environment, identified which affect the product development process (Hubka & Eder, 1992). However, product development work is even more complex, since there also are external aspects to consider i.e. aspects that are not inherent in the organization, such as the market in which the users can be included, legislation and society that also influences the product development process (Blessing, 2003).

Product development processes are unlike typical business and production processes in several ways. Instead of doing exactly the same thing over and over, product development seeks to create a design that has not existed before. Terms like iterative and creative apply to it. Designers may start with one design, find it deficient in several ways, learn more about the problem from it, and then change it (Braha & Maimon, 1997; Suwa et al., 2000; Verganti, 1997). Especially with novel products, designers learn much along the way about what will and will not work (Nightingale, 2000; Petroski, 1985).

3. PRODUCT DEVELOPMENT MEHTODS

Every design and development project is unique since the aim is to create a product or a product variant that does not yet exist. In addition, the design work is influenced by the differences in the context in which it takes place, such as company organization, strategies, procedures, market, legislation, society, technologies, knowledge and experience of the team members (Blessing, 2002). Thus, design and development is a complex process. A host of functional departments and their activities have to be organized and coordinated in order to drive product development forward. The issue of developing model for customer driven product development does not pertains to selecting a specific model, but is more concern with designing a whole system of methods linked together in an overall process that focuses design and development efforts on the customer's future satisfaction. A method for determining the voice of the customer is needed to provide the best quality products to the market. Customer focus is one of the key components in a Total Quality Management approach (Kaulio, 1998). There are several methods that firms use to develop products. From the research studies reviewed and feasible solutions found in the available and accessible literature are:

3.1 User-oriented Product Development Process

The user-oriented product development process uses human factors and ergonomics to develop the design of the product (Kaulio, 1998). The primary characteristic of this process includes providing an analysis of the problem or opportunity suggested by customers as a starting point to create a set of user requirements. The user requirements are transformed into quantifiable engineering requirements. At this point in the process, prototypes are tested by users and modified by designers. This specification process in user-oriented product development typically requires the combination of high volume sales with low production costs. This method has been applied to areas such as designing work and military clothing, hand tools, public systems, and public transports (Kaulio, 1998). These examples either have very large research and development budgets, or the cost of prototyping is relatively low.

3.2 Participatory Ergonomics

Participatory ergonomics uses customers in the design phase to actively work as designers. This method is primarily used in workspace design and has not been reported as a method that has been used with the design of mass market products (Kaulio, 1998).

3.3 Consumer Idealised Design

Consumer idealized design can be described as a process for having customers involved in the actual design of 'new-to-market' goods or services (Kaulio, 1998). This process involves focus groups similar to concept testing. This method involves the consumer in the actual design of a new manufactured product. The focus group session begins with a blank sheet of paper and the members of the focus group develop the product as compared to a focus group evaluating the product. From a functional point of view, this approach proposes that the average user, equipped with the proper tools, is the most suitable candidate to design a product. Generally, focus groups will provide an excellent voice of the customer if the sampling for the focus group fairly represents the customer market. However, customers always want a feature loaded product at a featureless price point. This presents a contradiction in focus groups developing products. If the focus group does not weigh the features that they are specifying, then the designers and engineers do not have enough information to accurately rate these features, when features need to be removed for costing reasons. There are methods to obtain cost-benefit trade-offs in new products, however, this can be difficult to validate for new technologies which are not easily understandable by average users because they have not been previously introduced into the market.

In a process similar to that of focus groups, a small group of selected target market users, lead by a moderator, are asked to design a completely new product instead of an existing one. Specifications can include any feature desired by the participant, no matter how outrageous. All design options are then debated and modified until one remains that incorporates all of the participants' idealizations (Ciccantelli & Madigson, 1993). On this basis, a design is created, technical requirements are detailed out, and validation for the decisions is documented. The specification phase of the consumer idealized process includes 100% of the focus group's decisions and does not take into account the engineering or technical requirements to make that happen. There is no prototyping phase associated with this process.

3.4 Lead User Analysis

Lead users are described as knowledgeable, often technically trained and are considered to have keen interest in and experience with the product under consideration (Hippel, 2001). They are also extensively involved in the process of finding solutions to their own problems (Kaulio, 1998). Although traditionally this method was confined to the involvement of users in the idea generation stage of product development, it has however, in recent studies been extended to include users in the preliminary design and prototyping stages through the use of innovation toolkits (Hippel, 2001; Hippel and Katz, 2002). However, recent research has shown that while lead user analysis can be a valuable means of generating ideas, its implementation requires extensive effort on the part of manufacturers and so can be quite easily discounted by manufacturers (Olson and Blake, 2001).

The lead user method is very similar to the consumer idealized design method except that users are selected for a focus group based on their specific needs that are ahead of the product technology curve (Kaulio, 1998). The customers in a focus group for the lead user method are selected because they are users who face the needs of the market months or years before the majority of customers in that market. This method has similar relationships to the specification phase, concept development phase, and prototyping phase as the consumer idealized design method. The major difference is the selection of users. One advantage of this method over the consumer idealized design method is that the information is a peek into the future. The disadvantage is the risk involved. The reason for this risk is that the select focus group members do not necessarily represent what the entire customer base will want or need in the future. There exists a higher product risk with the lead user method because of the uncertainty in the ability of the focus group to accurately predict trends in the product market. The method aims to incorporate highly innovative customers in the development process through four phases:

- (i) Identifying the key company stakeholders and selecting the general target market,
- (ii) Identifying leading experts in the field, who understands and recognizes the current market and technical trends,
- (iii) Identifying, learning from and analyzing the lead users in the field of interest, and
- (iv) Improving the preliminary concepts and evaluating them in terms of technical feasibility, market appeal and management priorities (Lilien et al, 2002)

3.5 Beta Testing

Beta testing is a back end testing procedure frequently used in product engineering (Kaulio, 1998). Beta testing specification capabilities are completely in a back end approach where designers provide the original specifications, engineers produce design specifications and technical requirements, and manufacturing will implement the proposed product from the chain. At this point, customers evaluate the product and propose changes after all of the design has occurred. In a consumer setting, this approach aims to determine if the product does what it is designed to do (Kaulio, 1998). In order to test customer satisfaction and the products ability to perform in a real working situation, a prototype is placed with specific customers. Feedback is collected through retrospective studies or observation and any deficiencies in the product are rectified (Dolan and Matthews, 1993). In other words, beta testing is very useful for fine tuning a product, rather than

designing the product. It is very similar to a guess and check method, which would increase the time to market, unless the first product is good enough to pass the checks. Beta testing is frequently used in software engineering, for example, Microsoft incorporated users into all phases of their new software development process through the establishment of beta sites (Li and Calantone, 1998).

3.6 Concept Testing

Concept testing is similar to the user-oriented product development process in that customers are used in the concept stage. The purpose of the concept test centers around generating representative estimations of market reaction to, their intentions to buy, positioning and perceptions of a proposed concept (Rosenau, 1988; Moore, 1982). After the information is collected and analyzed, decisions have to be made regarding the continuation of the concept to the next stage, because the decision to move beyond this stage can involve substantial monetary costs (Baker & Hart, 1988). In order to extract specific responses from customers, a number of stimulus materials can be used such as prototypes, mock-ups, sketches etc and this should provided the customer with a realistic description of the proposed product. However, concept testing uses more of an integrated approach for prototyping and specification phases. Kaulio (1998) recommends that concept testing should be supplemented with later prototype evaluations such as beta testing. In concept testing, focus groups may be created to come together, and are made to react to stimulating drawings, models, and non-functioning prototypes. The major component missing from this process is engineering and manufacturing constraints. This method does not provide communications channels between different functions of the firm. Concept testing provides direct customer feedback to the department that is performing the process.

4. LITERATURE REVIEW: CHALLENGES, LIMITATIONS AND FAILURES

Over the last 15-20 years an impressive body of research has accumulated on the topic of product development and the purpose of this section is to synthesize and analyze the literature in order to assess the research progress in the area. The aim is also to highlight the associated weaknesses, limitations, problems and failures. In the end, the review also assesses our understanding of involving users in the development process. Based on the evidence reviewed, observations are drawn for future theoretical and empirical development in the field of customer driven product development.

4.1 Review of latest Product Development literature

Product development is one of the prime functional fields and there exist a wealth of studies in this field focusing on the design and development of different products and even services as well as on the different issues in product development and design, such as: Byggeth, Broman and Robèrt (2007) elaborated on a method for sustainable product development based on a modular system of guiding questions. Ibusuki and Kaminski (2007) studied an automotive company and discussed product development process with focus on value engineering and target-costing through the underlying case study adopted. Ljungberg (2007) wrote on the materials selection and design for development of sustainable products. Matsui, Filippini, Kitanaka and Sato (2007) elaborated on a comparative analysis of new product development by Italian and Japanese manufacturing companies through case study method. Steffens, Martinsuo and Artto (2007) studied the change decisions in product development projects. Gehin, Zwolinski and Brissaud (2008) devised and discussed a tool to implement sustainable end-of-life strategies in the product development phase. Langerak and Hultink (2008) adopted a case method of study to the effect of new product development acceleration approaches on development speed. Song and Di Benedetto (2008) studied and postulated the supplier's involvement and success of radical new product development in new ventures. Chin, Tang, Yang, Wong and Wang (2009) assessed new product development project risk by Bayesian network with a systematic probability generation methodology. El-Said, Fatah, Salwa and Gareb (2009) takes care of the functions to cite product development as one of the most adaptive thinking process close to the nature. Hestad and Keitsch (2009) study the activity and behaviour of the product users and uses gemba on active consumers to find out the systems involved in the process. Jolivet, Lanciano-morandat, Nohara and Pardo (2009) discuss the differences in founder profiles and experience pertaining to the biopharmaceutical entrepreneurship in two bio-clusters of Japan and France. Kengpol and Tuominen (2009) with the help of a case study highlight the application of an automated information system

in a logistics company in Thailand. Kettunen (2009) carried out a comparative study adopting key lessons from agile manufacturing to agile software product development. Lan (2009) reviews a web-based rapid prototyping and manufacturing systems in the light of new product development. Liem (2009) focuses on the process of mentorship and systems thinking within a vertical design studio environment in order to provide students with a head start in their career. Marion and Simpson (2009) practiced application to an early-stage firm by taking up the case of the PaperPro® StackMaster™ as an example to new product development. Mishra and Shah (2009) in their seminal research talks about the strength and how it can be garnered through right union and collaboration in new product development and its performance. Niu (2009) carried out a detailed conceptual analysis regarding the involvement of firms in industrial clusters. Tinmannsvik and Bjelland (2009) explored toddlers' aesthetic experience of everyday products. Wang (2009) evaluated new product development performance by fuzzy linguistic computing. Chen and Ko (2010) used fuzzy linear programming models for NPD using a four-phase QFD activity process based on the means-end chain concept. Lin, Narayan and Lee (2010) discussed hybrid client-server architecture and control techniques for collaborative product development using haptic interfaces. Lin, Qian, Cui and Miao (2010) explained overlapping and communication policies in product development. Thomas and Brocke (2010) expounded a value-driven approach to the design of service-oriented information systems - making use of conceptual models.

4.2 Challenges

In complex system or product development, determining how and when value is added is problematic. The goal of product development is to produce a product model that conforms to requirements or acceptance criteria with some certainty. Design work is done both to specify this developed model in increasing detail and to verify that it does in fact conform to requirements. The studies on product development describe it in various ways: as a functional (strategic) activity (Atuahene-Gima, 1995; Brown & Eisenhardt, 1995; Niosi, 1999), as a process subdivided in activities or stages (Cooper, 1983; Cooper & Kleinschmidt, 1991; Hart & Baker, 1994; Saren, 1984), and since 1990s as a capability (Leonard-Barton, 1992; Leonard-Barton, 1995; Lawson & Samson, 2001; Subramaniam & Venkatraman, 2001). The changing economic conditions and technologies combined with increased domestic and global competition, changing customer needs, rapid product obsolescence and the emergence of new market; require a fast resource allocation process in product development (Bower & Hout, 1988; Griffin 1992; Gupta, Raj & Wilemon, 1986; Rosenau, 1988). At the same time, market and technology uncertainty demand for flexibility in the program (Wind & Mahajan 1988).

Product development is a problem-solving and knowledge-accumulation process. The literature on product development mainly aims at determining the factors that affect the performance of the product; the product development project; and product development process (Poolton & Barclay, 1998). Taking into account these factors improves managing product development in organizations that is in essence, deciding about product strategy and controlling the development process (Urban & Hauser, 1993; Tidd, Bessant & Pavitt, 1997; Hart, 1996).

Since product development is a non-linear process, it is harder to determine what value is added and when (Kline, 1985). Especially in novel product development, design elements are proposed, analyzed, evaluated, and advanced or rejected. The effect of one activity changing its approach and output can have a domino effect throughout the process, changing other activities' inputs and assumptions and causing rework (Browning & Eppinger, 2002). Product development processes typically have lots of change and rework (Cooper, 1983). Product development is iterative, with additional details explored during each pass.

4.3 Problems with Sequential Product Development

The traditional process for product development is the sequential approach (Kotler & Armstrong, 1989). Projects proceed sequentially through the development tasks, which must be accomplished prior to commercialization. Different functions are responsible for completing each phase, so projects are handed over from one functional area to another during the development cycle. Management reviews each phase before the process proceeds to the next phase. Several refinements to this approach have been proposed, mainly because of the lack of speed and flexibility in the sequential approach.

Takeuchi and Nonaka (1986) set up a holistic approach. This approach is in correspondence with the growing literature on the importance of integration between functions such as marketing, R&D and manufacturing (Crawford, 1980; Gupta, Raj & Wilemon, 1986; Hauser & Clausing, 1988; Souder, 1988; Clark, 1989; Gomory, 1989; Hise, O'Neal, Parasuraman & McNeal, 1990; Narver & Slater, 1990). Although Takeuchi and Nonaka (1986) acknowledge that the product development process involves different stages, they stress that these stages interact with each other. Their approach to product development builds upon the iterative communication between the functional specialists and the parallel processing of tasks. Since the process does not delay when one functional department is lagging behind, this product development process is flexible and effective. The holistic approach is improving the sequential approach, but lacks criteria how much integration is to be achieved and this may hamper its use in practice (Gupta, Raj & Wilemon, 1986). Also, neither the approach explicitly captures the market and technology uncertainty, nor does it give guidelines for the optimal time to abandon the project or to go market with the project. Since development already starts when research is still in its embryonic stage, projects are liable to continue once research is finished.

4.4 Limitations and Failures

Meanwhile, evidence that product failures most closely linked to inadequacies within pre-development activities has steadily accumulated (Cooper, 1999). Models of product development, whether applied to consumer product or not, consistently link product success to 'up-front' activities such as consumer testing and the subsequent feeding through of consumer need into technical development. Although the involvement of senior personnel in the product development process has been found to be advantageous for success, more recent research has indicated that cross-functional teams are even more effective than coordinator led or top-down approach. Also important is communication between the different team members, particularly between technical and marketing personnel. This implies that companies, who bring together individuals from different departments and from beyond the company to work cohesively together, are more likely to be more successful. Cross-industry research therefore implies that an interdisciplinary team, an original product idea, in addition to thorough market research and careful planning at the concept stage of product development could potentially prevent problems arising elsewhere in the product development process.

Communication and cooperation between the different disciplines, such as marketing and R & D, have an essential role in the design process and improve the prospect of success for the product and product development project (Souder, 1988; Griffin & Hauser 1996). Cooper & Kleinschmidt (1995) and Cooper (1999) suggest organizations of cross-functional teams; with members from various functions and complementary skills are needed to achieve successful products and projects. Another approach intended to maintain rewarding product development is to get things right from the beginning in order to avoid expensive changes and delays. To do this, it is important to choose useful methods and ways of working, and at an early stage to engage different competencies and incorporate requisite knowledge and experience in the product to be developed.

At the beginning of a design assignment, knowledge about it - is relatively limited, while the degree of freedom is large. As development progresses, experiences and facts regarding the design problem are built up, whereas the designers, who have to make strategic choices along the way, become increasingly bound to a particular solution, since late changes are expensive. To avoid being confined to a particular outcome in early design phases with high risks for which it is possible to find better solutions, it is advisable at the beginning of the design process to investigate and analyze the design task, the users and the use situation, and to develop and try out a large number of concepts in order to broaden the solution space. Thereafter, the concepts may be evaluated and some of them chosen for further development. Hein (1994) states that product developers tend to hasten through the concept stage and make the product very concrete and detailed early in the product development process, with consequent decreases in competitive power and cost control.

4.5 User Involvement in Product Development

As mentioned in the introduction, several researchers have studied the relationship between user involvement and product development, but they mainly focused on how market orientation influences innovation. The conceptualization of custom-

er driven product development (i.e. the integration of voice of customers in product development process) has received scant attention. Yet, some studies provide interesting insights in this topic.

In the late 1970s, a new research impetus occurred in the product development literature with the publications of Eric Von Hippel's two seminal investigations (1976 & 1977), where he advocated the involvement of users in the idea generation stage of the product development process. Von Hippel's (1978) conceptualization of a customer active paradigm gave focus to a new generation of researchers and an emerging field of study into the involvement of users not only in the creation of ideas but to the whole product development process. (Foxhall & Tierney, 1984; Shaw, 1985; Voss, 1985; Parkinson, 1982; Biemans & Wim, 1991; Gruner & Homburg, 2000).

Empirical analyses from numerous research studies offer convergent evidence of the positive influence user involvement has on the development process and consequently product success. (Gruner & Homburg, 2000). Maidique and Zirger (1985) analysis of 40 products demonstrated that customer involvement was a necessary ingredient for product success. Similarly in another study, which concentrates on product development in a network context, nearly 50 per cent of companies claimed that forming relationships with customers had been a pre-condition for successful innovations. From analysing 34 medical equipment innovations, Shaw (1985) found that successful innovation is associated with continuous customer interaction throughout the development process. Additionally, research conducted by the Olsen & Ellram (1997) - International Marketing and Purchasing Group has provided supporting evidence that successful product development is significantly correlated to relationships with other parties such as a customer.

A diversity of research approaches has been used to study the modes of customer involvement in the product development process. The research approaches are represented by both descriptive and normative studies, as well as conceptual and empirical studies. The majority of research studies were found to be empirical and descriptive, which indicates a strong practitioner oriented focus to the research approach (Olson & Blake, 2001; Cristiano et al 2000; Moore, 1982; Lilen et al 2002). Empirical methodologies tend to favour surveys and interviews. A number of the articles also provide normative suggestions for involving users in the development process, such as Cicantelli's et al (1993) experience with consumer idealized design, von Hippel's lead user analysis and Dolan & Matthews (1993) managerial guide to beta testing.

Developing successful products requires the product developers to know the target group for whom they are designing (Gould, 1995; Margolin, 1997; Preece, 2002). Thus, a clear definition of the target market, i.e. exactly who the intended users are and what customers' needs, wants and preferences are, before the project is approved, increases the prospects of a successful product (Cooper & Kleinschmidt, 1990). It is also better to define the users in early design phases, even if the user group eventually is going to expand from the initial definition. Otherwise, the design work is likely to become vague when it comes to consideration of user aspects (Gould, 1995). If the product instead is designed for everybody or an average user, it may not suit any real users, since that average user does not exist (Friedman, 1971). Moreover, the risk of disregarding detail in the user task and environment, which is important when it comes to working with usability, is also increased when the design work is directed towards an average user (Buur & Nielsen, 1995). Awareness of the importance of a user/customer focus has increased in recent years. However, there is a lack of support for handling this. Moreover, the enhanced technology of products and the increasing number of functions they contain may lead to more time and resources being needed for concentration on technological development, which competes with regard to the time that can be spent on working with user aspects.

Traditional design theories concentrate on the technical aspects and more or less neglect their interaction with the users (Buur & Nielsen, 1995). For example, theories of Hubka & Eder (1992) and Pahl & Beitz (1996) focus mostly on the technical functions and structure of the product, and omit the product's relation to the users. Some of the design literature, e.g. Pahl & Beitz (1996) and Ullman (1997), provides hints on how and where in the design process work with the users should be dealt with. Buur & Nielsen (1995) state that the traditional design models are too static for expressing the interaction between user and product, and call for new dynamic techniques for modeling user product interactions to enhance the usability of the products, such as scenarios and computer simulation of user interfaces. Other authors, such as Carroll (1995) and Clarkson & Keates (2001), also emphasize the need for use-oriented

representations and methods in design. Fulton & Marsh (2000) maintain that the existing methods and tools relating to user-product interaction, whether they have a quantitative or qualitative characteristic, are mainly intended for analysis or evaluation. Carroll (1995) also highlights the importance of enhancing the product developers' awareness of the importance of user-oriented approaches and supporting them in the adoption of such methods in their work. The methods for understanding the users and working with user data throughout the design process are not suited to designers in their way of working (Roussel & Le Coq, 1995; Hasdodan, 1996; Teeravarunyou & Sato, 2001). Also, they mainly concentrate on user behavior and have weak applications to product development work (Teeravarunyou & Sato, 2001). Consequently, there is a need for design methods that support the synthesis activity in early product development stages and take user aspects into consideration.

5. NEED FOR CUSTOMER DRIVEN PRODUCT DEVELOPMENT (CDPD)

While there is quite some literature on the relationship between customer orientation and product development, it is still unclear what customer driven product development really is. The concept of customer focused product development can be seen as a special case of market-based innovation since it focuses on the share of market intelligence pertaining to end-users or customer, developed for the manufacturers of customer goods. It is an integrated concept concerning the use of customers' current and future needs, and its determinants, in the development of improved or innovative products and services with added value (Urban & Hauser, 1993; Wheelright & Clark, 1992).

A customer focused approach to product development possesses a basic understanding of the fact that both technical knowledge and market information are necessary to run effective development processes, and the way market information can be gathered, disseminated and combined with technical information to develop successful products. Additionally, it is believed that the implementation of customer focus in innovation and product development processes can be a primary step in leading the rest of the organization to a more market-oriented conduct (Kok et al, 2001).

The key stages in the formulation of the customer oriented product development concept follow this approach: need identification, idea development to fulfil the need, product development to substantiate the idea and the product market introduction, communicating the fulfillment a need (Urban & Hauser, 1993). Central here is the ability to translate the subjective customer needs (e.g. reliable and sturdy) into objective product specifications, in order to, through the creation of the core product, substantiate the fulfillment of these needs. Concurrently, another type of translation is employed in developing a way to communicate to consumers the existence of a new product, which satisfies, distinctively and in a superior way, their needs. It is believed that such a consumer-orientated approach can greatly increase the likelihood of success of product development processes (Bont, 1996; Dahan & Hauser, 2002; Wheelright & Clark, 1992; Wind & Mahajan, 1997). The main principles of customer driven product development (Wheelright & Clark, 1992; Lord, 2000; Urban & Hauser, 1993):

Customer needs should be the starting point of the product development process;

The goals of product development should be the fulfilment of customer needs and the realization of customer value, rather than the development of products or enabling technologies per se;

Sales and satisfactory returns on investments can only be achieved by anticipating, identifying and satisfying customer needs; thus the product development's measure of success should be the degree of fit between the new or improved product and customer needs.

The collection of appropriate information concerning consumers' needs and perceptions, from the beginning of development up to the market introduction and beyond, is an essential requirement of a customer focused product development process. To understand the target consumers, and include their needs, views and problems at an early stage of the development process, is central in this concept (Bont, 1996; Lord, 2000; Ortt & Schoormans, 1993).

6. SYSTEMATIC FRAMEWORK FOR MAPPING VITAL ASPECTS OF CDPD

In QFD approach, the matrix to be built is the Product Planning Matrix, also called House of Quality (HOQ) due to its house-like shape. Its purpose is to translate important customer requirements regarding product quality into key end-product control characteristics. The HOQ comprises several different parts or rooms, which are sequentially filled in order to achieve an actionable translation from requirements into characteristics. Refer Figure 2.

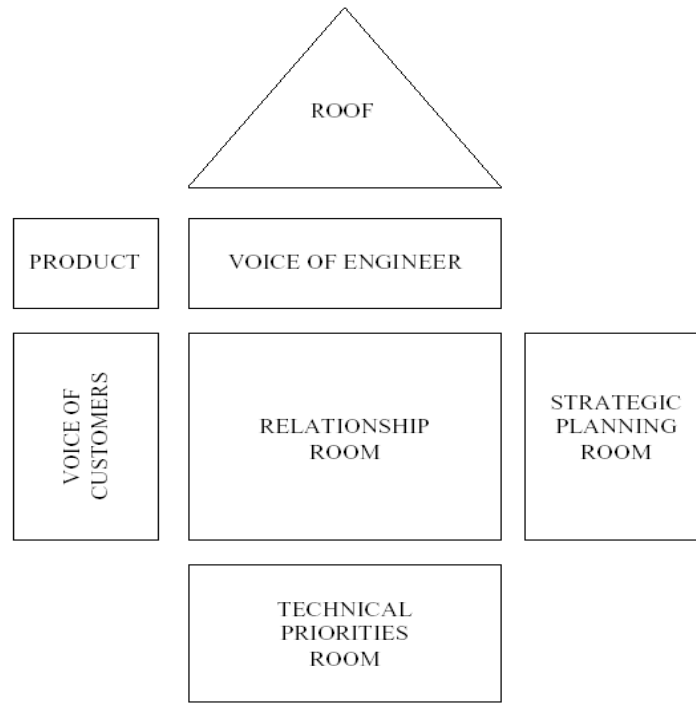


Figure 2: Basic Building Blocks of QFD

6.1 Voice of Customer (VoC)

The HOQ's first room concerns the product and deals with the definition of the selected product for which QFD is constructed. The second room concerns the Voice of Customer, but before this there is a need to identify as to who are the customers. There are different ways to identify the customers of a product or service. The commonly used approach is to ask - who must be satisfied with the product in order for the product to be considered successful. A customer is defined as - anyone impacted by the product, however some are obvious some are not. For most products there is more than one category of customers. An important tool for identifying all those who are impacted is through the customer-chain. In planning to collect information on customer needs, one must go beyond the search for the obvious needs to the more subtle ones that present opportunities for innovative product designs. Customers requirements are loose, vague qualitative statements in the customers own words, like easy to use or like faster ice making. Customer needs may be clear, unclear, stated, unstated, known, unknown, obvious, disguised, rational or not so rational. They indicate which benefits the customer expects to be fulfilled by the product or service. However, to create customers, these needs must be discovered, deployed and delivered. This is accomplished through extensive market research, or other more direct communication methods such as survey, product complaint history and direct customer feedback. The goal is to find the exact desires of the intended target group. The other possible sources of information about customer requirements are: market research data, sales data, customer complaints, retailers, focus groups, toll free lines, opinion surveys, in-depth interviews, etc. After their identification, the customer requirements are compiled and organized in a hierarchical structure of strategic, tactical and operational requirements, using the quality tools like Affinity Diagram. The strategic (primary) requirements consist

of a small number of broad needs that provide strategic direction to the development process, which are, in turn, specified into tactical (secondary) and operational (tertiary) requirements. These tactical and operational requirements indicate the design and engineering solutions that have to be developed in order to satisfy the strategic requirements. Finally, based on quantitative market research, relative importance weights are attached to each customer requirement. Although all the customers wants are probably important, but some are more important than the others and it is necessary to know their relative importance. The weighting will give an idea of how much effort, time and money is to be invested in achieving each requirement. Usually this is done at the operational (tertiary) level. This procedure establishes priorities for the product development process and the allocation of the necessary resources. The identification of customer requirements and their importance remains one of the most serious obstacles to a successful QFD application in product development.

6.2 Strategic Planning Room

Once the customer requirements and their priority rankings are established, the next step is to understand where the company and its competitors stand in terms of satisfying them in the marketplace. This achieved with the filling of the Strategic Planning Room. An index of the Customers Perceptions as to how well the product he uses meets his needs. This information leads to an increased understanding of what attracts the customers and also helps in verifying the present market position of the company's current product. Based on qualitative and quantitative market information, the customer perception of how the concept or product satisfies their requirements when compared to other products - Customer Competitive Assessment - is rated and graphically depicted. In order to understand the importance of these quality dimensions with regard to their effect on the sales of the product, the sellers and dealers are also contacted. They prioritise their own choices in terms of the impact which the fulfilment of a particular customer want will have on the sales of the product. This is termed as Sales Point. A Competitive Priority Rating is also considered. This section provides a link between the QFD project and the company's strategic vision by uncovering market opportunities and identifying priorities for product development or improvement. Moreover, it helps to build competitive advantage by focusing on the requirements that customers would like to see better addressed by the market.

6.3 Voice of the Engineer & Roof

At this stage, the QFD team should have a clear picture of what the customer requires from the concept or product and how this can be related to the company's strategy. The team has now to decide how these requirements can be incorporated in the final product, so that the customer is satisfied. This is achieved by building the Voice of Engineer Room. The goal is to develop a set of engineering specification from the customer requirements. Here, the end-product's technical characteristics directly related to the customer requirements are listed. These characteristics are known as the design requirements, engineering characteristics. These are measurable parameters that will be used to objectively evaluate product quality, since their values will be controlled and compared with target values. This procedure ensures that the customer requirements are being met. Since these parameters are often correlated, the QFD team has to specify their degree of interdependence, if any. This is done in the Technical Correlation Roof. This helps to determine the effects of changing one product characteristic on the others, enabling the team to identify and react to synergistic (positive correlation) or trade-off (negative correlation) situations. Trade-off situations often point out design constraints and should always be solved in the way that favours the customer most. For every technical characteristic exists a direction that customer prefers, this information is very helpful when examining the interactions and correlations, and is incorporated in between engineering characteristics row and the roof.

6.4 Relationship Room

The QFD team must now fill the core of the HOQ - the Relationship Room, where the relationships between each customer requirement (Voice of the Customer) and the engineering characteristics (Voice of the Engineer), as well as their intensity, are depicted. The relationships between Customer Requirements and Engineering Characteristics might be defined by asking, "To what degree does this engineering characteristic predict the customer's satisfaction with this requirement?" Based on in-house expertise, surveys, data from statistical studies and controlled experiments, the team seeks consensus as to

how much each engineering characteristic affects each customer requirement. This task is widely recognized as a highly complex one and represents another critical stage in the HOQ building process.

6.5 Technical Priorities Room

The last task in building the HOQ is filling the Technical Priorities Room. This starts with Technical Descriptors - directly below the relationship matrix, a row is to be added to address our targets. These descriptors pertain to the engineering characteristics and the units of measurement in each column. These technical descriptors add the detail necessary to bring the product definition from the abstraction of words to the concrete reality of product and process engineering. With Technical Competitive Assessment of the engineering characteristics (Voice of the Company) in the currently marketed products the QFD team can view the competitors and their own technical performance level regarding engineering characteristics directly affecting customer requirements. In-house product testing usually provides the data necessary for this assessment, which should be expressed in measurable terms. For each engineering characteristic, the comparison between the company's and the competitor's technical performance level is depicted in a graph. A row indicating the level of organizational difficulty related with realizing each engineering characteristic can also be added.

6.6 Comprehensive Matrix Analysis

6.6.1 Customer Competitive Assessment (External Benchmarking)

The Customer Competitive Assessment measures the customer perception of the product relative to the competition. Data collected from customers is used as a basis for comparison. The data shows how well competitors meet the requirements established by the customer focus group. As the product evolves these derived values are used to evaluate product's ability to satisfy customers' requirements.

- a. **Goal (Future Product):** This indicates as to what level the Company is trying to achieve with regard to each and every customer requirements.
- b. **Improvement Ratio (Effort Level):** Improvement Ratio is the ratio of the Goal Value to the Customer Satisfaction Rating. Higher the ratio, greater will be the effort needed; because of the gap between actual and the expected quality level.
- c. **Raw Weight (Priority Level):** This value signifies the overall importance of the customer requirement as regard to the development of the product. Raw Weight sums up the priority level for the design personnel, the more the raw weight, the higher the priority. This indicates where the design team should focus attention & where they have to do a lot of work.

6.6.2 Technical Competitive Assessment (Internal Benchmarking)

The Technical Competitive Assessment is similar to the Customer Competitive Assessment but involves technical details of the product rather than customer requirements. In the step above, competition products were compared to customer requirements. In this step, they are measured relative to engineering specifications. Engineers and technical personnel will provide the data for the technical competitive assessment. Studying the competition gives valuable insight into market opportunities and reasonable targets. A final technical importance rating in the form of technical weights for each engineering characteristic can also be calculated, based on the raw weight for each requirement and the strength of the relationships between the characteristic and each customer requirement (relationship room). These ratings indicate the relative importance of each engineering characteristics in satisfying all the customer requirements. They are often expressed as a percentage, since their absolute values are meaningless. The HOQ has been the main focus of QFD-related literature because it contains the most critical information a company needs about its relationships with customers and competitive position in the marketplace.

The technical weight when sorted on their values gives the area on which the manufacturer should focus its attention.

For carrying out these improvements the company needs to focus on the engineering characteristics with greater technical weights. These are the engineering characteristics that the respective manufacturer should be concentrating on. This will not only help to achieve better level of performance, per se but also give them an edge over their competitors as far as the customer satisfaction is concerned.

The relationship between the raw weight of the customer needs and the technical weights of the engineering characteristics is such that as the efforts are concentrated on engineering characteristics and the target levels are achieved, the customer needs are automatically taken care of. Thus, improving the product with respect to these engineering characteristics will be solving most of the problems. Because these considered engineering characteristics has a direct bearing on the disadvantages vis-à-vis our competitors.

Based on the information depicted in the HOQ, the QFD team now has to select the end-product characteristics to be deployed through the remainder of the product development and market introduction activities. Engineering characteristics showing a higher technical importance rating above a pre-determined threshold indicating a strong relative importance in achieving the consumer requirements are selected for further deployment. The same happens to engineering characteristics related with customer requirements that are having strong sales points or poor competitive performance satisfaction rating.

7. CONCLUSIONS

The analysis of the available literature published so far on various models and framework for product development, suggests that most of the methodologies have some or other weaknesses. Despite all efforts, many product development projects fail and lead to the introduction of products that do not meet customer requirements and in some other projects the process of product development is conducted very unsystematically and resources are wasted because of a lack of communication between the different functions involved. One of the major limitations in existing product development approaches is the relative lack of concrete and clear guidelines as to how one could adequately conceptualize and implement its various phases.

Several methodologies have been worked out, but their validity and applicability to product development remains inconclusive and also the implementation results and findings are scarce. The product development process carried out under sequential engineering suffers from a major drawback - here the process is not integrated with several internal functional modules such as purchasing, marketing, service etc. In context of present day scenario of global competition and aware stakeholders the existing product development process are too complex and cumbersome. Several research projects and thesis works have carried out and were aimed at product development to incorporate customer satisfaction; many of the proposed improvements have not been applied due to lack of clear-cut implementation methods.

In the light of above, a need is recognized to evolve a framework for customer driven product development to address the perennial problem of implementation and execution. Organizations need a set of practical step-by-step tools and methods which ensure a better understanding of customers needs and requirements, as well as procedures and processes to enhance communication by focusing on the voice of the customer, not only in creation of ideas but in the evolution of a whole new product development process.

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