A Guide for QFD Implementation in Product Development

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Abstract:The method of Quality Function Deployment (QFD) has achieved a state where is well-known in the academic literature of product development management and has been widely applied in many countries. This paper aims to further contribute to QFD applications in product development system of organisations around the world, by drawing reflections from results of an action research program on QFD applications in Brazilian organisations in the last ten years. A guide is formulated for application of QFD method in implementation processes, with a potential for context diagnosis, circumscription of problem situation, and operational features. The guide deals with two distinct levels of reasoning: 1 – level of Product Development System (PDS) in which QFD is placed; and 2 – QFD application level in which QFD basic elements operate. It is believed that the accumulation of knowledge of QFD comes in three interrelated forms: 1 – refinement of its methodological basis; 2 – refinement of operating guides, procedures and rules; and 3 – construction of models of reference applications. This paper aims at the second form.
Keywords: Quality Function Deployment, QFD, Product Development, Guide for Implementation, Guide for Practice.

1. Introduction

The method of Quality Function Deployment, better known as QFD, was first formulated by Professor Akao more than thirty years ago (AKAO, 1990a). Since then, many conceptual and methodological elements have been added by Professor Akao himself and by other important Japanese authors engaged in Total Quality Management (TQM) and QFD (AKAO,1990b; 1990c; KOGURE and AKAO, 1983; MIZUNO and AKAO, 1994; YOSHIZAWA et al., 1990). This resulted in a comprehensive model of QFD (OHFUJI, ONO and AKAO, 1990; OHFUJI, 1995) and a compendium on alternative possibilities of QFD applications (OHFUJI, ONO and NAGAI, 1997).

Applications of QFD method in Japan, initially in automobile and naval industries (AKAO, 1990a), originated from using cause-and-effect diagram for control points and later, tables for quality assurance, particularly in production. In recent years, QFD applications have moved toward the nascent of product development life-cycle (AKAO, 1995), and product planning (KANDA, 1998) within an enterprise. If in the past the applications were mostly on tangible products, more recently, there has been an extension towards less tangible ones, such as service (KANEKO, 1991) and software (SHINDO, 1998; SHINDO and WEI, 1995). There are excellent examples of application within a large range of Japanese industrial firms (ITOH, 1995; NOGUCHI et al., 1998; SUSUMU, 1996). In addition to the cases from Japan, there are some others from Asian countries, elaborated by Korean (BANG and LEE, 1995) and Taiwanese companies (LEE, 1996).

Parallel to this methodological evolution in Japan, from 1986 onward (SULLIVAN, 1986), there has been, in the United States, a diffusion and an intense application of QFD, mainly the two versions: ASI (1989) and KING (1989). These two versions are particularly concerned with Quality Deployment (QD), one of the two parts of QFD, though they are also nominated as QFD. It seems that QFDr, the other part of QFD, was not applied because there were already very well established processes of product development in U.S. (BOOZ et al., 1968; COOPER and KLEINSCHMIDT, 1986). An example of this is the use of Systems Analysis and Systems Engineering methods (CHECKLAND, 1981) by General Motors, replacing QFDr by these well-known

development processes for complex engineering projects (ROSS and PARYANI, 1995). More recently, there have been efforts by the QFD Institute in complementing those versions by presenting the Comprehensive QFD. It is also important to mention Clausing's work, called Enhanced QFD, in which the method of Robust Design is added to QFD, and both are placed within a broad development framework called Total Quality Development (TQD) (CLAUSING, 1994). With regard to the practice of QFD in U.S, it can be found in almost every sector of industry (Proceedings of QFD Symposiums in USA). Some special applications are in automobile industry (ROSS and PARYANI, 1995), service (MAZUR, 1999) and software (ZULTNER, 1990).

In Europe, QFD is also widely known and many cases of QFD application have been reported. For instance, applications in software development, in Germany (HERZWURM *et al.*, 1997; HERZWURM, G. and SCHOCKERT, S., 1999); urban planning and civil construction industry, in Switzerland (SWOBODA, 1999); housing development in Finland (LAURIKKA, LAKKA and VAINIO, 1996). In Sweden, in addition to applications of QFD (BERGMAN, 1995), there has been articulation of the use of statistical techniques in conjunction to QFD method (GUSTAFSSON *et al.*, 1996). In Italy, there are also a number of applications of QFD reported (ZUCCHELLI, 1995).

There are also consistent applications in two other countries. In Australia, there has been innovative QFD applications for strategic planning and development of new or improvement of existing business in conjunction to the already established method of Hoshin Kanri (HUNT, 1999). From Brazil, there have been reported applications of QFD in automobile and food industries since 1995 in QFD international symposiums (CABRAL, 1999; CARVALHO and CHENG, 1998; CHENG and SARANTÓUPOLOS, 1995a; GUEDES *et al.*, 1999; NOGUEIRA *et al.*, 1999; ORMENESE *et al.*, 1996; SANTIAGO, ARAÚJO and CHENG, 2000; 1999; SARANTÓPOULOS *et al.*, 1996).

Finally, there have been surveys on how the method has been applied in specific contexts. These exploratory or descriptive surveys have complemented the more detailed case reports and provided important insights to reflect upon the past and current actions, and above all to redirect QFD community's future plans and activities. The surveys come from Japan (AKAO and NAOI, 1987), U.S. (GRIFFIN, 1992; VONDEREMBSE and RAGHUNATHAN, 1997), Sweden (EKDAHL and GUSTAFSSON, 1997), Brazil (CAUCHICK MIGUEL and CARPINETI, 1999) and the UK (MARTINS and ASPINWALL, 2001). There is also an important comparative descriptive survey between Japan and U. S. (CRISTIANO *et al.*, 2000). All these surveys are concerned with who apply QFD, degree and ways of QFD usage, functional areas involved, types of product or project in which QFD is applied, and above all, the result obtained. The frequently cited success factors are mostly timing, resource committed, senior management support, team motivation and commitment.

Therefore, based on above brief review of the literature, one arrives at three positive statements: 1 – QFD method has its place and is well-recognised by the academic literature as an important method in the domain of Product Development Management (CLARK and WHELLWRIGHT, 1993; DOLAN, 1993; PUGH, 1991; URBAN and HAUSER, 1993); 2 – QFD is widely-known and has been widely applied for developing a diversity of products in many quarters of the world by the organisations; and 3 – there is an active and interested QFD community, composed by company practitioners, consultants and academics, who study, use and reflect upon the method in many corners of the world. It is surely a great achievement for a method.

As part of this QFD great community around the world, we are concerned about how to make QFD application more effective. Therefore, it is on this purpose that this article attempts to contribute. In our experience of managing an action research (BLUM, 1955; COUGHLAN and COGHLAN, 2002; EDEN and HUXHAM, 1996; RAPOPORT, 1970; SUSMAN and EVERED, 1978) programme on QFD application in product development in the last ten years, some questions on QFD practice have been posed: a – "what is the role of QFD and how does it fit into the set of methods for improving product development system of an organisation?"; b – "in which level does QFD act on, at the portfolio level or at project level?"; c – "what are the similarities and differences of QFD aim, orientation and outcome related to other methods and techniques?"; d – "how can QFD be placed along with other methods?"; e – "how can a relevant conceptual model be formulated"; f – "what concerns and criteria should be considered when formulating conceptual models"; g – "how can benchmarking studies be carried out (inter-organisational, intra-organisational, between generation

of products)?"; h – "does the rule of cells correlation (strong, medium, weak and null) apply in all matrices and in every organisational context?". In response to these questions a guide for QFD practice has been formulated.

It has been used on over a dozen projects by the researchers of the program from the outset of intervention processes (ARAÚJO and CHENG, 2001; CARVALHO and CHENG, 1998; CAUCHICK MIGUEL and CHENG, 2001; CHENG, 2000; CHENG and SARANTÓUPOLOS, 1995a; 1995b; CHENG and DRUMOND, 1994a; 1994b; DRUMOND et al., 1999; DRUMOND and CHENG, 1994; FONSECA et al., 1999; PAIVA and CHENG, 2001; PFEILSTICKER and CHENG, 2001; POLIGNANO, DRUMOND and CHENG, 2000; 1999; SANTIAGO, ARAÚJO and CHENG, 2000; 1999; TORRES, 2001; VILELA and CHENG, 1997). The great asset of this guide resides on its potential of providing important insights to the researchers at the very beginning of the projects on: 1 – what is the actual motive for which an organisation is requesting the intervention; 2 – what is the context of Product Development System (PDS) in which QFD method will be applied; 3 – what is the scope and the nature of the project in which QFD will be used; 4 – which type of role QFD method will have in the project; 5 – what is the extent and type of usage of QFD method; 6 – which functional area of organisation QFD method may contribute the most; 7 – which type and nature of conceptual model will be most helpful; 8 – what criteria have to be taken into account in the formulation of conceptual model; 9 – which type of tables and matrices will be relevant to the project; 10 – what has to be considered when carrying out correlation, conversion, prioritisation, competitive analysis and specification; 11 – what other concepts and tools are needed to complement QFD method in intervention processes. Thus, it can be said that the guide has a potential for context diagnosis, circumscription of problem situation, and operational features. This guide is more biased to Engineering than to Marketing standpoint as the majority of the lecturers and researchers of our Program has an Engineering or Statistics background.

The guide deals with two distinct levels of reasoning, each with three questions and their respective set of possible answers. The two levels are: 1 – level of Product Development System (PDS) in which QFD is placed; and 2 – QFD application level in which QFD basic elements operate. The intervention processes directed by the guide are normally carried out by senior lecturers and researchers with full participation of organisational actors concerned. The set of questions is not exhaustive, it is more indicative and to some extent prescriptive. Before the actual intervention takes place some general questions are also addressed for planning purpose: 1 – what types of outcomes are expected; 2 – what are the available resources; and 3 – what is the time constraint. Once these answers are obtained, a full research team, composed of lecturers and researchers according to their knowledge and skills, is brought into the situation to work alongside with the product development team of the organisation, forming together an action research team. Subsequently, an action plan is formulated to guide the intervention.

The structure of the article is thus divided into two sections which deals with two different levels concerning with QFD application.

2. At the level of Product Development System (PDS)

A Product Development System (PDS) can be regarded as an organisational system which deals with management of a portfolio of development projects and management of product development. The former has the role of permanently articulating between the needs of the market and the possibilities of the organisation, in terms of its technology and competence, in a horizon which allows the organisation to grow continuously through its products. At the latter, it performs tasks that run from idea generation to final prototype production, and it is referred to, in this paper, as product development process. This system is traditionally managed by both marketing and R & D functions of organisations at different managerial levels.

This first level of the guide has the aim of understanding the motive behind the request for intervention, the context of PDS in which QFD method will be used, and the role of QFD in the product development process. It consists of three broad questions with their respective set of possible answers (see Figure 1). On the first question, "why does PDS need improvement?", two possible motives are placed: one looking at the past and the other visualising the future[1]. On the second question, "is the intervention requested at the

[1] The idea behind the two alternative answers is borrowed from Kano and Koura (1990/1991) on the motives of implementing TQM.

organisational level?", three answers related to management process are presented. Still in the second question, two answers concerning work organisation (inter and intra-organisational co-ordination and integration) are placed. With regard to the third question, "is the intervention requested at project level?", six possible answers dealing with development process issues, from market and customer demands to scale-up and ramp-up of production, are placed. Finally, on work organisation at project level, two answers on co-ordination, integration, and learning are presented.

It can be said that answers 1, 2, 3 and 4, on Development Process at the Project Level, are the issues for which QFD can be regarded as a potentially useful method. QFDr is particularly important for tackling the answer 1, by deploying functions or needed work and tasks for Quality Assurance during the whole process of product development. However, from our experience it seems important that this deployment process should be complemented by existing literature on product development process, known as general stage-gate process, from both Marketing (DOLAN, 1993; COOPER, 1993; URBAN and HAUSER, 1993) and R&D viewpoints (CLARK and WHEELWRIGHT, 1993).

3. At the Level of operating QFD

The second part of the guide is concerned with operating QFD, in particular with what is the objective of using QFD and how QFD basic units can be operated. It also consists of three questions and their respective set of answers (see Figure 2).

I – Why does the Product Development System need improvement?

1. Feeling of uneasiness, caused by a set of facts and data, regarding organisational performance which proves that product development system of the organisation, compared to competitors or/and longitudinal evaluations, does not satisfy established targets;

2. Visualisation of a more competitive future and needs to prepare for that scenario.

II – Is the intervention requested at the organisational level?

Management Process:

1. Related to firm positioning to market linked to sector identity, business nature, economy of scale, level of competitiveness, technological innovation, etc.

2. Related to strategic alignment of functional areas involved in portfolio management and product development with overall organisational strategic objectives;

3. Related to optimisation of internal development capability or balance between types of projects to be developed;

Work Organisation:

1. Related to co-ordination and integration between firms in portfolio management and product development – consortium or network;

2. Related to co-ordination and/or integration of functional areas in portfolio management and product development.

III– Is the intervention requested at project level?

Development Process:

1. Related to establishing or improving formal development process and tasks ;

2. Related to understanding a product market structure, positioning, customers demands, concept definition, etc;

3. Related to converting, correlating and prioritising customers demands into specification of product quality characteristics, processes and raw-materials;

4. Related to identifying and balancing quality, cost, reliability targets due to innovations or technological bottlenecks in the processes of product design, process design and raw-material specification;

5. Related to establishing and achieving specifications during the process of product design, process design, raw-material selection and also, preparing and managing for mass production – scale-up and ramp-up;

6. Related to reduction of time-to-market, by the means of concurrent engineering or/and front-end problem-solving.

Work Organisation

1. Related to co-ordination and organisation of product development team;

2. Related to competence development and learning of members of product development team.

Figure 1: First Part of the Guide:
at the Level of Product Development System (PDS)

After answering the questions posed in the first part of the guide, if QFD is selected as an useful method for that particular situation, the second part the guide comes into play. According to Figure 2, the first question to be answered is "what is the objective of using QFD?". Three possible

answers, related to which organisational function QFD method is intended to support in order to perform particular tasks, will determine the extent and complexity of the conceptual model needed. If the answers are 2 and/or 3, then the next question on "how to formulate the conceptual model" should follow.

The first answer to this question draws attention to the need, in many cases of intervention, of having both a main conceptual model in one long flow of matrices and other auxiliary conceptual models made up of a number of broken matrices. Usually, the results generated by the latter are fed into the matrices of the main conceptual model.

I – What is the objective of using QFD?

1. Related to product development, to support Marketing function in refining concept definition and carrying out competitive analysis at the dimensions of customer requirements and of product characteristics – Quality Matrix would be sufficient;

2. Related to product development, to support Research and Development function in designing and specifying product, process and materials, so that customer requirements may be achieved – a more elaborated conceptual model would be needed;

3. Related to quality assurance, to support Manufacturing function to understand and relate product, part and materials specifications to process control parameters – a more elaborated conceptual model, including table of process control parameters would be needed.

II – How should Conceptual Model be formulated ?

1. Relate to type of conceptual model: main and auxiliary models;

2. Related to logic behind formulation of conceptual model: according to design rationale of development staff and/or to stages of manufacturing line.

3. Related to features of conceptual model: dependent on objective of study, type of industry, type of organisation, type of product, and proximity to end-user.

III – How should Tables and Matrices be deployed and filled?

1. Related to level of table deployment: dependent on usefulness to clarify what is 'hidden';

2. Related to matrix formation: dependent on usefulness, and creativity and flexibility are encouraged in combination of tables;

3. Related to importance attribution of lines and columns: independent of value specification, and creativity and flexibility are encouraged;

4. Related to value specification of lines and columns: independent of importance attribution, and specific technological knowledge, statistical and optimisation techniques are required.

Figure 2: Second Part of the Guide : at the Level of Operating QFD

The second answer is related to the logic of building the conceptual model. Conceptual models are the means of expressing relationship between outcomes and factors or effects and causes in a structured manner. The logic behind them has to do with the rationale of the development team on how a specific product may be formed, working from whole to broken parts and materials. One way which facilitates greatly how this structured flow can be expressed is by walking through phases of an actual manufacturing line when there is one.

With regard to the third answer, features of conceptual model, they are highly dependent on the objective of study, type of industry, type of organisation (design and manufacturing carried within one organisation or in separated organisations), type of product (assembled or not, process with or without change of material characteristics), and proximity to end-user. In some cases, a Quality Matrix is not relevant when the organisation is just a supplier of parts to a final product manufacturer and product specifications are provided by the latter. Another example is development of generic medicament in which product specifications are already given by the original drug.

Finally, the third question is on how to operate tables and matrices. The literature on procedures and rules of deploying and filling out tables and matrices step by step is well-known (AKAO, 1990b; KING, 1989; OHFUJI, ONO and AKAO 1990). Our intention here is to call attention to some specific aspects. Concerning the first answer, the deployment of table should go into as many levels as required, judged by its usefulness to clarify what is 'hidden'. In the second answer, matrices, in principle, can be formed by combination of any type of tables, whenever it is judged useful to relate one set of elements to another. The classical examples of matrices should be regarded merely as examples, not necessary to be followed strictly. Creativity and flexibility should be encouraged.

With regard to the second and third answers, related to importance attribution and value specification of columns and lines of matrices, they should be treated as independent tasks. Importance attribution involves activities of correlating columns and lines, converting importance of columns into lines or vice-versa, and then prioritising according to some rule. Again, we should like to encourage the use of creativity and flexibility. The procedures outlined in the existing literature on these activities should be regarded as examples rather than the norm. Concerning value specification of columns and lines, they are very often related to measurements or performances. To specify these values it requires technological knowledge in each particular sector of industry based on scientific disciplines and, quite often, statistical and optimisation techniques.

4. Conclusion

The published literature on QFD reveals that it has achieved a state where is well-known in the academic literature of product development management and has been widely applied in many countries. In order to contribute to further effective applications of QFD method, this paper offers a guide for intervention in product development system in organisations. This is a product of an action-research programme on implementing QFD method into product development systems in Brazilian industrial organisations, carried out by a group of lecturers and researchers. By reflecting upon the trajectory of our Program, which started in the early 1990's, it can be said that our practice of QFD has been greatly enhanced by our use of the guide described here. There is a strong consensus and drive in the group that there is an urgent need of, through what and how we carry out our research, making direct social and economic contribution to Brazilian organisations and, at the same time, contributing to accumulation of knowledge. Thus, our work in product development from an Engineering standpoint, in particular the application of the QFD method, is encapsulated by the conciliation of the binomial theory-practice, through bi-directional movement of reinforcing one another – good understanding of methodological theory leading to effective practice and, concurrently, good actual practice continuously generating or refining existing methodological theory (see Figure 3).

We believe that the accumulation of knowledge of QFD comes in three interrelated forms: 1– refinement of its methodological basis; 2– refinement of operating guides, procedures and rules; and 3– construction of models of reference applications. This paper aims at the second form. Figure 3 represents a synthesis of how we view the binomial theory-practice and their constituting elements. The contribution intended by this article is located in the figure by the underlined elements.

With regard to the limitation of the guide, our experience is geographically restricted to the Brazilian context and in number of applications. However, we believe and hope that this guide will be useful for those who are concerned with intervention in the complexity of product development systems within organisations.

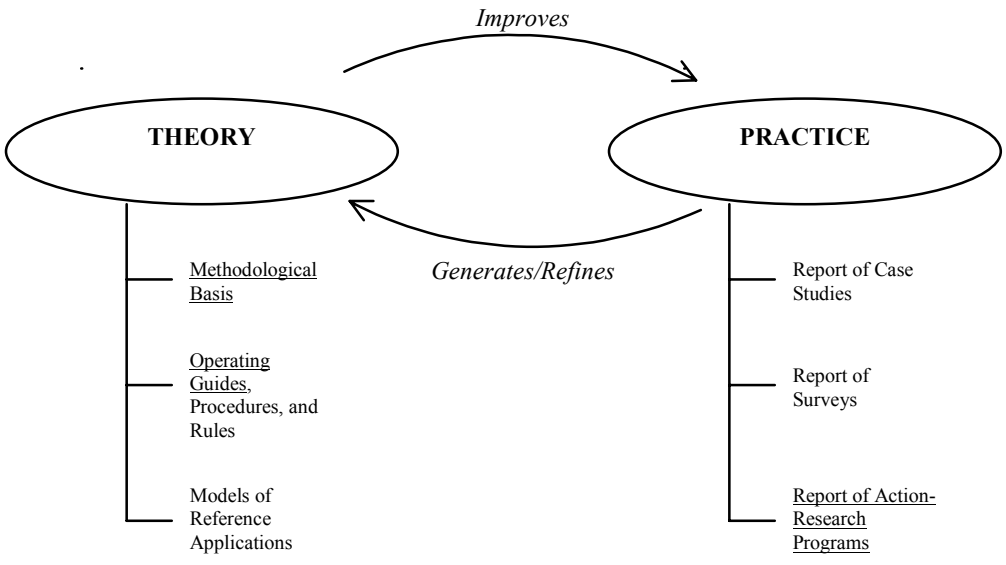

Figure 3: A Synthesis on the Dynamics of Theory and Practice and their Constituting Elements

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