An application of QFD to identify critical points in product development process through data gathered from technical assistance – an experiment in an information technology firm

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Abstract: This article discusses the application of QFD – Quality Function Deployment – for identifying deficient factors in product development process, starting from the negative quality of products. The improvement of product development process is directly related to the identification of deficiencies, which makes the corrective and preventive decision making process possible. The deficiency indicators are the negative quality of products, named critical events, represented by the data gathered from technical assistance, post sale or customer services. Consideration is made on the availability and potentiality of the data gathered from technical assistance and the feasibility of the QFD method for classifying these data. QFD deals, primarily, with the deployment when relating data from technical assistance to its critical characteristics; secondly, it deals with the critical characteristics within the development process; and thirdly, it deals with the stages of development related to the factors that are responsible for the deficiencies within the development process. The conclusions point to the pertinence of such application of QFD as well as to the importance of management at the operational level of product development.
Key Words: QFD, product development, technical assistance, negative quality, post-sales.

1. Introduction

The immediate actions taken by companies that search for a prominent position, are directed towards changes in management of development process. CLAUSING (1994) and CLARK and WHEELWRIGHT (1993) call to the fact that product development process has been considered a high priority in organization's success and must necessarily go through the strategic definition of market positioning as well as implementation of practices or procedures that maximize the performance of the development process. (GRIFFIN, 1997). Many forms of practice have been accepted by organizations in this sense. They deal with various issues such as: strategic product development, project concurrency, innovation, management method, customer proximity, multidiscipline and inter-functionality, communicational patterns, supplier involvement, training and learning, use of tools, quality and significance of prototypes, control of development stages, and finally, the use of helping agents. As shown by the research results accomplished by GRIFFIN (1997), the improvement of the development process is not reached by the extensive adoption of one practice, but by the parallel use of a number of them.

According to COOPER (1999), there is a crisis in task execution, thus, their deficiencies and their causes, denominated as "blockers", need to be identified. Frequently, the responsible factors for the success of product development are not perceived by managers. Management challenge is to apply a procedure aiming at the identification of factors that may interfere – negative or positively – in task performance.

Failures, which are negative qualities of a product, may be indicators of development performance and may be gathered through customer product complaints registered in technical assistance. CLARK and WHELLWRIGHT (1993) consider these product failures as critical events, and their cause and effect relationship with the development process must be explicit and direct. These information are available inside the company and are mostly underused when examined consciously, seeking the improvement of product development process.

The question at hand is about the feasibility of using data from technical assistance as indicators of performance, contributing to the improvement of product development process. Would it be possible, then, to establish relationship between data from technical assistance and deficient factors involved in development process? Is the QFD method feasible to classify this relationship?

In order to analyze the possibility of this relationship, data gathered from technical assistance must be eminently exact and technical. The data content is not explicit from the point of view of development management, therefore, it has to be deployed in relative significance to the process of product development. The QFD method allows this deployment since it enables (1) the work over the negative quality of products, (2) the use of a large amount of data, (3) the use of the cause and effect logic, (4) the deployment of data analysis by stages, (5) the clarification of relationship between data.

The QFD feasibility study, as a method to relate data from technical assistance to the product development process, seeks knowledge of following topics:

- The factors within product development;
- The potentiality of data from technical assistance to improve the product development process;
- The use of technical assistance data differently from previous employment;
- The relationship between data from technical assistance and factors that interfere with the product development process;
- The feasibility of the QFD Method in order to classify this relationship.

The practical verification of the proposal is performed in a large Brazilian company in Information Technology sector. This company is an information system developer, with information system products already structured. Therefore it is prepared to improve the performance of its development process.

This article is divided into following topics: Product Development Management and the factors that interfere with development process; the negative quality of products retrieved through technical assistance; the characteristics of QFD application in order to classify data from technical assistance; identification of deficient factors in product development process; and, conclusion.

2. PDM and factors that interfere in product development process

In parallel, the adoption of many practices or procedures, have guided companies towards reducing the occurrence of failures. According to GRIFFIN (1997), the transformation of the development process is evolutionary and constant in many fronts, and the focus on the development process has been transferred from the definition of an appropriate form of this process towards the creation of alternatives that assure its implementation, to manage in a better way planning activities and to continuously improve product development.

The most frequent factors adopted and shown in improvement practices - extracted from the literature (,1993; CLAUSING, 1994; BROWN and EISENHARDT,1995; GRIFFIN,1997; JURAN, 1997; BAXTER, 1998, MAZUR, 2000; COOPER, 1999 and CHENG, 2000) - are listed below, considering that they are not independent elements, and observing the co-existence and interference between them.

2.1. Sixteen factors which contribute to the effectiveness of the development process – a brief reference to the factors to be related to the negative quality of products

1. Establishment of the product development strategy: it deals with Product Portfolio Management; Aggregate Project Plan; involvement and support from senior management; and management for quality (CHENG, 2000; CLARK and WHEELWRIGHT, 1993; CLAUSING, 1994; GRIFFIN, 1997; JURAN and GRYNA, 1993).

2. Systemic vision of the product development process: to perceive product development as a system composed of action strategy and planning is to understand the interrelationship between the factors mentioned herein and to manage them in order to achieve maximum performance (COOPER, 1999; JURAN and GRYNA, 1993).

3. Simultaneity: the basic concept of simultaneous or concurrent engineering has two major characteristics, namely simultaneity and development of activities through multifunctional groups. The goal is to reduce project schedule (CLAUSING, 1994; CLARK and WHEELWRIGHT, 1993; GOFFIN 1998, 2000).

4. Innovation: the concept of innovation may be applied not only to products but also to the development process. During product development, innovations result from a structured process within organizational and management arrangements, as well as from the utilization of specific tools (BAXTER,1998; COOPER, 1999; GRIFFIN and PAGE, 1996; ZEIDNER and WOOD, 2000).

5. Management methods: there are different managing methods where one finds characters of "functional" managers, "light-weight" managers, "heavy-weight" managers; or informal management where there must be a point of balance in managing forces (CLARK and WHEELWRIGHT, 1993; COOPER, 1999).

6. Optimization x sub-optimization: they consist in attending to the needs of customers and suppliers, and in minimizing costs. One aspect of sub-optimization is the fact that project teams are formed by specialists who do not attend to the product development requirements as a system (JURAN, 1997; CLAUSING, 1994).

7. Customer proximity: some difficulties have been mentioned regarding the 'translation' of customers needs into attributes. Early involvement of users, follow-up of post-sale customer satisfaction through research and establishment of practices in customer service activities, maintenance of fidelity through the ability to work with clients in partnership and mutual trust (CHENG et al.,1995; VANDERMERWE, 2000; CLARK and WHEELWRIGHT, 1993; DUFFIELD,1999).

8. Inter-functionality: the importance of multidisciplinary teams and inter-functional integration during the development activities are based on the fact that the ideal situation is that which project decisions are made, involving people who have relevant knowledge in different areas within the organization. Integration must occur not only between departments of marketing, manufacturing and engineering, but also at an individual level in day-to-day task performance (CLAUSING,1994; GRIFFIN, 1997; CLARK and WHEELWRIGHT, 1993; COOPER, 1999).

9. Interaction and communication: the need to have precise information has become even more recognized, due to the increase of product complexity and their development process. Four dimensions of information must be observed: consistency, frequency, direction and moment. Tools and methods are mentioned as auxiliary in the flow of information and the visualization of activities, there are also software for product data management (JURAN, 1997; CLARK and WHEELWRIGHT, 1993; (JURAN and GRYNA, 1993; ZANCUL et al., 2000).

10. Supplier involvement: suppliers must be recognized as an extension of the company's operational forces, even as to reduce duplicity of installations, instruments, tests, reports. The relationship company-supplier must be based on mutual trust (CLAUSING, 1994; JURAN and GRYNA, 1993).

11. Lessons learned: historical events turn into lessons learned only after they have undergone retrospective analysis that change these events into useful knowledge. Product development needs to be revised periodically and at the end of individual projects, in order to question weak points and increase confidence on strong ones. The generation of organizational knowledge is accomplished by transforming tacit knowledge into explicit knowledge (JURAN, 1997; CLARK and WHEELWRIGHT, 1993; COOPER, 1999); NONAKA and TAKEUCHI, 1997).

12. Training: it is necessary to invest in education, training and experience. At planning level, management training promotes a systemic view of product development and of strategic goal accomplishment (CLARK and WHEELWRIGHT, 1993; JURAN, 1997).

13. Use of methods and tools for decision making and problem solving: in order to be effective, the tools and methods chosen must be specific for the context of the problem. However, due to a great variety of situations and problems, particular to each phase of the development process, the authors' approach tend to be limited to their market segment.

14. Quality of prototypes: the stages of construction, testing and analysis of prototypes acquired the status of management tool for analysis of project conduction. Four aspects are distinguished as management actions fomented by the analysis of the prototyping stage: (1) feedback and learning; (2) sharing of information; (3) evaluation of external agents; and (4) establishment, process and monitoring of development activities (CLAUSING, 1994; CLARK e WHEELWRIGHT, 1993).

15. Constant monitoring: control points. It refers to the control of targets, quality requirements and stages of product and project development process, the establishment of feedback procedures, structuring product development process into "stage-gates" (CLARK and WHEELWRIGHT, 1993; MAZUR, 2000; CLAUSING, 1994).

16. Use of facilitators: quality improvement agents, assistants in setting up project teams, responsible for specific training, who provide technical consulting, reduce

relationship conflict within team members, supervise the project process, become an interface promoting inter-functionality (JURAN, 1997 , JURAN and GRYNA,1993; BROWN and EISENHARDT, 1995).

3. Negative quality of products retrieved by technical assistance

According to many authors, the sixteen factors listed above interfere with the development process. Through the effectiveness of these factors, the product development process may be improved, however, their deficiency may bring the occurrence of critical events. These events correspond to product and services failures, or to unattended established targets, brought to the company's knowledge by way of customer complaints (technical assistance data).

The data from technical assistance may assume the role of these symptomatic critical events, since the customer asks for post-sale assistance to correct product failures, which could have been identified during development. Companies from various segments have used data about product performance gathered from customers.

The number of publications about customer support services, technical assistance, field assistance, post-sale assistance or other correlated denomination, is not very large, although their importance are recognized as (1) a source of revenue, (2) an argument to increase competitiveness, or (3) an essential factor for customer satisfaction (GOFFIN, 1998; HUL and COX, 1994).

Although a large number of companies have customer assistance services and, consequently, have in their hands information about product performance, it was observed that these data are largely used for corrections and little for performance analysis of the team and of the product development process. Another observation is that, although customer proximity – specifically regarding customer complaints and improvement of product development processes – exists as a frequent theme, it has not been systematically listed, seeking for an alternative for growth of company's ability.

Figure 1 compares the current status of organizations regarding the use of data from technical assistance and the proposal of this work on the use of these data.

4. An application of QFD

The QFD method in this study is applied with some particularities differently from the classical application of the method. Here, QFD is applied at the systematization level of information, that is, at QD (Quality Deployment)

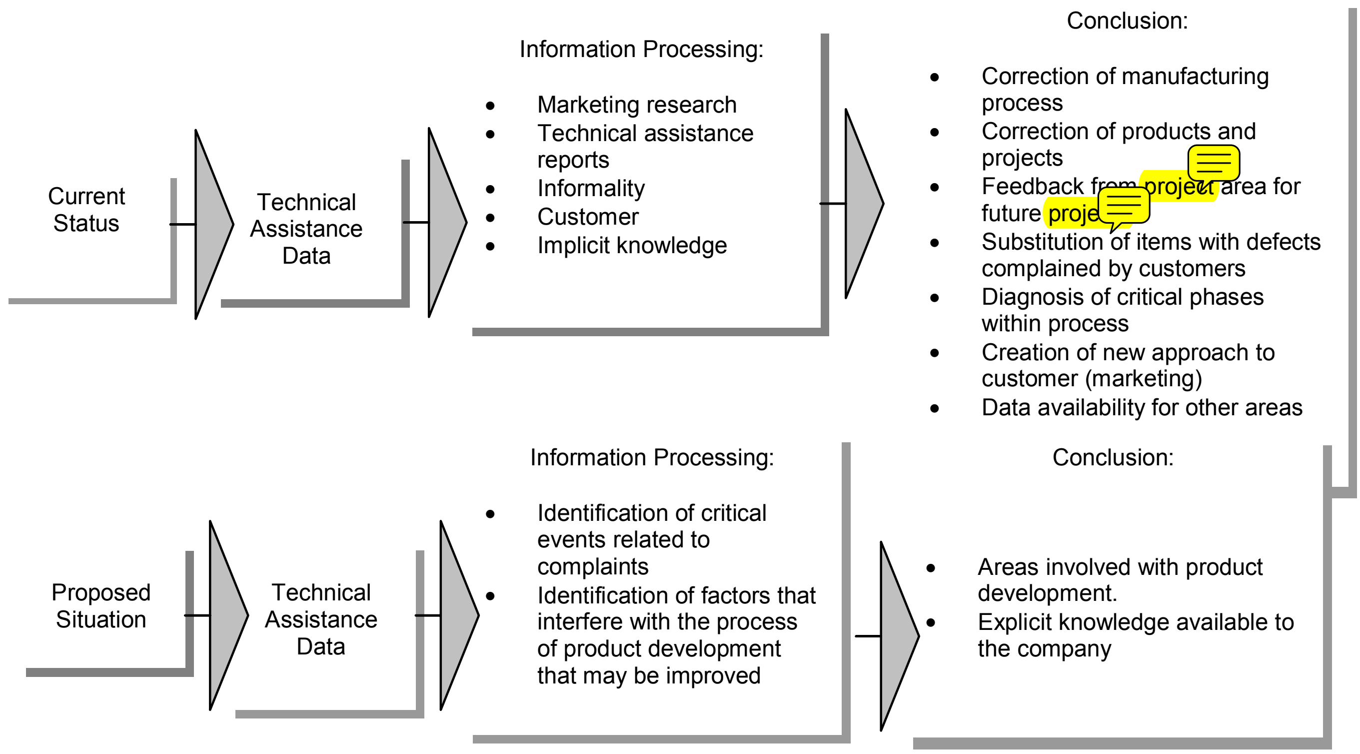

Figure 1: Current Status of Companies Regarding the Use of Technical Assistance Data and the Proposal of This Work

level. It does not work with the Quality Matrix. The Conceptual Model proposed is based on three Matrixes, whose logical sequence leads technical assistance data (customer complaints) to the identification of deficient factors within the product development process. The difference between this specific application and the traditional QFD application is not related to the logic, but to the source of data and final result, as explained in Table 1.

5. The concept of the proposed listing and the reasoning of correlation between performance factors of product development process and information gathered from technical assistance

As mentioned before, the relationship between product failures identified by customers and the deficiencies occurred during the process of product development, if properly established, may contribute to the effectiveness of the development process. The fundamental question to establish this relationship is: which deficiency within the product development process allowed failure to occur?

Therefore, to answer this question it is necessary to identify in which stages of the development process the failure occurred. And, within these stages, which factors were deficient. The deployment of this issue is the reasoning of the model proposed in order to relate product failures (customer complaints registered in technical assistance) to the deficiencies within the development process.

Figure 2 illustrates the starting and ending points, enabling the visualization of intermediate points. It is the logic of the traced path. Therefore, the logic of the proposed relation is established by the intermediate terms of: identification of corresponding technical failure and identification of the corresponding stage in the development process. The application model inside the company must be structured in this sequence that relates customer complaints to the factors that interfere with the development process, thus, providing a base for creating the QFD Conceptual Model. The approach used in this study is analytical, where cause and effect are investigated.

QFD is considered a pertinent method for the proposed listing since it (1) enables work on negative quality of products; (2) enables the use of a large amount of data, (3) uses the cause and effect logic, (4) enables deployment of data analysis by stages and, (5) enables a view of the interference between data (through correlation).

5.1.1. The adopted QFD Conceptual Model

In the Conceptual Model, there are representations of sequences of correlation, being that the resulting data from one matrix is the data entered in the next one. At the starting

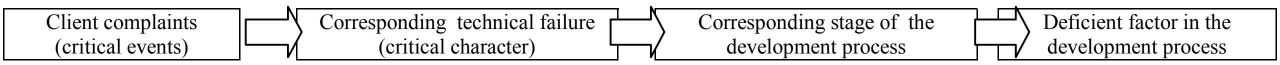

Figure 2: The Logic of the Proposition

Table 1 – Differences Between Traditional QFD Application and the Proposed Application

	Classic QFD application	Application proposed in this research
Source of data	"customer's voice"	negative quality (customer complaints gathered from technical assistance or post-sale services).
Matrixes that compose the Conceptual Model	Quality Matrix Technology Matrix Cost Matrix Reliability Matrix	Matrix I: data from technical assistance x corresponding technical failures. Matrix II: technical failures x stages of product development process where failures occurred. Matrix III: stages of product development involved x factors of development process
Result of Matrixes	Projected Quality Planned Quality	Critical failures (by priority) Stages of development process involved with failures (by priority) Factors of the development process that need improvement (by priority), considering the final result.

point, the data entered in the first matrix is the information gathered from post-sale services (customer complaints, critical events). See Figure 3.

The Conceptual Model consists in the presentation of the matrixes showing correlated data, following the sequential order of Matrix I, Matrix II and Matrix III. In order to structure each matrix, tables are necessary to correlate them by pairs.

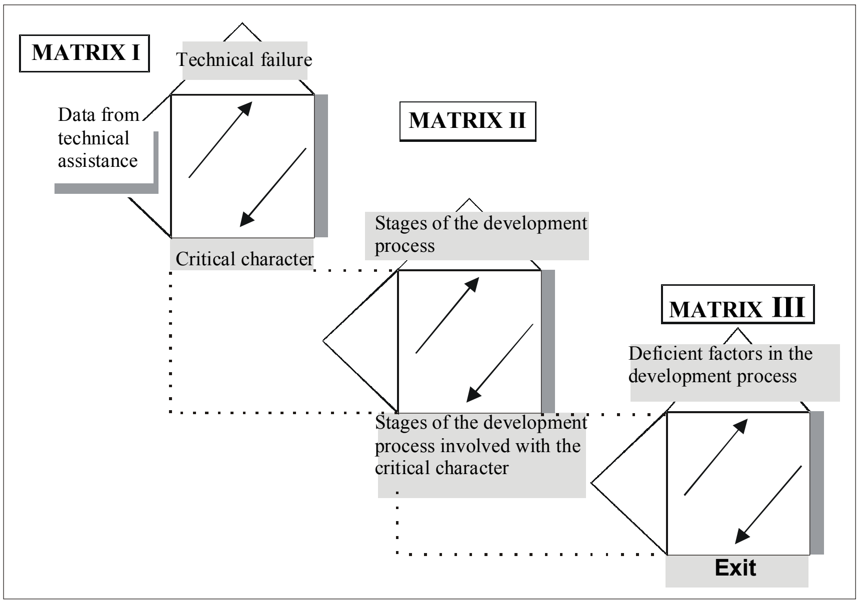

Figure 3: The Adopted QFD Conceptual Model

5.2 The application within the organization

The intervention occurred in a Brazilian company in the Information technology Sector, whose product development system is structured following the model of "stage review".

One of the businesses provided by the company is Information System Integration, performed by the Information System Business Unit – ISBU. The ISBU has150 employees and revenues of around US$ 10 million. The company provides services for two segments: GIS (Geographic Information System) technology and NMS (Network Management System), sharing 70% of utilities[1] market in GIS and 40% in NMS.

As for the type of activity developed, the ISBU is considered an on demand software developer, corresponding to 57,2% of activities provided by the companies in the same segment (MASIERO, 1999). As an information system solution provider, project activities are intense, which leads the company, strategically, to be concerned with the qualification of its product development team. The increased systematization of development control, according to the information provided by the ISBU Director, has led to the reduction of project schedule, the reduction of errors and the improvement of customer assistance.

According to the Director, the process of product development in the ISBU is being improved by the Project team and by the ISO quality system. Corrective actions are under way and the preventive action is the next step towards improvement. The process of data gathering and treatment from technical assistance is as follows:

- Customer complaints that come from Customer Service Management Department (GAC) are treated in two manners: as a Quality Complaint or as a Technical Complaint. Quality Complaints refer to quality of service, such as assistance, delay in solving problem etc. Technical complaints refer to product performance.
- Quality Complaints arrive via telephone or e-mail to the GAC team. They are then passed on to the Quality Department, where complaint records are created through a Pending Control System, with constant follow-up until its solution. The nature of the problem is identified and is delivered to the department responsible for its correction.
- Technical Complaints are delivered from different sources, which are, then, treated by a proper documentation system, containing the history of the complaint, from its opening to its treatment, interactions involved and solution. A simulation of the problem is carried out by the project team to identify technical failure, for example, bugs, implementation errors, error from customer operation, among others. Customer is then informed about the diagnosis and the procedure to be adopted for its correction.
- No specific procedure was created in order to identify causes of failures or problems complained. They are identified during the process of correction. The stages within

[1] It is a commercial classification that limits the activities of Information Technology into two segments: Telecom (telecommunications) and *Utilities* (energy, gas, water and wastewater companies).

product development process where failures occur are identified through meetings between project team members. Whenever there is a complaint regarding implementation, the stages of product development are identified by using a check list (Quality System document) to help in problem identification, including where they occurred. Although the process stage is found, the attitude is limited to the awareness about their occurrence, without a procedure for dissemination of knowledge acquired between functions.

◆ Until the moment of research, no records or statistic control were found about the amount of technical assistance calls received in the year, nor the percentage of complaints per product, nor the percentage of quality and/or technical complaints of products, nor the percentage of items complained (logic, implementation, specification etc). The company has the intention of implementing these procedures in short term.

The data selected from technical assistance are:

1. Publication of Raster Maps via WEB (User machines crashed);

2. Non accomplishment of the initial plan to deliver functionality;

3. Delay in delivering Rational Rose *licenses;*

4. Delay in hiring analyst to work at customer site;

5. Customer request for changes in the scope of functionality originally contracted;

6. Revision of project's technical documentation. Lack of definition regarding which methodology to use - ISO x MDSI.

After gathering the selected complaints, the next step was the construction of the first matrix of the Conceptual Model, in order to extract the technical denomination of failure - critical characteristics referring to each complaint. From these data, Matrix I was structured: Technical Assistance Data x

	Matrix I **Technical assistance data** **x** **Critical characteristic** Correlation: high: 4 medium: 2 low: 1 non existent: 0	**Critical Characteristic**										Relative weight	
		Hardware dimensioning or specification		Non accomplishment of quality validation stages of developed products.		Attending contract requirements		RFP / Contract specification does not correspond to customer's real needs		Lack of definition as for ISO x MDSI methodology			
Technical Assistance Data	▪ Publication of Raster Maps via WEB (User machines crashed)	4	125,0	0	0,0	0	0,0	4	125,0	0	0,0	31,3	
	▪ Unable to accomplish initial plan to deliver functionality.	1	6,3	4	25,0	4	25,0	0	0,0	0	0,0	6,3	
	▪ Delay in delivering *Rational Rose* licenses	0	0,0	0	0,0	0	0,0	0	0,0	0	0,0	15,6	
	▪ Delay in hiring analyst to work at customer site .	0	0,0	0	0,0	0	0,0	0	0,0	0	0,0	21,9	
	▪ Customer request for changes in scope of functionality originally in contract	0	0,0	2	37,5	4	75,0	4	75,0	0	0,0	18,8	
	▪ Revision of project's technical documentation. Lack of definition regarding which methodology to use - ISO X MDSI.	0	0,0	0	0,0	0	0,0	0	0,0	2	12,5	6,3	
Absolute weight			131,3		62,5		100		200		12,5		506,3
Relative weight %		**25.9**		**12.3**		**19.8**		**39.5**		**2.5**			

Figure 4: Matriz I

Matrix II Critical Characteristic Development Stages			Stages of Product Development Process								
			Project Management		Specification and Analysis of Requirements	Project Architecture	Tests	Implementation		Relative weight % (exit to Matrix I)	
Correlation: high: 4 medium: 2 low: 1 inexistent:0			Quality Plan	Feasibility analysis	Identification of Requirements	environment architecture	Mass of tests	Implementation plan	System acceptance		
Critical Characteristic	test	Hardware dimensioning or specification	0.0	0.0	2 51.8	4 103.6	4 103.6	0.0	0.0	25.9	
		Non accomplishment of quality validation stages of developed products.	4 49.2	0.0	0.0	0.0	0.0	1 12.3	1 12.3	12.3	
	specification/ contract	Attending to contract requirements	0.0	4 79.2	0.0	0.0	0.0	0.0	0.0	19.8	
		RFP / Contract specification does not correspond to customer's real needs	0.0	0.0	1 39.5	0.0	0.0	0.0	0.0	39.5	
		Lack of definition as for ISO x MDSI methodology	4 10.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	
Absolute weight			59.2	79.2	91.3	103.6	103.6	12.3	12.3		461,7
Relative weight % (out coming data to Matrix III)			**12,8**	**17,1**	**19,8**	**22,5**	**22,5**	**2,7**	**2,7**		

Figure 5: Matriz II

Critical Characteristics. See Figure 4. Then the Matrix II was structured - Critical Characteristics x Stages of Product Development Process. The extraction of these elements is accomplished starting from the compromised development stages. From this point, Matrix III is setup: Stages of Development x Elements of Product Development System. See Figure 6.

5.3 Results

The numeric values corresponding to the resulting data from Matrix I indicate the estimated critical characteristics relative to each critical failure identified. They are organized below, in table format and in decreasing order, from the most engaged to the less engaged with customer complaints (technical assistance data) (See Table 2). These values indicate the critical level of each critical characteristic in relation to the rest. Values are given by the "relative weight" parameter, which is intrinsic to the method.

The critical characteristics which values after correlation are equal to zero are not listed in this table. The values of "relative weight corresponding to priority" are the data entered in Matrix II which resulting values are listed below, in decreasing order of critical level of stages involved (from the largest priority to the smallest priority) (See Table 3).

Therefore, these values are entered in Matrix III, in order to perform the correlation. The numeric values, resulting from Matrix III, represent the relative critical level between factors which have contributed to the deficiencies in the process of product development, due to the lack of these factors or the lack of effectiveness.

The numeric values correspond to the relative weight of each factor and are represented in Table 4. This table shows the immediate result. It refers to the correspondence between technical assistance data and the deficiencies in the product development process. This result is expressed in numeric values relative to each factor responsible for deficiencies (See Table 4).

Table 2 – Resulting Data of Matrix I

	Critical characteristics of technical assistance data	Relative weight corresponding to priority (%)
1.	RFP / contract specification does not correspond to customer's real necessity	39.5
2.	Hardware dimensioning or specification	25.9
3.	Attending to contract requirements	19.8
4.	Non accomplishment of quality validation stages of developed products	12.3
5.	Lack of definition as for ISO x MDSI methodology	2.5

Matrix III Stages of Development x Elements of Development System Correlation: high: 4 medium: 2 low: 1 Inexistent: 0		Elements of Product Development System																		Rel. weight . % *	
		Establishment of strategy for product development	Establishment of Quality Goals	Systemic vision	Concurrency and simultaneity	Innovation	Management methods	Optimization x sub-optimization	Customer proximity	Inter-functionality integration between functions	Interaction and communication	Supplier involvement	Lessons learned	Training	Quality Measurement During Planning Phase	Use of Methods and Tools for decision making, Problem Solving, Management and Statistics	Quality of prototypes	Constant Monitoring: Points for Control and Measurement	Use of Facilitators		
Stages Of Development Process / Development Methodology - Subsystems: Project Management	Quality Plan	4 51,3	0,0	0,0	2 25,7	0,0	0,0	1 12,8	4 51,3	1 12,8	1 12,8	1 12,8	0,0	0,0	0,0	0,0	0,0	0,0	0,0	12,8	
Project Management	Feasibility Analysis	0,0	0,0	4 68,4	0,0	4 68,4	0,0	0,0	2 34,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	17,1	
Specification and analysis of requisites	Identification of requisites	0,0	0,0	4 79,1	0,0	0,0	0,0	4 79,1	4 79,1	0,0	0,0	0,0	4 79,1	0,0	0,0	0,0	4 79,1	0,0	0,0	19,8	
Architectural project	Environment Architecture	0,0	0,0	4 89,8	0,0	0,0	0,0	0,0	0,0	0,0	0,0	4 89,8	0,0	4 89,8	0,0	0,0	4 89,8	0,0	0,0	22,5	
Tests	Mass of Tests	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	4 89,8	0,0	0,0	22,5	
Implementation	Implementation Plan	4 10,7	0,0	4 10,7	0,0	0,0	0,0	0,0	0,0	4 10,7	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,7	
Implementation	System Acceptance	2 5,3	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,7	
Absolute weight		67,4	0,0	248,1	25,7	68,4	0,0	92,0	164,7	23,5	12,8	102,7	79,1	89,8	0,0	0,0	258,8	0,0	0,0		1233
Relative weight % (final exit: elements most engaged according to critical character.)		**5,5**	**0,0**	**20,1**	**2,1**	**5,6**	**0,0**	**7,5**	**13,4**	**1,9**	**1,0**	**8,3**	**6,4**	**7,3**	**0,0**	**0,0**	**21,0**	**0,0**	**0,0**		

* resulting data from Matrix II

Figure 6: Matriz III

Table 3 – Resulting Data of Matrix II

	The stages of product development involved with critical characteristics	Relative weight corresponding to priority (%)
1.	Mass of Tests	22,5
2.	Environment architecture	22,5
3.	Identification of requests	19,8
4.	Feasibility analysis	17,1
5.	Quality plan	12,8
6.	Implementation plan	2,7
7.	System acceptance	2,7

Table 4 – Resulting data from Matrix III

	Development Process Factors	Relative weight corresponding to priority (%)
1.	Quality of prototypes	21.0
2.	Systemic vision	20.0
3.	Customer proximity	13.4
4.	Supplier involvement	8.3
5.	Optimization x sub-optimization	7.5
6.	Training	7.3
7.	Lessons learned	6.4
8.	Innovation	5.6
9.	Establishing strategy to develop products	5.4
10.	Concurrency and simultaneity	2.1
11.	Inter-functionality/ Integration between functions	1.9
12.	Interaction and communication	1.0

Note: the factors not mentioned above had relative weight value equal to zero.

6. Conclusion: positive points and limitations

The discussion about the positive points and limitations considers the aspects placed in question during the field work in the company. Although these questions did not have immediate answers, they were registered in order to contribute in outlining the final discussion.

6.1 Regarding the characteristics of the research

◆ The discussion about each item of result from the matrixes – the value of the deficiency – is not part of the scope of this research. This is an analysis to be considered in future stages, involving management and project team.

◆ One of the characteristics of this work is its qualitative character and not quantitative. The values presented in the matrixes and tables are representative, allowing a comparative analysis between the data, in order to establish a hierarchy of their critical levels. The role of values is related to the correlation intensity and not only to the numeric value – quantitative. AKAO (1996), by mentioning about the use of numeric values in QFD, clarifies that, in case problems arise regarding precision of values, or regarding the existence of ambiguous points, the most significant factor to consider is the overall agreement based on something visible.

◆ The value of items within the matrixes (high, medium, low or non existent correlation) is a result from group discussion. It is not a quantitative character, but a perception of the intensity of correlation, relatively. This subjectivity was questioned by the group and its consensus was also agreed by the group.

6.2 Reference on the group / team of people

◆ In the beginning of the work, there was a discrete resistance by group members since the proposal of the research was to treat the negative aspects of failures, complaints and deficiencies on factors involving the product development process. In a way, this approach exposes the people responsible for failures. This behavior is similar to the one described by CLARK and WHEELWRIGHT (1993) when analyzing the use of project auditing procedure. This effect can and must be minimized by the attitude shown by the manager in charge and, in the case of research, also by the researcher.

◆ Although the team involved in the research is representative in terms of decision autonomy, as well as management development and opinion makers within the ISBU, the discussions could have been more questionable regarding the causes of failures and the method used

◆ The question raised by the researcher is about the diversification of results due to team composition. If the team was larger or had other people, different from the ones who participated, or even if one or another element from the group was replaced, the result could have been different. ANDERY and HELMAN (1995)comment this instance when analyzing the application of methods such as FMEA and FTA and propose the repeated application of the methods in different teams, before concluding. In this case, the objective is the preservation of result veracity and not the veracity of the method itself.

◆ The same way the number of people may interfere in the result, the profile of each participant may also be an important factor, since the perception of relationships depends on the management view, individual experiences and behavior of each participant

◆ The participation of the person responsible for quality was fundamental, since the interest for the subject and the perception of its benefits are clearer to people who deal with this activity daily, considering that they necessarily work with the vision of the whole and constant search for improvements.

◆ Regarding multi-disciplinary groups, it could have been richer if the commercial area had been involved more intensively in the work. One of the team members was responsible for Customer Assistance Management, under a post-sale point of view. The moment could have been more advantageous for exchanging experiences with the commercial area, since they participate from the beginning until the end of the development process, according to the "Product Development Methodology" used by the company. Their absence left a gap in the process.

◆ Employee availability is fundamental and depends on the involvement of the senior management. The work schedule presented to the company was measured in hours. In the beginning, this schedule was revised together with the team and some changes were made to fit to the routine of the company. However, although it had been agreed by team members, it suffered intense pressure to be concluded as fast as possible, since project deadlines were not extended to fit this "new activity".

6.3 Amplitude of action

◆ The requests made by technical assistance, in case of research, were restricted to one product, while the deficiencies during the process of development may occur (1) in the same manner in different projects, (2) in certain moments within a project and in different moments in other projects, (3) depending on time pressure of team members. This limits the time amplitude of the work, that is, it should be applied periodically during the development of the same project and in different projects

◆ Not all recorded requests were treated due to data confidentiality. The number of items does not invalidate the result nor the research, since it is not quantitative. However, the number of requests registered (technical assistance data) has a definite effect on the quantity of deficient factors registered.

◆ The work is restricted to the identification of deficiencies which, if corrected, contributes to the improvement of performance of the development process. Planning of corrective and preventive actions aiming at improvements are not included in this proposal.

◆ At the end of the work, some questions such as: in which level the deficiencies contribute to the occurrence of failures? Or, how may we assure that these deficiencies are not compromising? This takes us to the indication for future researches: search for a way to measure the interference of the deficiency. The proposition of this work is that QFD serves as a method to be applied in the proposed relation. The subject must bring to the attention of people responsible for product development the fact that improvements are not restricted to the product or to the manufacturing process. Improvements may also appear in planning of product development.

6.4 About QFD

◆ This is not a traditional application of the QFD method. The pertinent study of the method, based on existing theory and practice, was directed towards the potentiality of the method and not towards its operation using traditional concepts.

◆ Some group members already had some experience with QFD to specify the quality of products and there was a certain resistance to use this method. They claimed that QFD is extremely complex and this complexity diminishes the objective, making it difficult to reach a final result. By gaining knowledge of the conceptual model and setting up the matrixes, during practical work activities, the resistance was reduced since there was a small number of matrixes, all were very objective. By working in the QD sphere, of information treatment, it showed the simplicity of the matrixes. The understanding of the group was evident after showing that QFD, if used locally, can be very accessible, and can contribute to proving the flexibility of the method (ARAUJO, 2002). From this vision, it is easier to see a more complex application, structured in subsequent deployments, as it occurs in QFDr (QFD in a restrictive sense).

◆ There was some questioning related to the subjectivity of valued correlation, during matrix set up, which was discussed at the time. It was evident to the group that, firstly, this subjectivity loses importance at the moment when the assumed values become a consensus of the group; secondly, the higher goal is not related to absolute values, but to relative values; and thirdly, the acquisition of knowledge during discussions for evaluation of items must be the focal point of improvement.

◆ The method for data organization and registration allowed comings and goings to search for concepts already discussed, which enriched the inter-relational dynamics of the method.

◆ Although it may seem antagonistic, the vision of the whole is delivered by partial reasoning of the method, proving adequacy to its fundamental principles.

6.5 About the concepts and reasoning applied

◆ Are some of the factors typical of certain stages of development? This question was raised at the end of the work. Primarily, it is considered that all factors that interfere in the development process are present in all stages of this process. The variation of incidence of certain factors, within some stages, in this work, does not interfere in the result.

◆ In the beginning, when the subject was unknown, the group's expectation was towards the improvement of the product development process, as a final result. As the seminars took place, daily and individual experiences and acquired knowledge became the motivation of discussions. The fact is that the theory about product development is a present subject in daily routines of the professionals who work with projects, even if in an intuitive form, known as tacit knowledge. When these professionals see before them a formal theory, the group associates it to tacit knowledge and recognizes the opportunity to consolidate practical and intuitive knowledge. This consolidation happens by a new proposition (innovation), in associating problems in the past (lessons learned) with the explicitness of group necessity to discuss improvements of development process (interaction and communication).

◆ The role of the researcher is known as a facilitator, and the method proposed is valued as an efficient support to show evidence in promoting knowledge within the group.

◆ The result analysis must lead, necessarily, to the argument that the factors listed may be improved. For example, the quality of prototypes has not been sufficient to check on product performance or efficiency of stages, and its verification has been sub-used during the course of projects. This evidence points to the need for action, as a second step. This subject was raised by the group and will de treated during the discussions of this work.

◆ This work has characteristics of a diagnosis, when dealing with the identification of deficiencies. In continuation, a new method that delivers problem solutions may be created, that is, a second model that provides proposals to solve the deficiencies found.

◆ Also as a recommendation – in case there is replication of the proposed proceeding or continuation to improve this proceeding – it may be pertinent to revise the success factors of the product development process, under the perspective of the company being researched. Identification of the factors that are already incorporated in the process of development, whether they are efficient or not, what is wrong, and how it can be improved, using QFD to make this relation.

6.6 QFD contribution and the potentiality of data from technical assistance

◆ The use of QFD, in the context of identification of deficiencies in the product development process, showed to be efficient as a management action to promote – conduct – discussions about problems in products. Specifically, the company's involvement should be during the implementation of preventive actions aiming at the control of customer requests and complaints. QFD may be applied as a method to make this intention feasible.

◆ During discussions to find improvements for deficiencies in the product development process, the role of management becomes explicit, in the sense of expanding strategies for development beyond the horizon limited by simply accomplishing product requirements. The highest reach is to plan the execution of activities during the process of development, in the best way possible, taking the maximum advantage of available resources – human, financial and material.

◆ The understanding of co-relations between complaints from technical assistance / stages of development process / deficient factors in the process, according to the conceptual model of QFD, contributed to expand comments of team participants about deficient factors considered in the work.

◆ The structure used to organize information, through the conceptual model and matrixes, helped the group to understand the amplitude of management action in order to identify deficiencies in the process of development. The discussions were not restricted to the identification of causes of failures (event critic), but also to become aware of the possibilities of deficiencies within all product development process.

◆ The deployment of the problem into three matrixes (I, II and III) enabled the expression of intermediate results, corresponding to matrixes I and II, including data about the most compromising stages of the development process.

◆ It is possible to see that the global grouping and analysis of customer complaints, about a specific product, enabled a holistic view about product performance and about the level of seriousness of customer complaints. Also, although only one product was treated, it was possible to reach a final result to identify deficient factors in the process of product development.

◆ In a social-technical organization point of view, some aspects were benefited by multi-disciplinary characteristics of QFD. The most interesting remark was the group's cohesion to assume new atitudes required by the method application. The identification of deficiencies performed together with a heterogeneous team, preventing connections to individual responsibilities, required very clear group focus on a common objective and understanding of the product development process as a multidisciplinary activity. This way, the application of QFD to identify deficiencies within product development was not seen as a auditing process searching for guilty parties.

◆ A fact that deserves attention is that the use of QFD for this type of application shows a different procedure to reach results in a short and medium/long term. In a short term, it allows an immediate use of resulting information from Matrix III, in other words, it identifies promptly which are the critical factors in the product development process, enabling immediate actions to be taken for corrections. In a medium/long term, the application of QFD proposed is a practice used to generate organizational knowledge, to learn from experience. It may be formalized and diffused by the periodic repetition of the proposed application in the same or different products, in order to evaluate the results comparatively and make them available for future decisions. It requires a period for raising consciousness within the company, reinforcing the premise for commitment of managers responsible for planning in a medium/long term. According to AKAO (1990), when handling points of improvement in the development process, the company is directly dealing with the improvement of planning activities, or quality of planning.

◆ One point to be considered in this discussion deals with the simplicity of the matrixes which results from the conceptual model proposed. As mentioned before in this article, this is not a traditional application of the QFD method, therefore, some changes occurred, considering the flexibility of the method (ARAUJO, 2002).

The contributions provided by QFD as a method to relate data from technical assistance to the process of product development, as described above, are remarkable, considering the management aspect of the method application for this purpose. The accomplishment of QFD principles and the adequacy of the conceptual model, in order to attend to the proposal, are aspects that confirm the operational adequacy of the QFD for the proposed application.

The potentiality of the data from technical assistance, as a source of information about the process of product development, may be verified in the practical finalization of the work, shown in the presented results. It is interesting to note that, at the end, customer complaints – data entered in Matrix I – lose the importance as an indicator for product performance, such as critical events. The critical points within the development process assume the importance, characterized by means of explicitness of the responsible factors.

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