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# TRANSFORMING USER REQUIREMENTS INTO TECHNICAL REQUIREMENTS FOR DEVELOPMENT OF A NEW CONTROL ACCESS FOR PEOPLE WITH REDUCED ENVIRONMENTAL IMPACT

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## ABSTRACT
This paper presents a proposal for evaluation of product development in the electronics industry based on the application of the tool QFD (Quality Function Deployment) oriented environmental parameters. The article presents the development of access control systems guided by the requirements of different segments of users. The survey of demands was performed an exploratory stage through qualitative questionnaire with experts from the company and the users of turnstiles. The use of the tool was adapted from a conceptual model of QFD proposed by Ribeiro et al. (2001), with inclusion of environmental parameters in the matrices. With the result of applying the deployment of QFD matrices were obtained the main criteria for prioritization of needs leading to greater acceptance of the system by users. One feature that has been observed by the users and that can easily be used in developing new turnstiles to access control is the use of recycled materials in building the product. Users also pointed to the construction of the turnstiles with less material and that they were lighter which will reduce the amount of natural resources.

*Keywords: eco design, requirements, product architecture, product/service systems*

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# 1 INTRODUCTION

An increased concern for the environment brings companies the need to incorporate in their products and/or processes related questions their responsibility to the planet. Thus, the ecodesign can be taken as further actions in the development of products aimed at minimizing the impacts of products throughout their life cycle, without compromising other essential features such as performance and costs (Johansson, 2002). According Pigosso (2008), the methods comprise ecodesign currently an amount exceeding one hundred.

In this context, the quality function deployment (QFD) proves a very useful tool that acts as the identification, prioritization and control of important requirements from the standpoint of customers Waisarayutt Siritaweechai (2006), Miguel (2009), Deros et al. (2009), Kasim et al. (2009). Applications of QFD emerged in a context in which the user was the only source of information. Future trends point to incorporate new technologies, requirements related to marketing and involvement of all stakeholders considering different dimensions in the product such as: functional, ecological, social, environmental and emotional (Akao and Manzur 2003).

The adoption of environmental requirements is an important dimension in New Product Development (NPD) management and it should be taken into account in the early stages of development. In Brazil, studies like those of Marx et al. (2011), Pigosso (2007) and Puglieri et al. (2010) have pointed to new research themes related to sustainable change in developing new products.

In an attempt to unite the study of products based on ecodesign in the electronics industry and identifying and prioritizing product requirements generated by this branch of industry, it was decided to perform an analysis from the requirements demanded for access control systems with focus on product. It is understood that such systems are materialized on devices that are already part of everyday life in urban corporations, universities, banks, public transport, etc... As an example, turnstiles with magnetic cards which are used daily, however identifies a lack of comprehensive studies that consider how such access controllers are perceived by those who use them. Also lacking depth research on the requirements of the equipment exactly for those who deal with them, but they are not direct buyers of the product and, therefore, are distant from the companies responsible for their production.

Therefore, the rapprochement between the perception of the users on the access controllers in academic and development of these products in order to lower environmental impact presents an opportunity to study. In this scenario, we intend to evaluate the perception and survey requirements in relation to controlling access by users and discuss the development of the project from the manufacturers of these controls, from the perspective of minimizing environmental impacts. Such questions take into account the current context of mobility of people in environments associated with the need for flow control in order to restrict unauthorized access through barriers, but through intelligent systems, adapted to different contexts.

This research is organized in an initial exploratory phase in which data are collected on the side access equipment combined with primary data - obtained from qualitative interviews with users and experts. In the next phase, quantitative data are extracted together with other users in order to make the quality function deployment (QFD). The data to be generated by a structured method for measuring performance with environmental concern aim to provide assistance to the process of decision making in product development and its corresponding performance evaluation in the university environment.

# 2 REVIEW

One of the tools that support emerges as possible to meet the demands for product development based on ecodesign in the electronics industry is the quality function deployment (QFD). Initially structured by Akao (1990) in Japan between the late 1960s and early 1970s, can be used as a tool applicable in the process of new product development to translate user needs and environmental requirements that meet the quality requirements demanded by the client from the beginning of the project. The tool of QFD spread in different branches of Japanese industry - among which are some related to software development, integrated circuits and electronics production - having then expanded to Western companies, with emphasis on the U.S. market, which also provided an increase in the case studies and the literature produced about (Chan and Wu, 2002; Lai et al., 2008; Mahdavinejad and Abedi, 2011).

However the environmental impacts along the life cycle of a product are, in general, determined during the early stages of its development and, therefore, the consideration of environmental aspects during

the NPD plays a fundamental role in reducing these impacts related to all the life cycle of the products (Pigosso et al. 2007).
There are different methods proposed for the adoption of environmental criteria to QFD that use different nomenclature, as the Green QFD, QFD Ecodesign, DfE QFD, QFD environmental QFDE, among others. In a systematic review conducted in 2011, Puglieri et al., identified 17 ecodesign methods based on QFD. Virtually all 17 methods analyzed cannot be considered extensions of traditional QFD tool; mostly are simplified versions of a matrix of quality where environmental requirements are introduced (Puglieri et al. 2011).
To develop this work proposed in this paper, methods of QFD to the environment were studied for the subsequent inclusion of environmental parameters in the matrices of the chosen model (Ribeiro et al. 2001). These works served as inspiration for the creation of parameters that take into account issues such as reducing the use of materials and recycling.
The logical structure of QFD is based on unfolding of matrices, which can be composed and arranged in different ways and according to the goal that is providing answers. The precursor model developed by Akao (1990) includes 27 matrices, new conceptual models emerged adapted to different purposes and industries, making a more dynamic and pragmatic, with bias directed at the need for agility by firms (Marx et al. 2011).
One of the conceptual models that show comprehensive QFD for different lines of business, but more simplified model proposed by Ribeiro et al. (2001). The matrix structure of the authors for manufacturing comprises five main headquarters: quality products, processes, resources and costs. Considering the definitions of the authors, is presented in Table 1 understanding of each matrix and adaptation performed for this study.

*Table 1. Model proposed by Ribeiro et al. 2001*

| | Matrices of Proposition Ribeiro et al. (2001) | | | | |
|---|---|---|---|---|---|
| | Quality | Product | Process | Resource | Costs |
| Objectives | Relates Demanded quality Deployment (Customer requirements priorizated through market research) With quality characteristic (technical requirements) Involves | Deployment the product into its constituent parts (systems, subsystem's and components) and relates with Technical requirements | Deployment processes steps and relates with the technical requirements | Deployment of personnel and infrastructure items and relates with priorizated process steps | Deployment of calculating the approximate monthly cost of each process steps. |
| Output | Customer requirements prioritized Technical requirements prioritized | Parts of product prioritized | Process steps prioritized | Human and infrastructure resource | Costs related to each steps of the process |
| Indicators | Idi*: prioritization of quality demanded, corrected | Pqij: quality characteristics relationship with the constituent parts of the product | Pqij: quality characteristics relationship with the constituent stages of the manufacturing process | Prij: relationship processes with items of infrastructure and human resources | Monthly cost: Monthly costs distributed over the processes according to the intensity |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | of relationship |
| | Idj: importance of each item of quality demanded | Ipi: defining the importance of parts | IPI: defining the importance of process | Irj: definition of the importance of the items of infrastructure and human resources | Ipi: defining the importance of process |
| | Ei: strategic assessment | Ipi*:prioritization of parts | IPI*:prioritization processes | Irj*:prioritizing items of infrastructure and human resources | |
| | Mi: competitive evaluation | Fi: assessment of the difficulty of deployment | Fi: assessment of the difficulty of deployment processes | Ci: evaluation of the cost | |
| | Iqj: importance of the quality characteristics | Ti: evaluating the implementation time | Ti: time evaluation of the implementation process | Lj: difficulty assessing the deployment of infrastructure items and human resources | |
| | Iqj*: prioritizing quality characteristics | | | | |
| | Dj: assessment of the difficulty of acting on the quality (Dj) | | | | |
| | Bj: competitive assessment of the quality characteristics | | | | |

# 3 METHODOLOGY

The understanding of quality requirements associated with access controllers, designed as environmental principles can be implemented from the modeling of the QFD matrix structures. The completion of this step applied research is focused on raising the quality characteristics of the product demanded by users 'access controller', materialized from the analysis of turnstiles.

The environmental analysis is limited to the university, so the inclusion of access controllers was considered at a Public University, chosen for convenience by the researchers. As users were identified undergraduate and graduate, alumni, teachers, servers and other attendees of the university.

As the choice of access controllers purchased is not made directly by end users, were also consulted experts, working in electro-electronic companies - which are involved in routine manufacture of access controllers. These experts often still do the intermediate between users' needs identified in the market and the needs required by organizations purchasers of access controllers - if the chosen university for study.

To do this research, two approaches were made to collect data: qualitative and quantitative. First, a qualitative phase was conducted to survey the unfolding characteristics and perceptions of access controllers for users and experts. Following the quantitative stage was conducted among users of splitting matrices, adapted from Ribeiro et al. (2000). The models analyzed in this research are presented in Table 2. In inch case a focus group were realized. The focus groups with experts and users were realized with 4 people from 2 companies and other 10 users. On the second stage a survey were realized with 232 users of turnstiles at university.

*Table 2. Models turnstiles presented to users in the qualitative phase*

| | Model Presented | | |
|---|---|---|---|
| Type |  |  |  |
| Description of the model of access controller | Turnstile accessed through use of a magnetic card or of a code, with a fixed base and a movable shaft comprising three arms bidirectional fixed axis at an obtuse angle | Turnstile accessed through use of a magnetic card or of a code, with a fixed base and a movable shaft comprising three arms bidirectional axis at an obtuse angle | Turnstile accessed through use of magnetic card or typing code with a fixed base and a movable shaft shaped clip |

The features mentioned by users, experts, current standards, taking into account the objectives of the research, provided the basis for the creation of a quality tree defendant, i.e., a hierarchical organization of items at the primary, secondary and tertiary.
The Tree of quality coming from the defendant qualitative stage, allowed the preparation of the questionnaire with closed questions, quantitative, used to determine the importance given by the users to the secondary level, providing also the importance given to each item deployed (tertiary).
In quantitative questionnaire were established 26 issues on the corresponding requirements (tertiary) raised by users related to the quality demanded (secondary level). Each question was stated as to the relevance of the requirement on a scale of 1 (one) to 10 (ten), where 1 represents minor point and point 10 is very important. In addition to the questions at the end, requesting that the user rank the order of importance of each item side, with 1 being most important and 5 the least, considering five items due to be evaluated.
The weights of secondary level items (W0) are calculated based on the order of importance attributed by the respondents for each item, and converted in percentage. The weights of the Secondary level items may be computed by the geometric mean of the importance attributed by N respondents in the quantitative questionnaire, using the 1-10 scale, and the geometric mean will also converted in percentage. Thus, the primary level weight is distributed through the weights of the secondary level items that compose it, and the sum of the secondary items percentage weights is equal to the primary item percentage weight, from which they belong. The final result is the Demanded-quality Importance Index (IDi).
The degrees of importance obtained from the qualitative levels for the primary, secondary and tertiary were transformed into weight percentages to ensure that each block had their weight properly assigned. The weights assigned (IDi) were corrected considering competitive evaluation (Mi) and strategic assessment (Ei). The Mi is obtained by analyzing the quality demanded in relation to competition and direct Hey defendant regarding quality and its relevance to the goals set for the future of the company. Thus, the prioritization of quality items corrected demand was calculated taking into

account IDi, Mi and Ei. The assignment of weights and its correction were based on Ribeiro et al. (2001).
Note that IDi reflects only costumer' prioritization, while IDi* reflects also the company strategy (Ei) and the position in the market (Mi). However, the square roots only in the indicators Ei and Mi in the equation assure that the costumers' opinion will prevail over the organizations' perception; the adjustment contributes to a better prioritization of those items that were not perceived as very important by the costumers, but that are important for the company strategy or market position.

*Table 3. Scales used for the adjustment factors demanded-quality importance index adjusted*

| Scales for the adjustment factors | | | | | |
|---|---|---|---|---|---|
| Score | Competitive comparison ( Mi , Bj ) | Strategic Contribution ( Ei ) | Difficulty for acting/implementing ( Dj , Fi ) | Time to implement ( Ti ) | Costs for implement ( Cj ) |
| 0.5 | Above competitors | Of Little Importance | Very difficult | Very long | Very high |
| 1.0 | Similar to competitors | Moderately Important | Difficult | Long | High |
| 1.5 | Below competitors | Important | Moderate | Moderate | Moderate |
| 2.0 | Far below competitors | Very Important | Easy | Short | Low |

IDi is adjusted using two different factors, whose scales are detailed in Table 3. The first factor is used to consider the relevance of each item, considering its importance to the company strategy (Ei) and the second factor is used to consider the company competition position in the market (Mi) in comparison to a benchmarking organization. The result is the Demanded-quality Importance Index Adjusted (IDi*), expressed in the Equation 1.

$$ID_i^* = ID_i \times \sqrt{M_i} \times \sqrt{E_i} \quad (1)$$

# 4 RESULTS

As one of the main results of the qualitative research stage gave the tree of quality demanded. At primary level we identified two key items that distinguish the system. A primary level was the physical structure - which includes shape, its presence in the environment, their parts and their design project in Table 4. The other item was the primary identified usability - which includes the use of modes, i.e., mode of user interaction. At the secondary level, stood technology, design and ergonomics, safety, friendliness, technical performance, deployed in other Tertiary requirements.

*Table 4. The quality of the tree - Access Control*

| Demanded Quality Deployment | | | Client Requirements | | | | |
|---|---|---|---|---|---|---|---|
| Primary | Secondary | | Tertiary | | | | |
| | | W0 | | IDi | Mi | Ei | IDi* |
| Physical Structure | Technology | 29.40 | System resource utilization with innovative and sensitive identification | 5.00 | 0.50 | 1.00 | 3.54 |
| | | | Combined use of two systems | 4.70 | 0.50 | 2.00 | 4.70 |
| | | | Construction employing technology/ process sustainable | 4.65 | 1.00 | 1.00 | 4.65 |
| | | | Operating on the principles of low energy | 5.28 | 1.50 | 2.00 | 9.15 |
| | | | Use cards/tickets with longer life allowing reuse and avoiding disposal immediately | 5.17 | 1.00 | 2.00 | 7.31 |
| | | | Opening and closing smooth and continuous | 4.60 | 1.00 | 1.00 | 4.60 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Design And Ergonomics | 9.23 | Design non-aggressive to the environment | 1.44 | 1.00 | 1.00 | 1.44 |
| | | | Construction based on recycled / recyclable materials | 1.28 | 1.00 | 1.50 | 1.57 |
| | | | Use of materials that give the impression of lightness in his handling | 1.43 | 0.50 | 2.00 | 1.43 |
| | | | Ergonomic (that respects the body) to ensure easy passage of the body and belongings of the person who carries the access control | 1.76 | 1.50 | 1.50 | 2.63 |
| | | | Adaptability and compatibility for the disabled and people with mobility difficulties | 1.80 | 1.00 | 1.50 | 2.20 |
| | | | Decreased physical contact between system and user | 1.53 | 1.00 | 1.50 | 1.87 |
| Usability | Security | 33.25 | Security requirements should be applied the same for all (standardized) | 4.37 | 0.50 | 2.00 | 4.37 |
| | | | Adequacy of the security environment | 5.10 | 1.00 | 1.50 | 6.24 |
| | | | System must identify the user input and output | 4.56 | 1.00 | 1.00 | 4.56 |
| | | | That does not present problems in identifying user | 5.21 | 1.00 | 1.50 | 6.38 |
| | | | Control persons not entered into the system, entering sporadically in a given environment | 4.75 | 0.50 | 1.00 | 3.36 |
| | | | System capable of identifying fraud | 3.98 | 1.00 | 1.00 | 3.98 |
| | Use | 14.60 | Identify clearly the right way to position the means of identification (card, finger, ticket) | 5.29 | 1.50 | 2.00 | 9.16 |
| | | | Correct use, intuitive and friendly | 2.93 | 1.00 | 1.00 | 2.93 |
| | | | auto aperture | 3.14 | 1.00 | 1.00 | 3.14 |
| | | | That has low maintenance | 2.58 | 1.50 | 1.00 | 3.15 |
| | | | With appearance of cleanliness and hygiene | 2.84 | 1.50 | 2.00 | 4.92 |
| | Technical Performance | 13.52 | Need to keep a person overseeing the system to support and assist in controlling | 3.11 | 1.00 | 1.50 | 3.81 |
| | | | Low incidence of failures / locking in passing | 2.37 | 1.00 | 1.00 | 2.37 |
| | | | Fast decoding of identification | 3.07 | 1.50 | 2.00 | 5.31 |
| | | | Dispense the use of identification devices that need to be searched (like cards, documents ...) | 3.13 | 1.00 | 1.50 | 3.84 |
| | | | Facilitating the access of frequent users | 2.57 | 2.00 | 1.50 | 4.46 |

From the split tree quality, can proceed to the other matrices adapted Ribeiro et al. (2001). Figure 1 shows the model matrices original Ribeiro et al. (2001) and their arrangement, explaining the order of the matrices used in this paper and also the matrix that was discarded in this application (matrix of process parameters).

## 4.1 Quality Matrix

The index Mi pointed out that the analyze is below the competition in meeting the demands for a system that uses cards / tickets with longer life, enabling the reuse without discarding; ergonomic system that facilitates the passage of the body and objects that the user I can carry, with low maintenance and automatic opening; system with fewer failures and less prone to fraud. A strategic assessment (Ei) associated with competitive evaluation (Mi) helps to identify future trends, which may direct the behavior of the company in relation to its market (Ribeiro et al., 2001). Among the points very critical stand out that may serve as competitive differentiators know if the company developing them in their production process. They are: exemption from use of identification with each access and identification of frequent users.

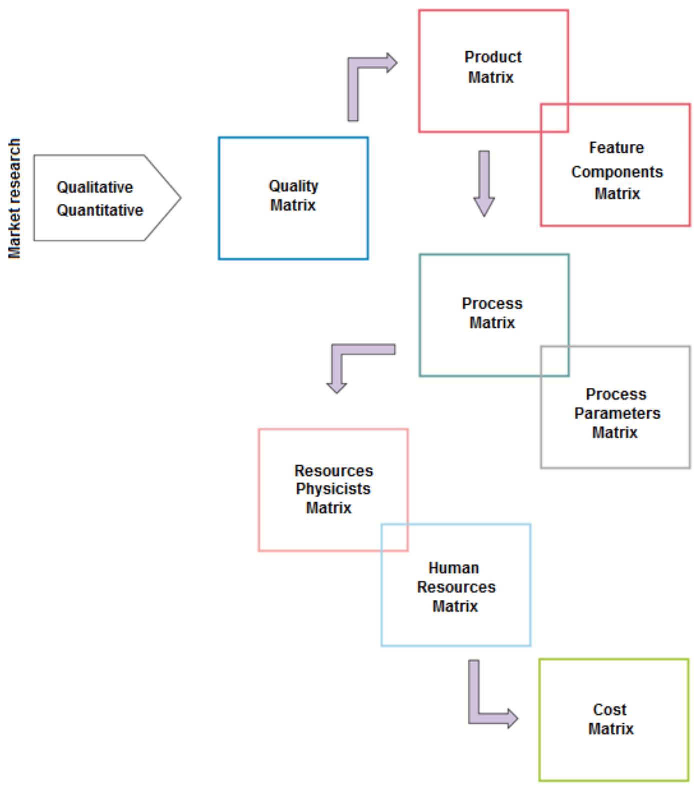


*Figure 1. Conceptual model of QFD method proposed by Ribeiro et al. (2001)*

## 4.2 Product Matrix

The matrix product is then derived in the matrix of parts, where it's possible to view features to be controlled in critical parts. Were considered 'characteristics of the parts' to the ratchet on analysis: cards per minute voltage (v) megabytes of software processing by the second, mobile part of the mass (Kg) of the movable part area ($m^2$), length of the movable part (m) angle of the fixed mass (kg), the fixed area ($m^2$) of the fixed part height (m), diameter ($m^2$). Of these, the first three should be prioritized.

## 4.3 Process Matrix

The matrix shows which process the importance of each step in the production of access control. This importance is calculated with the same formula of importance of the parties, the matrix product, considering each 'process i'. The prioritization process occurs similarly. Were considered important processes: planning product development, software development, electronic circuit mount, prepare materials for construction of metal parts, fabricate fixed part, making mobile part, ratchet mount, test operation of the access control set up, clean up access control, to inspect the product, the packaging, shipping the product.

Among these, the process priority to meet the quality characteristics of software development is followed by the stage of planning the development of access control. The less relevant step is the process of shipment.

## 4.4 Resources Matrix

In the human resources matrix were listed the following human resources involved in the production of access control: product engineer, process engineer, quality engineer, operator, mechanical, electronic operator, operations supervisor, maintenance supervisor, production assistant. We identified the required quantity of each resource, as well as salary and of each class. We estimated what is the percentage of time that the employee is directly involved in the process. Companies that produce different products can have people working on various projects, devoting himself to the project partially analyzed by QFD.

Similarly, the physical resources matrix initially lists all of the physical resources needed for the process of developing and producing an access control checking the cost of equipment, depreciation time, the percentage of usage time devoted to this process, costs of operation and maintenance. The laboratory R&D is the most important physical feature of this process, then followed the test lab and the lab of electronics assembly.

### 4.5 Cost Matrix

The process is more cost productive mounting the turnstile, followed by fabrication of the moving part and the fixed part. Lower value-added processes showed lower cost as cleaning, inspection and packaging, which points to a balance in the use of productive resources in the current situation.

## 5 CONCLUSION

This paper presented a proposed review of the development of an access control based on the application of quality function deployment considering environmental parameters. In this scenario, the study demonstrates the adaptability of the tool in QFD survey of requirements in relation to controlling access by users and includes the development of these controls with manufacturers considering an environmental perspective in the process of product development for the electronics industry. Exploratory research conducted with the company through qualitative interviews with production managers and customers with these systems served to raise the system characteristics, allowing the knowledge of the same. Similarly, quantitative data extracted with users allowed to make the quality function deployment, ensuring that items perceived as most important by customers were prioritized product development.

In view of the limitations observed conclude that current production methods of access control industry surveyed do not consider environmental parameters. With the result of the application of this tool were obtained major prioritization criteria, resulting in better match customer needs, which may result in greater acceptance of the system by themselves.

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