CLIENT REQUIREMENTS PROCESSING IN LOW-INCOME HOUSE-BUILDING USING VISUAL DISPLAYS AND THE HOUSE OF QUALITY

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ABSTRACT

Several studies have pointed out the importance of client requirement processing and the difficulties of implementing it in the construction industry due to the complex nature of its products. In Brazil, new forms of housing provision have resulted in innovations on the relationship between governmental and non-governmental organizations and the final users, resulting in a complex net of interests. In the low-income housing sector, the final users rarely take part directly in the product development process and for this reason their needs and requirements in general are not properly considered by the design team. This demands radical changes on the way the product development process is managed. This paper presents a case study on the management of requirements in the Residential Leasing Program, currently one of the most important programs for low-income housing provision in Brazil. The study emphasizes the task of processing client requirements in this context based on visual displays development and on the house of quality adaptation. Visual displays and tools are used to support requirements data processing and analysis, including the partial application of quality function deployment (QFD). Based on this discussion, the limitations and benefits of the proposed tools for requirement processing in the context of low-income housing are pointed out, considering the peculiarities of this product in terms of value generation.

KEY WORDS

requirements processing, low-income house-building, client satisfaction, visual displays, house of quality, quality function deployment

INTRODUCTION

Low-income housing has been a topic of great economic and social importance in Brazil. For this reason, it has been one of the main focus of attention by the academic community in this country.

The role of the state in the provision of low cost housing has suffered major changes worldwide. As it has happened in other countries (Barlow and Ozaki 2000), in Brazil the state is reducing its role as a direct developer or client in the construction industry, and has been increasingly

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assuming an enabling role, partly due the lack of resources for investments (Keivani et al. 2004).

Nowadays, the development of a low cost housing project involves a large number of stakeholders and a wide range of disciplines, resulting in the need of managing requirement conflicts and trade-offs. The level of integration among those stakeholders and the relationship among them have a strong impact on the outcomes of housing provision (Werna et al. 2004). This has led to growing financial, regulatory, environmental, social and technical complexity, mostly due to the fact that the promotion of social housing projects is now highly decentralized in Brazil (Keivani et al. 2004). For this reason, there is a need for devising innovative approaches for managing the product development process in low cost housing projects, especially regarding value generation.

Compared to other products, housing projects have long life cycles, and a wide range of client requirements is involved. Due to the increasing complexity of product development in the construction industry, more effort should be spent on clients requirements management, including capturing client requirements, making them explicitly available for the product development team, and controlling whether the requirements of different stakeholders have been properly balanced (Bailetti and Litva 1995, Huovila and Serén 1998, Barrett et al. 1999, Koskela 2000, Kamara et al. 2002, Shen et al. 2004). Such tasks can potentially result in a better definition of possible design solutions, consequently increasing the perceived value by the client, without increasing costs in the same proportion. Simultaneously, a major challenge for a designer is to define the best solution to meet the client's needs considering all parts represented by the client, specially the final client (Kamara et al. 1999).

Research on client requirements management related to the building industry has mostly emphasized the brief-taking process or is focused on the use of specific tools, such as quality function deployment (QFD). Improving client requirements management is particularly important in social housing due to the need of maximizing value, under existing cost constraints. Requirement can be defined as functions, attributes and others characteristics of the product or service required by the client (Kamara et al. 2000a). Client requirements management involves the control and refinement of the requirements while the product is developed (Bruce and Cooper 2000). These tasks can potentially result in a better definition of possible design solutions, consequently increasing the perceived value by the client.

The quality of a design solution depends on whether it meets the client's needs. Therefore, much attention should be given to information related to the needs and expectations of the final client (Kamara et al. 1999). This information often needs some kind of processing to ensure that it is presented in a form that enhances adequate understanding of what the client desires (Kamara et al. 2000b). Client requirements processing consists of making available information in a suitable format to support the decision making in a product development process (PDP). It involves the identification, structuring, analysis, rationalization, and translation of explicit and implicit

requirements into design specifications (Kamara et al. 2000a).

The importance of client requirements processing in construction arises from various factors (Kamara et al. 2000a): clients usually find it difficult to make their requirements explicit; there are several categories of clients in the project; the need to consider both client and other project requirements; and the need of integrating the work of different product development professionals.

This paper describes the main results of a research project which aimed to devise a protocol for client requirements processing in low cost housing projects. It was based on a study carried out in the Residential Leasing Program (PAR – Programa de Arrendamento Residencial). This housing provision program was chosen because it is currently one of the most important initiatives for low-income families in Brazil, and represents well the growing complexity that exists in social housing, as discussed above. Nearly one million people in Brazil have been assisted by this program in Brazil since 2000.

BRIEF DESCRIPTION OF THE PAR PROGRAM

In the PAR program, a project starts when a construction company decides to develop and build the project. This company finds a suitable land plot and proposes a scheme design that is submitted to the assessment of the National Savings Bank. If the project receives a preliminary approval by the Bank, the design is completed and submitted to the analysis of the local government housing department. The local government is usually responsible for enrolling potential dwellers, identifying whether there is demand for that kind of project. If the project is approved by the housing department and there a high potential demand for the project, a contract is signed between the National Savings Bank and the construction company.

The production stage typically lasts for twelve months. The construction company builds the project and the Bank technical staff monitors both the quality and the duration of the project usually through weekly site visits. This project control tends to be fairly strict since the Bank plays the role of project owner. Towards the end of the project the selection of users is jointly carried out by the local authority and the Bank – the former is responsible for establishing priority criteria for selecting leasers.

Once the dwellers are known, the social work project starts, aiming to create a community attitude among them, since they will live together (some for the first time) in a condominium. At the end of the production stage, the project is initially delivered to the National Savings Bank. After final inspection, the dwelling units are then delivered to tenants. After living in the housing development for 15 years, the tenants will become owners of the units. During the 15 year leasing period, the National Savings Bank hires a facilities management company that will take care of the estate.

RESEARCH METHOD

Multiple case studies were carried out on nine low-income house-building projects, developed in the South of Brazil. Data on clients' requirements were captured in 2004 and 2005. The research project was divided into three main stages, which correspond to three stages of requirements processing:

identification, analysis and structuring of requirements, based on data collected directly from final users; weighing requirements based on the perception of other project stakeholders; and translation of requirements on product attributes, using a QFD matrix.

Multiple sources of evidence were used in those studies, such as a questionnaire with final users, direct observation of housing estates, and interviews with both specialists on this topic and professionals involved in the product development process. The questionnaire included an evaluation of the user satisfaction through closed questions and the application of the critical incident technique.

The first stage was strongly based on the iterative model proposed by Miles and Huberman (1994) for qualitative data analysis. In this model, data analysis is divided into three activities that establish a continuous and iterative cyclic process: data reduction, visual displays, and conclusion drawings and verification. Data reduction refers to the process of selecting, focusing, simplifying, abstracting and the transforming extensive qualitative data (Miles and Huberman 1994). A visual display is an organized framework of information that helps to understand qualitative data and allows checking the need to further process and to analyse data (Miles and Huberman 1994). Visual displays were the main resource used in this study for requirements processing.

In the second stage of requirements processing, a questionnaire was answered by a number of experienced construction professionals that have been previously involved in the product development process of PAR projects: designers and managers from construction companies involved in the development of the project; technical staff from the Brazilian Public Savings Bank in charge of design analysis and approval; facility managers that were in charge of housing estates after delivery; and social workers hired by the Bank that had the role of supporting the adaptation of the new leasers to the condominium.

The aim of this questionnaire was to capture the priorities and constraints of different stakeholders in the product development process, as well as to identify their perceptions on the user requirements. A group of academics was also asked to fill a questionnaire, in which they were asked to compare the PAR programme to other housing programmes in terms of fulfilment of user requirements. All those academics had previous experience in undertaking post-occupancy evaluation studies on low cost housing projects. Based on the questionnaires a set of weighs was produced so that the perceptions of the users and the priorities and constraints of some construction organizations could be jointly considered.

In the third stage of the study, the first QFD matrix, named the house of quality, was produced. Previous studies (Chan and Wu, 2002, 2003) have indicated that this matrix is useful for guiding the design process, since it connects the demanded quality and quality characteristics (Miguel 2005).

RESULTS

FIRST STAGE

The initial qualitative data processing involved the following steps: individual analysis of each project, joint analysis of the set of projects, and final grouping.

The individual analysis aims to organize the data of each project in an initial hierarchy and to standardize the language used in the critical incident technique. The analysis was developed in three steps, as showed in figure 1:

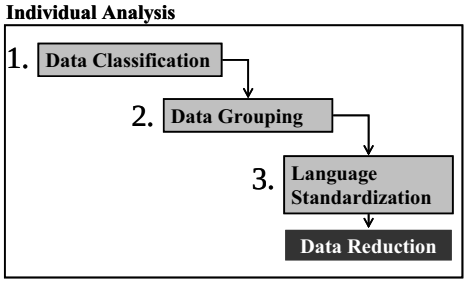

Figure 1: Steps for individual analysis

In the data classification the positives and negatives points from the critical incident technique were initially classified in categories, based on similarities. Data kept the same language expressed by the users. In the next step the data were grouped in categories for each project. Positive and negative critical points were grouped in two levels, primary and secondary. This step of processing resulted in a first hierarchical framework of critical points. This hierarchical framework can be understood as a representation generated from the preliminary steps of data classification, grouping and ordering that are organized and disposed according a hierarchical principle. The last step was the language standardization. Considering that often the same critical points are mentioned using a different language data was reduced by using a unique language. The main result of this processing was the reduction from 824 to 68 positives critical points and from 590 to 124 negatives critical points. The reduction of the negative data was smaller because the critical points tend to be more specific than positive critical points.

Joint analysis was divided into two steps: (a) classification and ordering positive and negative critical points; and (b) grouping critical points into a matrix, as shown in figure 2. Ordering means a data arrangement that depends on a pre-determined attribute.

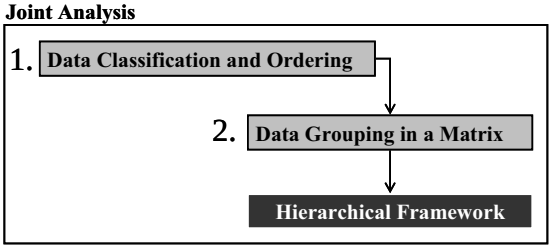

Figure 2: Steps for joint analysis

In this case, ordering was established considering the importance as the main criteria. The importance was measured according to the number of critical points mentioned by the users. This step was necessary because the critical points still were presenting characteristics with different levels of specificity, in both positive and negative points. Then, critical points were classified and ordered in a logical tree. Through this processing, a hierarchical framework was created presenting in an ordered form all critical points, and the relationships among themselves. This processing makes it clear the relationship between specific and broader critical points.

Afterwards, a matrix type visual display was created, including data from all nine projects. Such matrix provided in a single display, a visualization of key information that could be used to do a joint analysis of nine projects, including comparisons between them and between project attributes. In fact, two matrixes were produced, one for positive and another for negative points. Part of the matrix of negative points is presented in figure 3.

Critical negative points										
Number of interviews	**26**	**32**	**32**	**39**	**25**	**23**	**74**	**33**	**14**	**298**
Projects	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**Nº**
Service of Facility Management Company	**11**	**3**	**5**	**20**	**11**	**7**	**43**	**23**	**16**	**139**
Bad Facility Management Company	3	1	4	1	4	1	8	4	3	**29**
Disorganized Facility Management Company						1	6	2		**9**
Bad service of Facility Management Company		1	1							**2**
Lack of preventive maintenance					1		1		1	**3**
Lack of elevators maintenance				13					3	**16**
Lack of water systems maintenance				1					2	**3**
Unsupervised maintenance					1					**1**
Lack of gas system maintenance				1						**1**
Bad service of Construction Company						1				**1**
Delays on services providing						2	4		3	**9**
Dirt around the condominium				1	1		3	1		**6**
High cost of condominium	4	1					8	10		**23**
High cost of water							2			**2**
Payment for the use of the community room								1		**1**
High cost of security								1		**1**
Bad communication of Facility Management Company							1	1		**2**
Difficult to contact the facility manager				1		1	2	1	1	**6**
Condominium meetings are not effective							2			**2**
Bad communication among employees									1	**1**
Inappropriate time for meetings							1			**1**
Accounts provision is not clear	1						1	1	2	**5**
Lack of interest from the Facility Management Company					3	1	2			**6**
Lack of interest by employees				1	1		2	1		**5**
Facility Management Company is not effective	3			1						**4**

Figure 3: Visual display of the Facility Manager Company Services (negative points)

Final grouping consisted of grouping the critical points as a tree to be used on the house of quality. Such a tree allows visualizing user requirements in a hierarchical framework that can include tertiary, secondary and primary levels (Ribeiro et al. 2001). In this study, the positive and negative data were grouped together in the same framework considering some recommendations: the complaints and negative qualities were transformed

into positives qualities; the logical tree had to be balanced, i.e. the number of tertiary items associated to each secondary item had to be similar; and there should not be any overlapping between items.

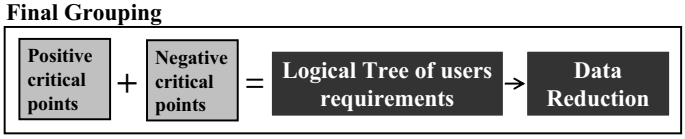

Figure 4: Final grouping scheme

The logical tree of user requirements allowed data on positive and negative critical points to be merged. Such processing is important to understand the main failures and successes related to the PAR projects. According to Hayes (1998), positive critical points are related to the client satisfaction, or what the client would like to find in a service or product to be delivered. Negative critical points can be considered as opportunities of improvement, because they indicate characteristics of the requirements that cause dissatisfaction and in general result complaints. Some opportunities of improving are related to design decisions that may result in an increase in the cost for the financial agent. Often, this improvement could not be made in the product because this type of project is subsidizes by public funds. In this case, is important to understand the real value that this improvement for the client. According to Saliba and Fisher (2000) the client's perception of value is related to the ratio between the benefits perceived in a product and the sacrifices that are necessary due to its acquisition and use. The figure 5 shows part of the requirements grouping.

Positive critical points		Negative critical points		Logical tree of user requirements	
Good location	Pleasant place	Bad location	Unpleasant place	Good location	Pleasant place
	Easy access to public transport		Difficult to access the public transport		Easy access to public transport
	Easy access to welfare services		Difficult to access welfare services		Easy access to welfare services
	Easy access to shops		Difficult to access the shops		Easy access to shops
	X		External noise		Little external noise
Good experience in condominium	Good neighbours	Bad experience in condominium	X	Good experience in condominium	Good relationship between neighbours
	Fulfillment of condominium rules		Condominium rules not fulfilled		Fulfillment of condominium rules
	X		Noise from neighbours		Less noise from neighbours
	Good organization between dwellers		Desorganized dwellers		Good organization between dwellers
	Good condominium space		Bad condominium space		Good condominium space
	Pleasant environment		Unpleasant environment		Pleasant environment
Security	Fenced condominium	Insecurity	Absence of wall	Security	Fenced condominium with walls
	24 hours guardhouse		Bad location of the guardhouse		24 hours guardhouse well located
	X		Insecurity neighbourhood		Security neighbourhood
	Good intercom		Bad intercom		Good intercom

Figure 5: part of the final grouping (location, experience in condominium & security)

CONSTRUCTION OF THE HOUSE OF QUALITY

The construction of the house of quality was divided into six steps (figure 6): (1) user requirements definition; (2) product attributes definition; (3) identifying the relationship between user requirements and product attributes; (4) user requirements prioritising; (5) identifying the relationships between product attributes; and (6) establishing the importance of product attributes.

This process required some adaptation due to the peculiarities of low-income housing projects.

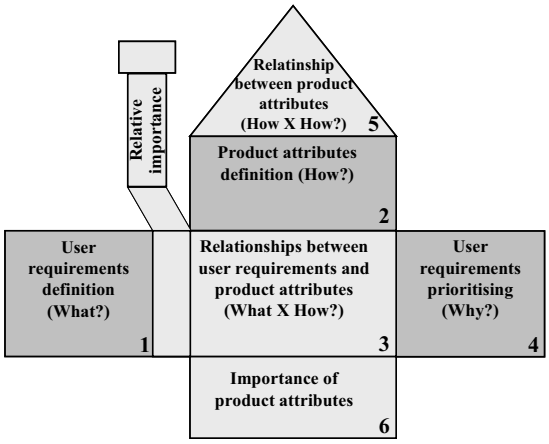

Figure 6: House of quality scheme

The first step of this matrix considered the requirements classified in the logical tree developed in the previous stage of this research. The definition of user requirements should allow the selection of measured characteristic and their importance. However, this task was difficult to be executed due to the lack of evidences from the literature. Moreover, some key requirements may be lost if they are not translated into a measurable characteristic, though all demanded qualities had been collected (Akao 1996). This seems to be an important gap in knowledge that needs to be explored by future research.

This second step was also based on the user perception. For each client requirement, the original critical points were analyzed in order to identify needs that could be measured. The need for guidelines to define attributes was identified considering the lack of sources to establish its definition in construction. Moreover, in the establishment of the product attributes it is also difficult to define what is possible and easy to measure in practice.

The third step was the application of the geometric progression as suggested by Kamara et al. (1999). Each product attribute that had a strong relationship to a client requirement received a score 9, for a medium relationship score 3, and for a weak relationship score 1. The construction of this matrix was very time consuming due to the large number of possible relationships. This step allowed the identification of the attributes that affect the user requirements and the intensity of this

relationship. One attribute can establish relationship to several requirements, and also some attributes can be related to only one requirement. Therefore, more then one row or column should be affected, resulting in a matrix that may be densely populated (Prasad 1998). The establishment of those relationships is important for the house of quality, because they influence the prioritization of product attributes. The stronger the relationships to attributes the higher their importance.

Step four involves the integration of the agents' perception in the user requirements evaluation, which may create new priorities. At this stage, some changes were made in concepts and procedures that are usually adopted in QFD. Firstly, the competitive evaluation was changed in this research for comparative evaluation, since in low-income housing projects the focus is not market competition but to offer an adequate product for people with limited financial resources. For this reason, comparisons between PAR projects and others low-income housing projects were made based on the perceptions of academics. In the strategic evaluation, the perceptions of Bank technical staff and construction professionals were considered. They analyzed the importance of each factor considering their company strategies. Regarding facility managers and social workers, although they have no participation in product development, their perception was considered in the strategic evaluation because of their participation in the building operation phase of those projects. The main result of this step was a set of weights from the strategic and comparative evaluation of the agents involved in the product development process, resulting in a new classification of the requirements importance.

The relationship between product attributes was defined using the symbology proposed by Ribeiro et al. (2001). This helps in the decision making process, since it is identified how each attribute differs from others. Based on this, during product development the professionals can have a broader control in the decision making because the choice for one or other attribute is based on a systematic analysis.

The final step consists simply on the prioritisation of the product attributes. It considers the relationships between those and the client requirements and also the relative importance of these later. The main result of this step is the prioritisation of product attributes, based on the development of the house of quality.

CONCLUSIONS

The main result of this study was a protocol for processing client requirements in low-cost housing projects. Data directly obtained from users and also from professionals involved in the product development process, and academics were processed separately and jointly using a QFD house of quality.

User requirements processing allowed a refinement of qualitative data, collected through the critical incident technique. At this stage, information on user requirements were classified, grouped, ordered and organized in a hierarchical form to provide a broader understanding of user needs and preferences. The use of visual displays allowed the reduction and the visualization of data in order to facilitate the systemic analysis of

existing qualitative data. Data reduction in this study was used, but adopting a different perspective, compared to positivist research. The conclusions were not drawn only from the reduced data, but from crossing this information with the qualitative data available. Moreover, this processing provided the necessary preparation of data to be used in the house of quality.

The application of the house of quality provided an opportunity for adapting this requirement processing tool for the context of low-income housing building projects. The study pointed out the benefits of the information provided in each processing step of and also the main difficulties and limitations in using QFD in low cost housing. A major difficulty faced in this study was the lack of sources for translating qualitative data in measurable attributes. According to the literature, this demands much effort of analysis (Sommerville and Craig 2002, Dikmen et al. 2005). Moreover, it was difficult to get members of product development teams to help in all processing steps that are necessary for producing the matrix. In fact, QFD is a tool that requires the participation of a multidisciplinary team operating along all planning of the matrix (Eldin and Hikle 2003). By contrast, the participation of stakeholders was very fragmented.

Another difficulty related to the application of the house of quality is its large size, and the time spent in producing it (Tan; Pawitra, 2001; Dikmen et al. 2005). The larger the number of user requirements and product attributes that are inserted in the matrix, the greater the complexity and time required for its development. Nevertheless, in the construction sector generally the clients' needs and requirements are not treated in a systematically way: there is a lack of integration between the involved parts and a lack of attention given to clients needs (Dikmen et al. 2005). The use of the house of quality allows a systematic way of processing client requirements in this context.

However, it is clear that further studies are needed, such as: (a) develop visual displays to integrate data from different sources, customer satisfaction surveys, and users complaints; (b) investigate further the demand for client requirement information by key decision-makers in the product development process; (c) devise and improve tools for collecting more suitable data for the application of the house of quality; (d) carry out studies for full application of QFD, extending the understanding about its application in the context of social housing.

ACKNOWLEDGEMENTS

Thanks to FINEP - Programa Habitare and CNPq for the financial support and to the public and private organisations that have been partners in this study.

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