APPLICATION OF A MODEL OF DESIGN PROCESS FEEDBACK FROM MEASUREMENT OF CUSTOMER SATISFACTION

Paula Lima Sombra [1], Neliza Maria Silva e Romcy [2], Juliana C. Schlachter Sampaio[3], José de Paula Barros Neto[4]

ABSTRACT

Sampaio (2010) proposes a theoretical model of design feedback, which helps to process the data collected in satisfaction surveys, through the integration and simplification of tools to support decision making for manufacturing.

This paper aims to apply this model and provide the analysis and discussion of its feasibility, as well as propose changes to its improvement. It describes the application of the theoretical model of Sampaio (2010) through a case study, which enabled the registration of the process and its discussion.

The feedback model proposed by Sampaio was verified, as well as the systematic analysis of data collected from a satisfaction survey, and its transformation into design parameters. As some practical limitations were found, a simplification in the theoretical model was proposed. Therefore, it contributed to the reduction of activities, which do not add value to the final product, according to the lean thinking.

The use of the simplified model provides benefits to companies and customers, as it gives support to generate better products, which increases user satisfaction and enhances the acceptance to new projects.

KEY WORDS

Design process, feedback, tools, value.

INTRODUCTION

The literature points out the importance of the incorporation of data from satisfaction surveys on new designs and the need for proposals that contribute to the systematization of this feedback (Orstein 2008).

Besides, it is important to consider the role that the project has on the entire lifecycle of the built environment, from production to use, and to recognize the construction industry as a strategic element to the success of the projects, since it influences all subsequent steps (Bertezini and Melhado 2005). As the first step of the process, and the point in which important decisions take place, mistakes and shortcomings that emerge at this time tend to echo in construction, use, and especially in customer satisfaction.

[1] Architect and Master of Engineering from the Civil Engineering Post Graduation Program, Structure and Civil Constructions, Universidade Federal do Ceará, Brazil. paulasombra@yahoo.com.br

[2] Architect and Master of Engineering from the Civil Engineering Post Graduation Program, Structure and Civil Constructions, Universidade Federal do Ceará, Brazil. neliza.romcy@gmail.com

[3] Architect and Master of Engineering from the Civil Engineering Post Graduation Program, Structure and Civil Constructions, Universidade Federal do Ceará, Brazil. julianaschlachter@yahoo.com.br

[4] Ph.D Professor from the Civil Construction and Structure Engineering Department, Universidade Federal do Ceará, Brazil. jpbarros@ufc.br

However, despite its importance, the design process is rarely addressed according to the lean philosophy, which considers it a strategic opportunity to add value to the final product. As an example, Koskela (2002) highlights the lack of a systematic planning and a ineffective management of the project's value from the standpoint of the end customer.

The design-construction-use sequence should not be considered as a linear procedure, but a continuous cycle. Thus, the value generation is not exhausted in a single sequence, but it enhances through new experiences. Since the feedback becomes a practice carried out by the developer, the end customers tend to become more satisfied. The search for continuous improvement, therefore, must become a primary objective of these developers.

Womack (2002) includes the specification of the value desired by the customer and the management towards perfection (Kaizen) among the five key guiding principles of the lean thinking. Whelton and Ballard (2003) point out that without proper understanding of what customers try to achieve, designs are not likely to meet those needs. The authors also explain that the stakeholder values and their value judgments are the dominant influence on how to purpose transitions from needs to requirements, affecting the way customer needs are construed and represented.

Even with the consideration of its importance, it is clear that the potential of data collected in satisfaction surveys have not always been consistently used in the feedback process for new projects. In the housing market, the interest in the satisfaction ratings is induced only by quality management programs, which companies undergo.

Looking forward to enable the incorporation of clients' needs information in a more systematic way and to support exploratory activities of the initial stages of the project, some researchers have demonstrated how the use of tools to support decision making, originating from the manufacturing industry, can be used in the design process for construction (Gondim 2007, Kiatake 2004, Lima 2007, Monica and Supplies 2004). The use of these tools, however, has limitations.

Sampaio (2010) sought to integrate and simplify the use of some tools to support decision making by the establishment of a theoretical model that helps to process satisfaction information from assessments carried out in real estate projects. The use of this model by the designers enables the supply chain feedback and creates value for the final client.

This paper, therefore, aims at apply this model, enabling the analysis and discussion of its feasibility, its advantages and limitations, and, finally, proposes changes to its completion. However, the present research must be considered an exploratory study (Stebbins 2001) as that's the first practical application of the model. Thus, future studies are required for its final validation.

THE FEEDBACK MODEL

DECISION-MAKING TOOLS

The feedback model has, as an initial condition, the selection of clients' needs that have been considered insufficient, in satisfaction surveys, and their subsequent transformation into new design parameters. These, therefore, can be incorporated in the development process of new products, allowing the feedback of the production chain (Sampaio 2010).

According to the general scope of the model, some tools to support decision-making, of which attributes could be applied in the model, have been selected and analyzed. The positive and negative aspects of each tool and its feasibility on the context established were considered the criteria for this analysis.

Thus, four tools were used in the final feedback model presented here. The first, the affinity diagram, groups verbal information into classes based on their affinities and aims to

facilitate the acquisition of new information (Cruz Júnior and Carvalho 2003). It is used in the model to separate the user's needs in affinity groups, which facilitated the organization for further analysis.

The hierarchical analysis process (AHP), considered a method to support multi-criteria decision making (MCDM), allows the pair wise comparison between alternatives according to specific criteria defined by the evaluators. In the model, it is used in the unsatisfactory needs prioritization, allowing the classification according to the importance and setting the order in which they shall be discussed by the designers.

The methodology of axiomatic design (AD) enables the systematization of the design process and considers it as a continuous relationship between "what is the purpose they want to reach" and "how to achieve these goals" (Suh 1998). Thus, it contributes to the understanding of the problems and clarifies the critical aspects in points in which a conflict occur between the parts of the system. In the model, this tool is used to define the new design parameters, defined from the unsatisfactory needs.

Finally, the quality function deployment (QFD) helps to identify and prioritize the customers´ needs and covert them into product characteristics. The model includes a matrix called House of Quality[5], through which the relations between customer's needs, identified in the satisfaction survey, and design parameters are verified. Thus, it becomes possible to check the interferences that might exist among them.

The critique about the application of these tools was established during the development of the theoretical model (Sampaio 2010, Sampaio and Barros Neto 2010).

MODEL APPLICATION

The theoretical feedback model consists of five sequential steps (Fig. 01), performed in order to allow a systematic discussion about the client´s needs at the first stage of the design process - product design.

Next, each of these steps will be presented for a better understanding of the process (Sampaio 2010):

1. Definition of customer needs from the satisfaction evaluations´ results: the satisfaction evaluations´ results, performed in a similar typology compared to the building being designed, are analyzed and evaluated. Then, each requirement is listed under satisfactory rating, neutral or unsatisfactory, for further analysis;

2. Classification of customers' needs under primary, secondary and tertiary, using the affinity diagram: the customers' needs are listed and written in colored data cards, magenta for the unsatisfactory ones, yellow for neutral and green for satisfactory (tertiary needs). Later, the cards are put together according to the similarities between them, forming the so-called affinity groups (secondary needs). Finally, the affinity groups are combined into broader groups, which are again entitled (primary needs).

3. Prioritization of unsatisfied needs with the help of AHP, the criteria (attributes) for prioritization are defined by the designers and compared to verify the relation of importance among them. Subsequently, the unsatisfied needs are prioritized according to each criterion to finally be compared to the criteria themselves. The results from the prioritization define the order in which the discussion occurs about the needs, but all should be assessed.

[5] The house of quality is obtained by crossing the table of customer requirements (or quality demanded) to the table of quality characteristics (Akao, 1990).

4. Transformation of the unsatisfactory needs into design parameters through the concepts of AD: the unsatisfied needs from the clients are opposed to the functional requirements and design parameters, which must be defined by indicating solutions by designers. After consensus on solutions, the forms for each specific need may be filled.

5. Interference evaluation, both positive and negative, between the client's needs and the design parameters through the house of quality: the house of quality is filled with the design parameters defined in the previous step and with all requirements found in step 1, grouped according to the affinity diagram in step 2. The interference between the new parameters and customer requirements are checked and marked. Green for positive interference, lack of interference yellow and red for negative interference.

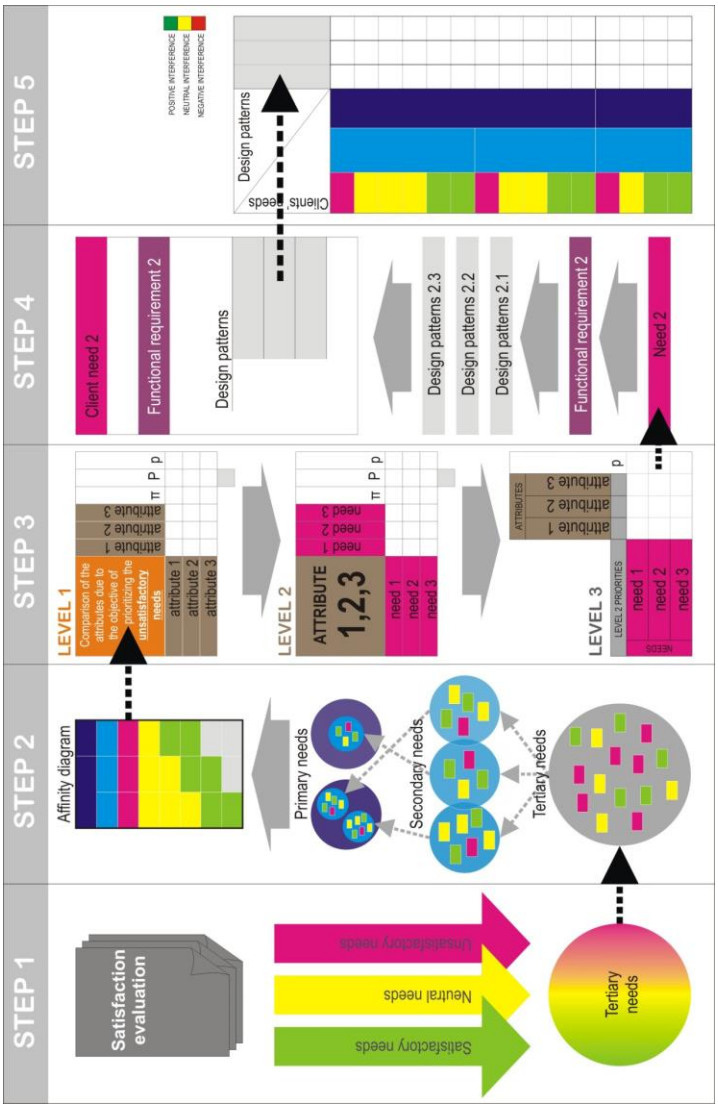

Figure 1. Relation among the five steps of the third version of the model
Source: Sampaio and Barros Neto, 2010.

CASE STUDY

The application of the model was conducted out of a satisfaction survey, developed by the Research and Advisement Group in Civil Construction Management (GERCON) of Universidade Federal do Ceará, Brazil. The satisfaction survey referred to two real estate ventures of a builder in the city of Fortaleza (Brazil), directed to the audience of upper middle class.

After the analysis of the the research data from the survey, two architects performed the application of the model with the architectural firm responsible for both projects and the designers form the construction firm that had executed the towers.

The A project included two apartment towers with 23 floors each, for a total of 184 units, with private area in order of 80m². The recreation area was common to both towers, including ports court, pool, sauna, gym, games room, four independent parties environments with bar and grill, plus a jogging track.

The B project consisted of one apartment tower, also with 23 floors, having a total of 23 units, with private area of 297.70m². The recreation area was made up of party room, sports court and games room and gym.

The following will describe how each step proposed by the model was applied.

DEFINITION OF THE CLIENTS' NEEDS FROM THE SATISFACTION SURVEY RESULTS

After the analysis of the chosen satisfaction surveys, all the customers' needs were listed in order to be classified as satisfactory, unsatisfactory or neutral. An adaptation of the classification criteria was required due to the fact that the satisfaction survey was not developed aiming a further application of the model and had established their own tools to collect and analyze the data.

The data collection tool used in the satisfaction survey was a questionnaire of satisfaction versus importance, which addressed various aspects of housing, in a total of 33 items, ranging from the common areas of condominium to the proper aspects of the housing unit. Each item should be evaluated by the user, with a score from 0 to 10, according to its level of satisfaction and its level of importance, separately.

Based on these data, satisfaction versus importance matrices (Fig. 02) were established, relating the level of customers' satisfaction about a particular item with the degree of importance considered by them.

Such matrices of satisfaction versus importance were used for the classification of clients' needs, establishing the following criteria: 1. Unsatisfactory needs - high importance scores and low satisfaction scores, 2. Satisfactory needs – high scores for both importance and satisfaction aspects, 3. Neutral needs - low importance scores, regardless the satisfaction scores.

Thus, all needs were listed and ranked in both ventures and resulted in a total of eight unsatisfactory needs, 25 satisfactory needs and no neutral need, since all of them had high importance scores and the satisfaction scores varied.

It is noteworthy that, in cases in which an specific need didn´t present the same classification in both ventures, it was considered as an unsatisfactory one, in order to make possible the discussion at a later stage.

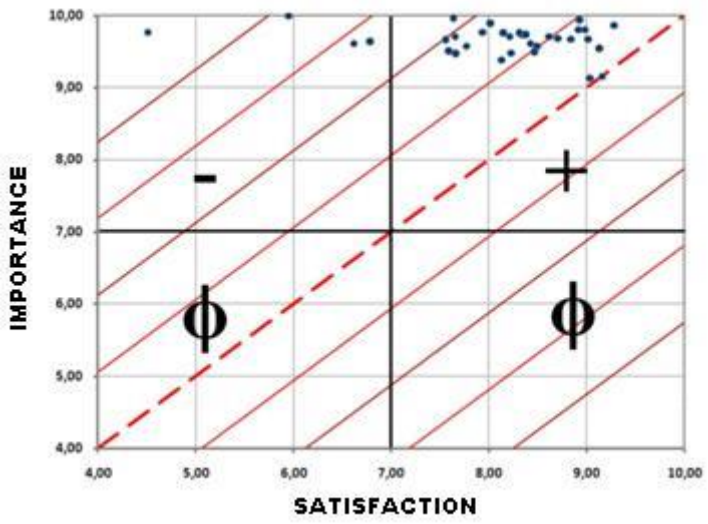

Fig. 02. Satisfaction x Importance matrix
Source: Adapted from the satisfaction survey (GERCON, 2010).

AFFINITIES DIAGRAM GENERATION FROM DEPLOYMENT OF NEEDS IN PRIMARY, SECONDARY AND TERTIARY

The requirements listed previously that were considered tertiary, according to the classification model, were written on data cards with specific colors, grouped according to their affinities. It is noteworthy that there were no neutral needs. This step was followed exactly as presented in the original theoretical model.

UNSATISFYING NEEDS PRIORITIZATION

In order to prioritize the unsatisfied needs for further discussion, the model proposes the application of AHP tool.

In the application proposed by Sampaio (2010), the prioritization criteria were the number of citations (in how many projects that specific need was considered unsatisfactory), the existence of a reason (available data to qualify the need as unsatisfactory) and interference with other affinity groups (if the unsatisfactory need already had negative relationship with other affinities).

Again, the need to adapt the prioritization criteria to become adequate to the analysis tools used in the satisfaction research became evident. As an example, there was no record of justification on the needs and, therefore, it was not possible to differentiate them according to this criterion.

Further, during the application of the AHP tool in the existing data, negative aspects were found, such as time consumption and increased complexity. As causes of this complexity, it can be pointed out the possibility of excess criteria, paired comparisons, calculations and generation of arrays for the establishment of weights among the criteria. Another aspect is the fact that the tool is not commonly used by designers and, confirming that statement, the architects who applied the model had no previous knowledge about it.

The knowledge that the prioritization phase should only establish the order of discussion for the unsatisfactory needs, not being used for elimination, it is clear that the proposition of a more simplified procedure would allow optimization of time, which could be used in further evaluation and generation of design parameters, which demands a larger debate.

Thus, to replace the AHP tool, it was proposed a new criterion for prioritization, one of the analytical instruments used in the satisfaction survey: the delta value calculated from the

subtraction between the satisfaction and the importance scores, included in the matrix. Therefore, items of more negative values, which represent less satisfaction and a great importance to the client, should have higher priority for discussion. Another criterion considered was the repetition of the same item as unsatisfactory in both projects, since they represent recurring problems. So, items which appeared in both projects as unsatisfactory, and which had the most negative deltas, had their deltas summed, generating an even more negative value and confirming its position as critical items (Table 01).

General Order	Delta
Noise Level	-8,9
Adherence to Deadlines	-7,6
Access to the Condominium	-3,7
Safety of the Condominium	-3,5
Guardhouse	-3,4
Leisure Complex	-3,2
Frames	-3
Kitchen / Service Area	-2,8

Table 01 – General list of unsatisfied needs in prioritized order. Emphasis on the items which were considered unsatisfying in both projects. Source: primary data.

TRANSFORMATION OF UNSATISFYING NEEDS IN DESIGN PARAMETERS

In this phase, the participation of the designers responsible for the projects was sought, so that they could propose new design parameters based on the unsatisfactory needs. In both projects, the construction company responsible had a partnership with a private architectural firm, besides the participation of their own team.

Due to the construction company´s limited free time, it was impossible to establish a meeting with the participation of all the designers involved at the same time. Thus, the model was applied in two separate stages: first, with the architectural firm designers and later with the project coordinator, who represented the developer.

From the customers' unsatisfactory needs list, functional requirements and, subsequently, the design parameters that would allow their application were established. There were filling out forms (Fig. 03) based on the original model, containing the following fields: customer need, functional requirements and design parameters. Throughout the discussion of each unsatisfactory need, it became necessary to include also a field containing additional relevant comments brought by the designers.

COSTUMER NEED	NOISE LEVEL
FUNCTION REQUIREMENT	Reduction of the level of noise
DESIGN PARAMETERS	01.01. Selection of the openings according to the road type.
	01.02. Adoption of acoustic frames (external noise), floor and acoustic lining (internal noise).
OBS.	The designer determines only the frame operation type, leaving its material selection to the contractor. Due to high costs, acoustic elements are recommended only for luxury projects.

Fig.03 – Example of filled form. Source: primary data.

EVALUATION OF INTERFERENCE, POSITIVE AND NEGATIVE, BETWEEN THE COSTUMERS NEEDS AND DESIGN PARAMETERS THROUGH THE HOUSE OF QUALITY.

Based on the new design parameters, defined by the designers in the previous step, it was conducted the filling of the House of Quality matrix. Thus, these solutions were evaluated for their influence (positive, negative or neutral) on all the needs identified by customers in the satisfaction survey, which had been listed and grouped along the first two steps.

The evaluation of the advantages and disadvantages of each design parameter was set, confirming or not its applicability in future projects. For example, the design parameter "selection of the openings according to the road type" which, despite being positive for the need "noise level", as suggested by the unsatisfactory research, may have a negative influence on the need "window view" considering that most valuable areas, which generate contemplative landscapes, often have the busiest routes and, therefore, a higher noise level. In this case, the designer would need to choose which would be prioritized.

RESULTS AND DISCUSSION

During the application of the feedback model, it was needed to harmonize the criteria of the model with the ones from the satisfaction survey, source of the data that would be analyzed. This has occurred because the satisfaction survey was not conducted anticipating the subsequent application of the model, so its own tools were used for collecting and analyzing the data, which were the questionnaire and the satisfaction versus importance matrix.

To address this issue, the architects decided to prioritize the criteria of data source, making a model adaptation, which also contributed to its simplification and time savings, by replacing the AHP tool for the delta of the satisfaction versus importance matrix.

It is noteworthy, still, the difficulty to promote meetings with all the designers, highlighting the shortage of time for companies and the need for further encouragement for carrying out activities aimed to analyze and evaluate results.

In the architecture firm case, the architect responsible for the design of both projects highlighted the model as a positive feedback, because "allows an important feedback, which the architects do not usually have access to, because of the lack of direct communication with the users, usually held by the brokers". That shows that the main contribution of the model is to establish this communication. Although in some cases the current practices cannot be changed in the present projects, the designers can have insights about new solutions for future situations.

The generated design parameters yet allow the creation of a checklist, ensuring that solutions already discussed can be used in future endeavors, and prevent that any of the costumers' needs will be unnoticed, since there is much information involved in the project.

CONCLUSIONS

With the practical application from the feedback model design duly proposed by Sampaio (2010), it was possible to realize its potential for the systematic analysis of data collected from client's surveys, and its transformation into design parameters. Therefore, the use of satisfaction ratings for a feedback process, allows new projects to search for new solutions and create value for users.

The aforesaid application allows the detection of some limitations, such as the incompatibility between some of the tools used by the said model and some criteria used by the satisfaction survey. However, this situation allows a new contribution to the stated model: the replacement of the AHP tool for the importance versus the satisfaction matrix, which was used in the satisfaction survey, simplifies the initial stage process.

The contributions to the aforementioned model are important, since these enable its simplification, especially considering the practical difficulty of conducting meetings involving the various project teams, mainly due to a lack of time. This simplification also contributes to the reduction of activities, which do not add value to the final product, according to the lean thinking.

Nevertheless, it is necessary for companies to have major motivation, in order to participate and promote a feedback in the design process, as the ongoing research in this area have duly provided a better systematization of this specified activity. Thus, it is encouraged the creation of better products, the user satisfaction increases and, consequently, new developments achieve better acceptance in the real estate market.

REFERENCES

Akao, Y. (1990). Quality function deployment: integrating customer requirements into product design. Transl. by Glenn H. Mazur, Cambridge, Productivity Press.

Bertezini, A. L.; Melhado, S. B. (2005). Evaluation of design process from the perspective of the client. In: SIBRAGEC, 4., Encontro Latino-americano de Gestão e Economia da Construção, 1., 2005, Porto Alegre. Proceedings.. .

Cruz Júnior, A. T.; Carvalho, M. M. (2003). Obtaining the consumer voice: a case study in one eco-hotel. *Produção*, São Paulo, v. 13, n. 3, p. 88-100, set./dez.

Gondim, I. A. (2007). Decision support model for selecting technology for cladding. 180 f. Dissertation (Masters in Engineering). Graduate Program in Civil Engineering, Federal Universidade Federal do Rio Grande do Sul, Porto Alegre.

Kiatake, M. (2004). Creative design support model in architecture: an application of TRIZ - Theory of Inventive Problem Solving. 124f. Dissertation (Masters in Engineering). Escola Politécnica, Universidade de São Paulo, São Paulo.

Koskela, L., Huovila, P., and Leinonen, J. (2002). — Design Management in Building Construction: from theory to practice. *J. of Constr. Res*., 3 (1), 1-16.

Lima, L. P. (2007). Proposal of a system for processing customer requirements for housing projects of social interest. 178 f.Dissertation (Masters in Engineering). Graduate Program in Civil Engineering, Universidade Federal do Rio Grande do Sul, Porto Alegre.

Monice, S.; Petreche, J. R. D. (2004). Axiomatic architecture design : a study for implementation in CAD systems. *Boletim Técnico da Escola Politécnica da USP*. Department of Civil Engineering, BT/PCC/369. São Paulo: EPUSP, 20p.

Moreira, D. C.; Kowaltowski, D. C. C. K. (2009) Debate about the importance of needs program in the design process in architecture. Ambiente Construído, Porto Alegre, v. 9, n. 2, p. 31-45.

Nakagawa, Y. (2005) "Importance of Standard Operating Procedure Documents and Visualization to Implement Lean Construction" Proceedings of the 13th Annual Conference of the International Group for Lean Construction, Sydney, Australia.

Ornstein, S. W. (2008) POE and quality management in the design process. In: ENTAC, 12., 2008, Fortaleza. Proceedings...

Sampaio, J. C. S. Proposition of a feedback model of the design process from measurements of customer satisfaction. (2010) 187f. Dissertation (Master in Civil Engineering). Graduate Program in Civil Engineering, Ceará, Fortaleza.

Sampaio, J. C. S.; Barros Neto, J. P. (2010). Value Generation and its relation with the design process. In: IGLC-18, Haifa.

Stebbins, R. A. (2001) Exploratory research in social sciences. California: Sage Publications.

Suh, N. P. Axiomatic Design Theory for Systems. *Research in Engineering Design*. v. 10, n. 4, p. 189-209, dez. 1998.

Whelton, M. and Ballard, G. (2003). "Dynamic States of Project Purpose: Transitions from Customer Needs to Project Requirements - Implications for Adaptive Management." Proc. Eleventh Annual Conference of the International Group for Lean Construction (IGLC-11), Blacksburg, VA, USA

Womack, J.P. (2002), "Lean thinking: where have we been and where are we going?", Forming and Fabricating, Vol. 9 No. 9, pp. L2-L6.