ASSESSING THE QUALITY OF PRODUCT DESIGN FROM THE DESIGNER'S POINT OF VIEW: THE CASE OF A GLOBAL AUTOMOTIVE SUPPLIER

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Abstract. *This paper presents an application of the important concept of* ***effectiveness factor****, as introduced in Caminada Netto and Kaminski (2005; 2006), in the evaluation of the quality of the product design and development process from the designers' point of view. A brief review of effective factors identification is made. Following a comprehensive questionnaire is drawn up, and submitted to a selected group of designers in the Brazilian operation of a major automotive global supplier. Results are then compiled, presented and discussed.*

Keywords*: Automotive, Effectiveness, Product design, Product development, Quality.*

1. INTRODUCTION

In a previous paper (Caminada Netto and Kaminski, 2005), the authors described an exploratory survey that constituted a first phase in assessing the designer's opinion as regards the evaluation of the effectiveness of the product design process. That phase employed a combination, which once more proved very useful in surveys of this kind, of CIT (Flanagan, 1954; Hayes, 1998) and SERVQUAL (Parasuraman, Zeithaml and Berry, 1990) approaches as follows:

1. A Critical Incident Technique (CIT) questionnaire was drawn up;
2. A unique and very representative population of designers was selected;
3. Critical incidents were collected;
4. Satisfaction items for product design and development were identified as shown in Tab. 1; and
5. Critical incidents were classified according to satisfaction items.

Table 1. Satisfaction items versus SERVQUAL dimensions (Caminada Netto and Kaminski, 2005).

PRODUCT DESIGN	SERVICE QUALITY DIMENSIÕNS	
SATISFACTION ITEM	CONSOLIDATED	ORIGINAL
Documents Resources	Tangibles	Tangibles
Fundamentals Realization Results	Reliability	Reliability
Plans Budget	Responsiveness	Responsiveness
Competence Experience Information	Assurance	Competence Courtesy Credibility Security
Communication Motivation	Empathy	Access Communication Understanding the customer

The reason for establishing the aforementioned connection between product design satisfaction items and SERVQUAL dimensions is that although containing a high amount of software, and sometimes varying amounts of other product categories, design is basically a service supplied to either internal or external customers.

Once the preceding steps had been completed, the affinity diagram technique (Caminada Netto, 2003; Dellaretti Filho, 1996; Nayatani et al., 1994; Mizuno 1988) was used in order to translate the previous satisfaction items into the following six ***effectiveness factors*** capable of representing the effectiveness needs in the product design and development process as exemplified in Fig. 1:

1. Design preparation;
2. Organizational environment;
3. Information and knowledge;
4. Technical personnel;
5. Design realization;
6. Product success.

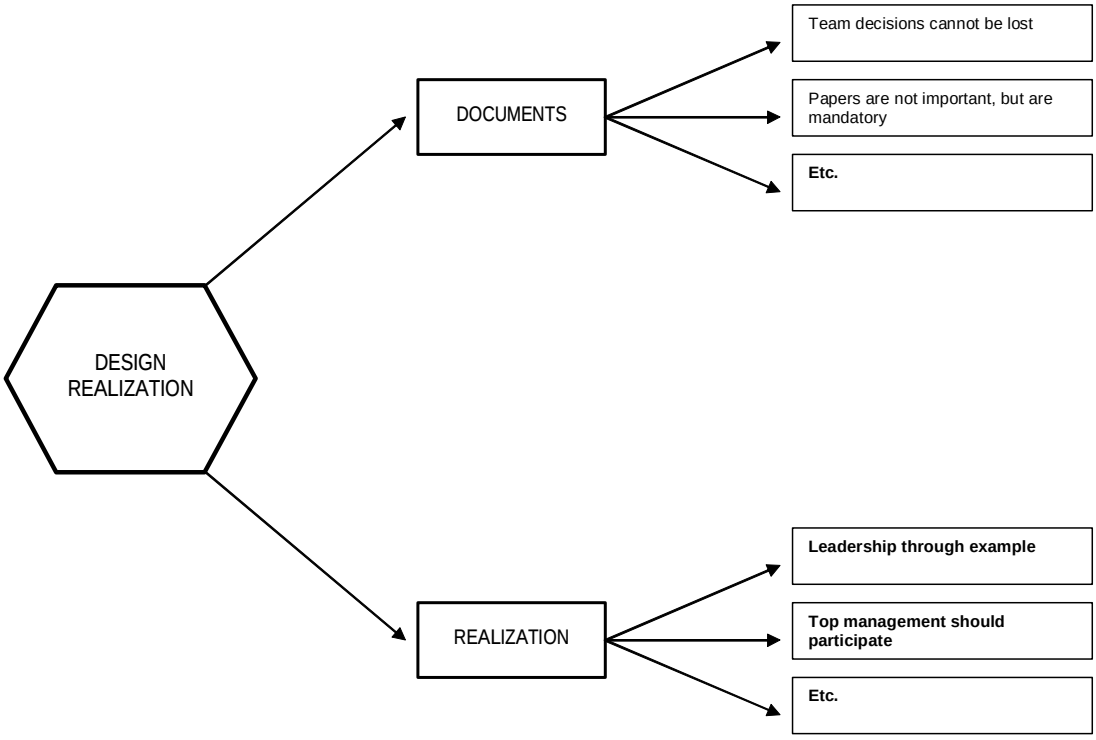


Figure 1. Critical incidents, satisfaction items and effectiveness factors (Caminada Netto and Kaminski, 2006).

Once having realized how SERVQUAL dimensions, satisfaction items and ***effectiveness factors*** closely interrelated, the authors realized that the latter constituted adequate building blocks for structuring an in-depth survey questionnaire aimed at assessing the effectiveness of the product design and development process.

In other words, ***effectiveness factors*** constitute an important concept that allows one to link the opinion of a designer – a central actor of the socio-technical network (Latour, 1994) of product realization – to the formal activities of effectiveness evaluation in the implementation of an organization's Quality Management System.

This paper deals with a second phase that was carried out in order to go from ***effectiveness factors*** to practical measures of process evaluation. With the completion of this second phase it is hoped that another stone has been placed to pave the way to a 'friendlier' method of evaluating the process of product design, and one which may actually be found useful by designers and design organizations alike.

2. RESEARCH QUESTIONNAIRE

The first step required to go from effectiveness factors to the product design and development process evaluation in the second phase of the research work was to draw up a comprehensive questionnaire, and then to submit it to a selected group of designers in the Brazilian operation of a major automotive global supplier, that had kindly agreed to cooperate with the authors´ research.

In the words of Caminada Netto et al. (2003), "The elaboration of any research questionnaire is a constant struggle between conflicting aspects … concision and comprehensiveness, concision and clarification, simplicity and rigour, etc.". The basic idea in this case was to present a logic sequence of design development to respondents, that is, to make each section of the final questionnaire refer to one of the ***effectiveness factors*** that had been developed by affinity grouping in the first phase, as illustrated in Table 2.

Table 2. Questionnaire Contents.

SECTION	EVALUATION OF ASPECTS RELATING TO
INTRODUCTION	Purpose and Instructions
DESIGN PREPARATION	Resources, Plans and Budget
WORK ENVIRONMENT	Communication and Motivation
INFORMATION AND KNOWLEDGE	Foundation and Information
TECHNICAL STAFF	Competence and Experience
DESIGN REALIZATION	Documents and Realization
PRODUCT SUCCESS	Results
THE WORD IS YOURS	Opinions and comments
PERSONAL DATA	Demographic Information

As to questions number and contents, they had to be kept as few as possible and at the same time adequately cover the respective satisfaction items shown in Table 3 in their relation to both SERVQUAL dimensions and ***effectiveness factors***.

Table 3. Dimensions, satisfaction items and effectiveness factors.

EFFECTIVENESS FACTORS ⇒ ⇓ DIMENSIONS	DESIGN PREPARATION	ORGANIZATIONAL ENVIRONMENT	INFORMATION AND KNOWLEDGE	TECHNICAL PERSONNEL	DESIGN REALIZATION	PRODUCT SUCCESS
TANGIBILITY	RESOURCES				DOCUMENTS	
RELIABILITY			FUNDAMENTALS		REALIZATION	RESULTS
RESPONSIVENESS	PLANS BUDGET					
ASSURANCE			INFORMATION	COMPETENCE EXPERIENCE		
EMPATHY		COMUNICATION MOTIVATION				

Once completed, the resulting questionnaire was kindly pre-tested by six designers at the Naval Centre of Technology in São Paulo, Brasil, with experiences ranging from 14 to 30 years in design activities. This pre-test revealed itself very important, not only due to the meaningful alterations suggested by designers, but mainly because it allowed the authors to counterbalance a bias relating to the relative importance of design experience, that had been detected in the first phase where respondents were designers predominantly in their late twenties and early thirties.

4. RESPONDENT ORGANIZATION

The respondent company is a U.S.A. based leading global supplier of mobile electronics and transportation systems a brief profile of which is presented below, data being accurate as of 31st December, 2006:

- Employees: approximately 171,000;
- Wholly owned manufacturing sites: 159;
- Operations: 36 countries;
- Sales: US$26.4 billion.

Engineered to meet and exceed the rigorous standards of the automotive industry, main products may be grouped as:

- Power-train;
- Safety, steering, thermal, and controls & security systems;
- Electrical/electronic architecture;
- In-car entertainment technologies.

Company's technology is also found in computing, communications, consumer electronics, energy and medical applications.

5. RESULTS

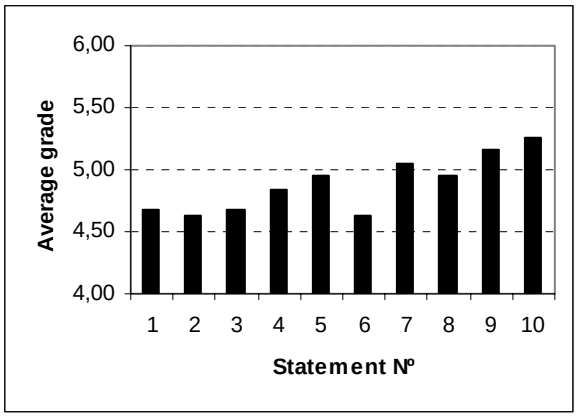
The questionnaire was submitted to 19 designers in the Brazilian operation of the aforementioned automotive global supplier and Table 4 provides the reader with information about the population of individual respondents.

Table 4. Personal data of individual respondents.

Respondent No.	Age	Experience (years)	Declared engineering speciality
1	30	4	Mechanical
2	39	5	Electronics
3	35	10	Production
4	37	8	Mechanical
5	31	2	Automotive
6	46	18	Materials
7	26	5	Mechanical
8	30	5	Mechanical
9	37	17	Electronics
10	39	11	Electrical
11	40	5	Mechanical
12	27	4	Automotive
13	24	2	Production
14	22	2	Automation
15	31	8	Production
16	34	10	Mechanical
17	36	3	Mechanical
18	30	6	Mechanical
19	35	10	Automotive

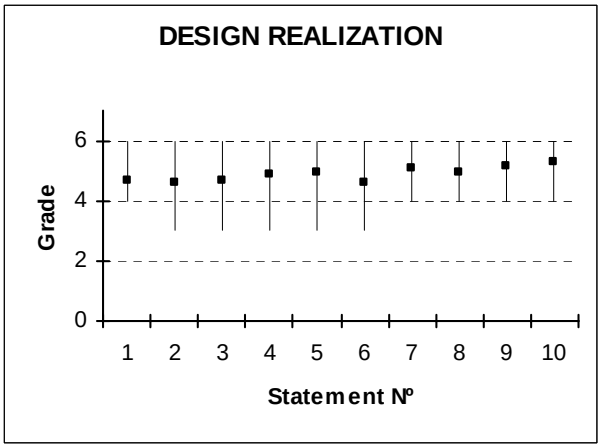
Individual answers were then processed and results represented in graphical form. Figure 2 constitutes an example of such graphics for the questionnaire section "Design Realization" as described inTab. 2 above.

The overall average grade for the section illustrated in Figs. 2 and 3 is *4.88*. Data analysis reveals that in this section statements 5, 7, 8, 9 e 10 show values higher than the overall average, with respectively standard deviation values of *0.85*, *0.71*, *0.71*, *0.69* and *0.73*.



1. Comprehensive records of design history
2. Availability of data base for lessons learned
3. Standardization of all that can be standardized (calculations, drawings, forms, etc.)
4. Use of a specific design methodology
5. Involvement of top management in the design effort
6. Involvement of other areas within the organization in the design effort
7. Monitoring of completion dates for design phases
8. Monitoring of design success indicators or criteria
9. Establishment of authorities and responsibilities for team members
10. Programming of design activities

Figure 2. Average grades for questionnaire section V, "Design Realization".



Statement No.	1	2	3	4	5	6	7	8	9	10
Average grade	4,68	4,63	4,68	4,84	4,95	4,63	5,05	4,95	5,16	5,26
Standard Dev.	0,67	0,83	0,82	1,01	0,85	0,83	0,71	0,71	0,69	0,73

Figure 3. Highest, lowest and average grades for "Design Realization".

Statement 5 reveals concern with leadership and managerial competence and its high average grade agrees with what was also verified in questionnaire section IV, "Technical Staff". On the other hand statement 7, that is a confirmatory statement, also matches the actual degree of concern about the compliance with the schedule for each design phase revealed in questionnaire section I, "Design Preparation".

The average grade received by statement 8 indicates a high level of awareness as regards the need for design process assessment, either as a consequence of requirements posed by the systematic application of quality management systems standards, or due to a genuine understanding of the value of quality, and therefore of continual improvement for competitiveness.

The degree of importance attributed to statement 9 seems to confirm the familiarity of the respondent designers with quality management standards, revealing a perception of the importance of the establishment of authorities and responsibilities of design team members – accordingly eliminating lack of definitions and/or duplicities – in order to assure the adequate management of the design process.

On the other hand, the highest average grade received by statement 10 reveals an understanding of the importance of the programming of design activities – although programming has not yet been satisfactorily dealt with in management standards – in order to assure the effectiveness of the design process.

It is interesting to note that statement 4 has not obtained an especially high grade, which may reveal a limited interest for methodology selection since designers in the automotive industry are already used to employing proven methodologies such as the APQP (IQA, 1997).

Results show that the main concerns expressed by designers in this questionnaire section can be summed up as:

- Programming and control of design activities;
- Establishment of authorities and responsibilities; and

- Involvement of top management in the design effort.

Table 5 shows statements with higher grades for the aforementioned questionnaire sections.

Table 5. Higher grades for Questionnaire Sections I, IV and V.

No.	SECTION/STATEMENT	AVERAGE	SD
I	**DESIGN PREPARATION**	**4,77**	**0,60**
1	Consult other involved areas for setting up time schedule.	5,63	0,60
2	Comply with the time schedule for each design phase.	4,79	0,85
3	Comply with the overall time schedule.	5,37	0,68
6	Stick to the planned design budget.	5,00	0,88
8	Have means for concepts validation (labs; prototypes; etc.).	5,16	0,90
10	Define quantitative objectives.	4,79	1,23
IV	**TECHNICAL STAFF**	**4,75**	**0,43**
1	Have members from different areas in the design team.	4,79	0,92
2	Have members with practical experience in the team.	4,84	0,60
4	Have members with prior design experience in the team.	4,79	0,79
5	Be concerned with the maintenance of technical capacity.	4,84	0,50
7	Have a leader in the team.	5,63	0,76
9	Have a mature organization for design management.	4,95	0,71
V	**DESIGN REALIZATION**	**4,88**	**0,23**
5	Involvement of top management in the design effort.	4,95	0,85
7	Monitoring of completion dates for design phases.	5,05	0,71
8	Monitoring of design success indicators or criteria.	4,95	0,71
9	Establishment of authorities and responsibilities for team members.	5,16	0,69
10	Programming of design activities.	5,26	0,73

7. CONCLUDING REMARKS

As to the second phase of the research, it has now been replicated for other selected companies in different tiers of the automotive industry. With all resulting data, the remaining of which the authors intend to disclose in future papers, it is believed that enough information has already been gathered in order to allow the authors to do the following:

1. Prioritize statements for both individual companies and the automotive industry as a whole;
2. Derive indicators from statements with higher priority;
3. Derive a single index that will take into consideration the mathematical content of the chosen indicators, and therefore provide a simple but consistent way of evaluating the effectiveness of the product design and development process.

In so doing the authors hope to come up with a more ‘friendly’ method of evaluating the process of product design, and one that may be actually useful not only for designers and design organizations in the automotive industry, but also for designers and organizations in any industry.

7. ACKNOWLEDGEMENTS

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8. REFERENCES

Caminada Netto, A., 2003, "As Novas Ferramentas". Programa de Educação Continuada em Engenharia da Escola Politécnica – PECE. Curso EQ-019 Técnicas Avançadas para a Qualidade Total. Apostila**.** São Paulo, 2003, 42p.

Caminada Netto, A. et al., 2003, "Qualidade em serviços: avaliação da satisfação dos clientes em educação continuada". *X SIMPEP - Simpósio de Engenharia de Produção*. Bauru, SP, Brazil: Unesp. Available at: http://www.simpep.feb.unesp.br/.

Caminada Netto, A.; Kaminski, P. C., 2005, "Assessing the Quality of Product Design from the Designer's Point of View". In: COBEM - International Congress of Mechanical Engineering, 18, 2005, Ouro Preto, MG, Brazil. Proceedings. Ouro Preto: Associação Brasileira de Ciências Mecânicas, CD-Rom.

____, 2006, "The voice of the Product Designer: A contribution to effectiveness evaluation in the automotive industry". In: Journal of Quality, 2006. Available at: http://www.iqa.org/journalofquality/recent.asp.

Dellaretti Filho, O., 1996, "As Sete Ferramentas do Planejamento da Qualidade". Belo Horizonte: Fundação Christiano Ottoni, 183p.

Flanagan, J. C., 1954, "The Critical Incident Technique". Psychological Bulletin, Washington, jul., p. 327-358.

Hayes, B. E., 1998, "Measuring Customer Satisfaction". Milwaukee: ASQ Quality Press.

Instituto da Qualidade Automotiva - IQA. Presents QS-9000 e VDA manuals. Available at: http://www.iqa.org.br/.

Latour, B., 1994, "Jamais fomos modernos" (Nous n'avons jamais été modernes, Éditions La Découverte, Paris, 1991) São Paulo: Editora 34, 1994. 149p.

Marquardt, D. et al., 1991, "Vision 2000: The Strategy for the ISO 9000 Series Standards in the '90s". Quality Progress, Milwaukee, v. 24, nº 5, p. 25-31.

Mizuno, S., 1988, "The Seven New QC Tools". Cambridge, MA, EUA: Productivity Press, 1988. 322p.

Nayatani, y et al., 1994, "The Seven New QC Tools: Practical Applications for Managers". Tokyo: 3A Corporation. 181p.

Parasuraman, A.; Zeithaml, V.A.; Berry, L., 1990, "Balancing customer perceptions and expectations". Nova York: The Free Press.

9. RESPONSIBILITY NOTICE

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