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Maeía Pérez
Processes and Systems Department - LISI

Kenyer Domínguez
Processes and Systems Department - LISI

Luis Mendoza
Processes and Systems Department - LISI

Anna Grimán
Processes and Systems Department - LISI

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María A. Pérez
Processes and Systems Department – LISI
Universidad Simón Bolívar
Caracas – Venezuela
movalles@usb.ve

Kenyer P. Domínguez
Processes and Systems Department – LISI
Universidad Simón Bolívar
Caracas – Venezuela
kdoming@usb.ve

Luis E. Mendoza
Processes and Systems Department – LISI
Universidad Simón Bolívar
Caracas – Venezuela
lmendoza@usb.ve

Anna C. Grimán
Processes and Systems Department – LISI
Universidad Simón Bolívar
Caracas – Venezuela
agriman@usb.ve

ABSTRACT

People have an essential role in the systems construction; especially when speaking about quality. For that reason, models studying the quality of people involved in the system development process are necessary; however, frequently, this dimension is not considered. In consequence, the proposal of a quality model that includes the Human Perspective is justified. This article describes the structure of a new model, pointing out the quality measurements related to Individual, Team, and Organization Context aspects. A Methodological Framework which is inspired by the Action Research method as well as DESMET methodology was used for obtaining the design of this perspective. The model proposes a hierarchical structure with four levels, and an algorithm that considers the quality estimation like a system (Product and Process). Finally, the results of two case studies to verify the effectiveness of this perspective are described, along with a model for quality estimation.

Keywords

Quality model, human perspective, system development process.

INTRODUCTION

In today's world, quality has become an element that can make a difference for a software development company. The search for system quality has encouraged the development of models, frameworks, and methodologies for quality assessment and assurance. However, two different approaches are distinguished when software quality is defined: development process and product, but this distinction does not consider the influence of the human factor on quality.

In this sense, Pressman (2002) defines software quality as the concordance with explicitly defined functional and performance requirements, with explicitly documented development standards, and with implicit characteristics expected from every software professionally developed. This definition implies human components where customers and users define functional and performance requirements, on the one side, and the development team acts according to certain standards and within a professional framework, on the other.

According to Sommerville (2002), software quality implies the fulfillment of product specifications. This author also highlights the tension existing between the quality of the customer's requirement (efficiency, reliability, etc.) and the developer's quality requirements (maintenance, reusability, etc.). Some quality requirements are ambiguous and difficult to specify and system specifications are usually incomplete and inconsistent.

In the search for an integral model that can be used to evaluate system quality, the Information Systems Research Laboratory (LISI for its acronym in Spanish) of the Universidad Simón Bolívar, Venezuela, formulated the Systemic Quality Model (MOSCA) (Mendoza et al., 2005), which integrates the Product Quality Model with a systemic approach (Ortega et al., 2003) and the Development Process Quality model (Pérez et al., 2001), based on the concepts of Total Systemic Quality by Callaos and Callaos (1996).

The purpose of this research is to integrate a Human Perspective Model in the Systemic Quality Model with the aim of specifying the quality of the individuals involved in a software system development. This Human Perspective is based on the best methodological practices, such as Personal Software Process (PSP), Team Software Process (TSP), People Capability Maturity Model (P-CMM), and on the advantages offered by the Microsoft Solution Framework (MSF) and Rational Unified Process (RUP) frameworks. This integration "closes" the quality triangle proposed by Voas (1999): Product, Process, and Personnel.

Related models used as background as well as their influence in our proposal are described below. Next, MOSCA current perspectives are reviewed to identify its model strengths and weaknesses. Subsequently, the model which was integrated is presented. This model was developed using the LISI Methodological Framework (Pérez et al., 2004), inspired in the Action Research method, and assessed with the method proposed by the DESMET methodology. Next, the results of two Case Studies as well as the most relevant Conclusions and Recommendations are described.

BACKGROUND

The following models were analyzed: Personal Software Process (PSP), Humphrey (2000), which considers personnel in the improvement of the software development process; Team Software Process (TSP), (Humphrey, 2002), which is a model that includes personnel improvements proposed by PSP in work teams; and finally People Capability Maturity Model (P-CMM), (Carnegie Mellon University, 2001). As a result of this analysis, a broader model is described below, which addresses the whole development process; this model, like the previous ones, is evaluated from the human perspective, and 3 specification levels can be identified:

- Individual: According to Humphrey (2000), each individual involved in the development process has to perform a quality work. The quality of his/her work can be evaluated based on education, human quality, self-management, team work, communication, and leadership.
- Team: Microsoft (2001) reports that the main flaws in the software development process are associated to people, being the main causes the lack of a common language between the individuals involved in the development and communication gaps.
- Company Environment: For Carnegie Mellon University (2001), the degree of the P-CMM workforce practices increases throughout the different organizational maturity levels. The organization should be the core from where quality guidelines will emerge.

The details of the aspects addressed at each level are presented in Table 1

Level	Aspect	Description
Individual	Education	Most authors included in the references highlight the significance of education in quality, total quality and software systemic quality. Deming (1994) recommends training and education at the workplace and the implementation of a vigorous educational and self-improvement program. Juran (1998) stresses the need of training and education.
	Human quality and natural environment	Quality experts, such as Arias and Heredia (2000) consider human quality a key perspective. In their opinion, this activity can be perceived from the viewpoint of the quality of the human beings and their natural environment.
	Self-management	According to Deming (1987) and Juran (1998), individuals should be capable of starting a rigorous self-improvement and self-control program. Carnegie Mellon University (2001), in a perspective closer to the industry, recommends as a managerial principle self-managed teams and decentralized decision making.
	Team work	Crosby (1994) identifies team integration as one of the main factors to attain quality and the zero defect concept.
	Individual communication	Deming (1994) recommends that communication should be considered as a key factor in the search for Total Quality; this author is particularly interested in the dismantling of communication barriers between departments. Sommerville (2002) points out that the ambiguity and incompleteness of requirements is a weakness and attributes this weakness to language complexity and communication problems.
	Leadership	Deming (1994) recommends adopting and implementing leadership to achieve total quality. This leadership emerges from individual leadership and from the capability and willingness of the individual to boost his/her coworkers.

Level	Aspect	Description
Team	Communication within the team	Microsoft (2001) points out that the main flaws in the software development process are related to individuals, and mentions the following as the main causes: lack of a common language between the individuals involved in development and communication flaws.
	Relationships	Carnegie Mellon University (2001), in its P-CMM model, stresses the quality that should have the members of the development team. To achieve quality within the team as a whole, it is necessary to improve quality of the relationships among the persons belonging to it.
	Attitudes	Humphrey (2000), in the PSP model, points out that to achieve quality software each individual involved in the process has to perform his/her work with quality. This not only requires a set of specific skills, but the team should be willing and committed to quality values.
	Management	Humphrey (2002), in the TSP model, states that to achieve quality, team members should be motivated and willing to achieve the proposed goal. A clear goal, shared by the whole team, makes it possible to harmonize efforts and focus on quality.
Company Environment	Mission and Vision	According to Carnegie Mellon University (2001) at the optimization or the maturity level 5 of the P-CMM model, the organization is focused on permanently improving the capabilities of individuals and the work team, the competence-based processes, and the activities of the workforce. These guidelines for improvement for change should evolve from bottom to top, from the organizational foundations, and take the form of a clear mission and vision, which should be disseminated and shared by all.
	Entertainment	Carnegie Mellon University (2001) defines workforce capability as the knowledge and skills available to perform activities within an organization. Accordingly, in a mature organization, workforce capability is directly proportional to business performance.
	Organizational communication	The P-CMM model proposed by Carnegie Mellon University (2001) points out that one of the problems that affects immature organizations is the lack of communication. As the organization matures, a process area, known as Communication and Coordination, develops. This area is aimed at establishing opportune communication throughout the organization and guaranteeing the workforce will attain the skills required to share information and coordinate their activities efficiently.
	Management	Deming (1994) states that management is responsible for 94% of the quality problems within an organization and that productivity improves when variability decreases. Management at the organizational level consists not merely of tactics to attain goals, but of strategies of personnel corporative management.

Table 1. Detailed description of Individual, Team, and Company Environment

Based on these three specification levels and their components, MOSCA is analyzed in the next section.

SOFTWARE SYSTEMIC QUALITY MODEL, MOSCA

The objective of the systemic quality model proponed by Mendoza et al. (2005) is to specify quality in software systems; it integrates the Product Quality model (Ortega et al, 2003) and the Development Process Quality model (Pérez et al., 2001) and is additionally supported by the concepts of Total Systemic Quality (Callaos and Callaos, 1996; Pérez et al., 1999). Its structure is presented in Figure 1.

MOSCA consists of the following four levels (Mendoza et al., 2005):

LEVEL 0. DIMENSIONS. This level comprises the dimensions proposed in the model: Internal and Contextual Aspects of the Process; and Internal and Contextual Aspects of the Product. According to the total quality matrix, the proper interrelationship between the four dimensions guarantees the global systemic quality in an organization.

LEVEL 1. CATEGORIES. This level comprises 11 categories. Six of them belong to the Product and five correspond to the Process. Balance is kept between both groups of categories.

LEVEL 2. CHARACTERISTICS. Each category has a set of Characteristics associated, which define the key areas that have to be met to assure and control product and process quality. In MOSCA, a series of process characteristics appear among the characteristics associated to each product category, because several process quality characteristics have a direct impact on product categories.

LEVEL 3. METRICS. Each characteristic has a set of metrics related to the qualities that are to be evaluated in the software product. MOSCA consists of a total of 587 metrics and one algorithm to measure systemic quality, which comprises three (3) phases (Mendoza et al., 2002): Product Quality Estimation, Process Quality estimation, and integration of qualities to achieve Systemic Quality.

The analysis of the metrics used by MOSCA showed that there is not a clear distinction between the characteristics corresponding to the development team (project leader, developers, consultants, sellers, post-sell personnel, service and attention center personnel) and the team or group of people that represent the customer (customer, end users, project leader on the customer side). This mere fact makes it difficult to determine the actual influence the customer and the development team can have on the software system quality.

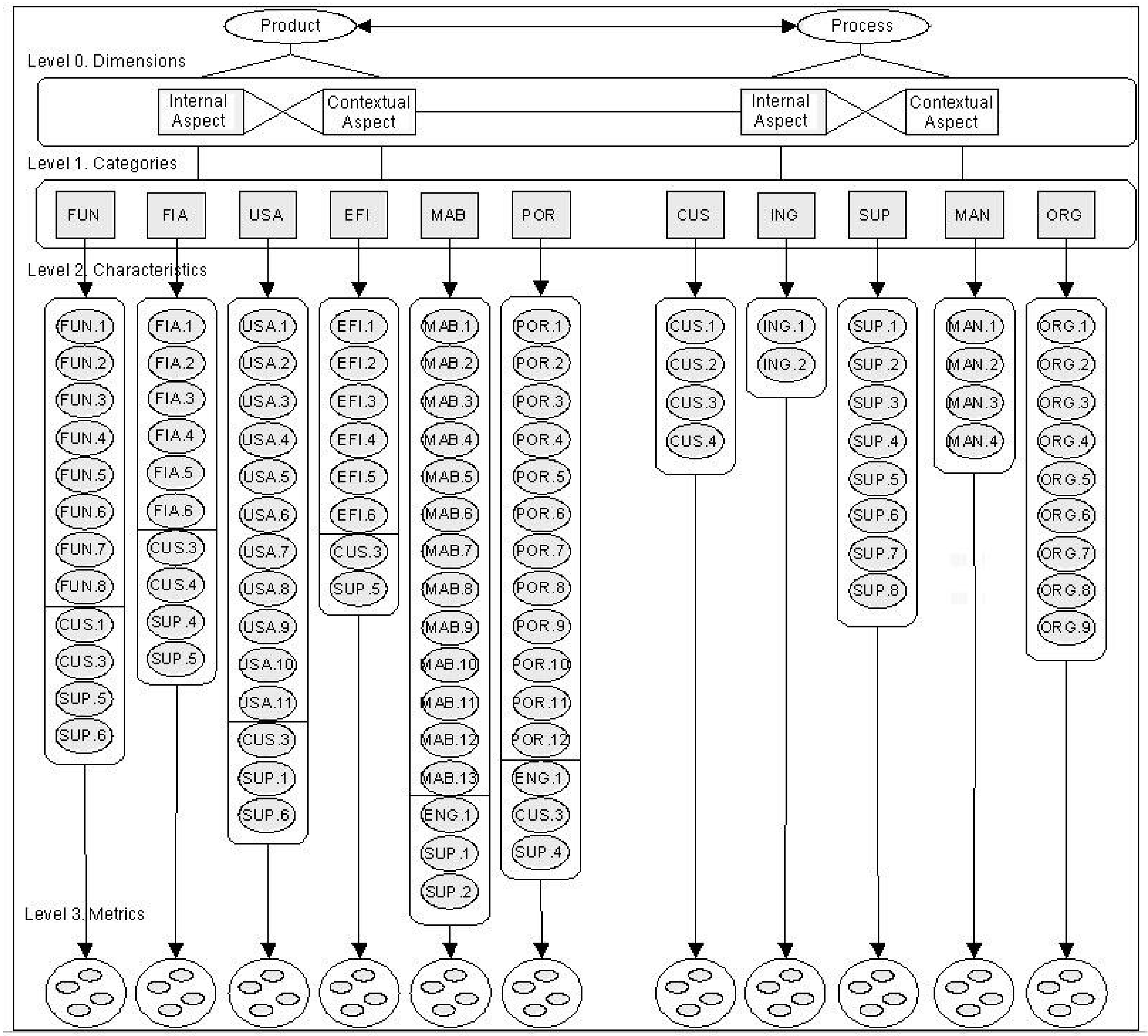

Figure 1. MOSCA Diagram (Mendoza et. al., 2005)

Ten percent of the 587 metrics addressed the user, 70%, to the developer and the developer leader, and the remaining 20% corresponds to the leader who does not clearly represent the Customer. The need to establish clear roles on the development team and the customer side and the categorization of users become an improvement opportunity for MOSCA model.

The research methodology applied to identify Human Perspective categories, characteristics and metrics to be incorporated in MOSCA is based on the methodological framework for research on Information Systems developed by the Information

Systems Research Laboratory (LISI) (Pérez et al., 2004). This framework is based on the Action Research method (Baskerville, 1999) and incorporates the DESMET methodology for the selection of an evaluation method (Kitchenham et al., 1996).

HUMAN PERSPECTIVE

The sub-tree proposed to cover Human Perspective in MOSCA is found below (Figure 2). Categories and characteristics inherent to this perspective are specified, but not all metrics are listed due to space restrictions. However, it is worth mentioning that the formulation of metrics is derived from the analysis of models and frameworks conducted previously. Each model and framework reviewed considers individual, group, and organizational aspects, which should be considered to achieve quality.

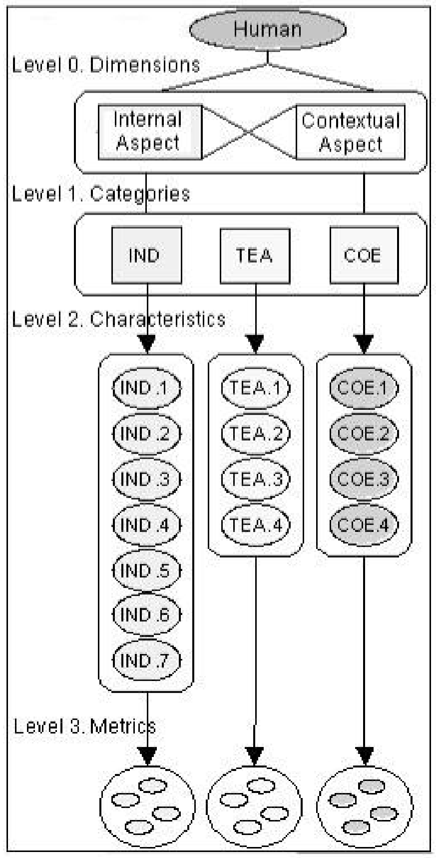

Figure 2. MOSCA Human Perspective Sub-tree Proposal

The **Human Perspective** sub-tree to be included in the MOSCA model consists of the following 4 levels:

LEVEL 0. DIMENSIONS. Internal and Contextual aspects of the Human Perspective sub-tree.

LEVEL 1. CATEGORIES. The sub-tree comprises 3 categories, each one of which, in turn, considers contextual and internal aspects.

- Individual Aspects (IND): these aspects consider the individual human quality, education level, self-management, attitude towards team work, communication, and leadership.
- Team (TEA): this category refers to the quality of the communication and management processes within the work team; it also considers the attitudes of the team members and the level of the relationships between them.

- Company Environment (COE): this category considers the company trends at a macro level in terms of its mission and vision dissemination, training, communication, and management process.

LEVEL 2. CHARACTERISTICS. The following depth level corresponds to a set of characteristics that define key areas that are to be satisfied in order to achieve, assure, and control quality both in the contextual aspect as well as the internal aspect of the MOSCA Human Perspective. Both characteristics as well as categories result from the analysis of the TSP, PSP, and P-CMM models presented in the Background section.

LEVEL 3. METRICS. Human Perspective proposes a set of 128 metrics used to estimate its quality.

The Goal/Question/Metric paradigm defined by (Basili, 1995) was used to formulate the metrics, as a mechanism to define and interpreter measurable and operational software objectives. The paradigm combines models of a case study and one or more approaches that can be analyzed from one or more points of view, in order to characterize, evaluate, predict, motivate, and improve a determined environment.

The starting point of the GQM paradigm is a critical objective to be evaluated; questions are formulated, which later are quantified with one or more metrics. Table 1 below shows a metric of each characteristic proposed according to the GQM approach.

Characteristic (Goal)	Question	Metric	Metric Formulation	Oriented to	Type
IND.1 Education in quality	Is there training in Software Engineering?	Number of hours/year devoted to education programs in Software Engineering	1= Less than 40 hours 2= Between 41-80 hours 3= Between 81-160 hours 4= Between 161-240 hours 5= Between 241-320 hours 6= More than 321 hours	Developer Leader	Contextual
EQU.4 Management	Does management accept the work plan?	Review and validation of the team work plan by the managers	1= Never 2= Occasionally 3= Almost always 4= Always	Developer Leader	Contextual
ENT.2 Training	Is the organization committed to certifications?	Motivation provided by the organization to participate in certification programs	1= Never 2= Occasionally 3= Almost always 4= Always	Developer Leader	Internal

Table 1. Example of Metrics for each Characteristic

As shown in Table 1, formulation, target (leader and/or developer), and kind of metric (internal or contextual) are specified for each metric. Metrics were formulated according to the techniques and activities established by MSF (Microsoft, 2001) and RUP (Rational, 1998) for the different types of roles within the work team.

MOSCA VERSION WITH HUMAN PERSPECTIVE

Now that the sub-tree covering Human Perspective has been described, the new MOSCA version is presented in Figure 3.

Not all characteristics of human perspective are measured in the same way. According to the GQM paradigm, one or several questions are defined for each objective. Each question, in turn, has its own way to measure the answers (metric). Acceptance criteria are similar to those described by (Mendoza et al., 2005), where each category should achieve at least 75% of satisfaction. This criterion is repeated for both characteristics and metrics.

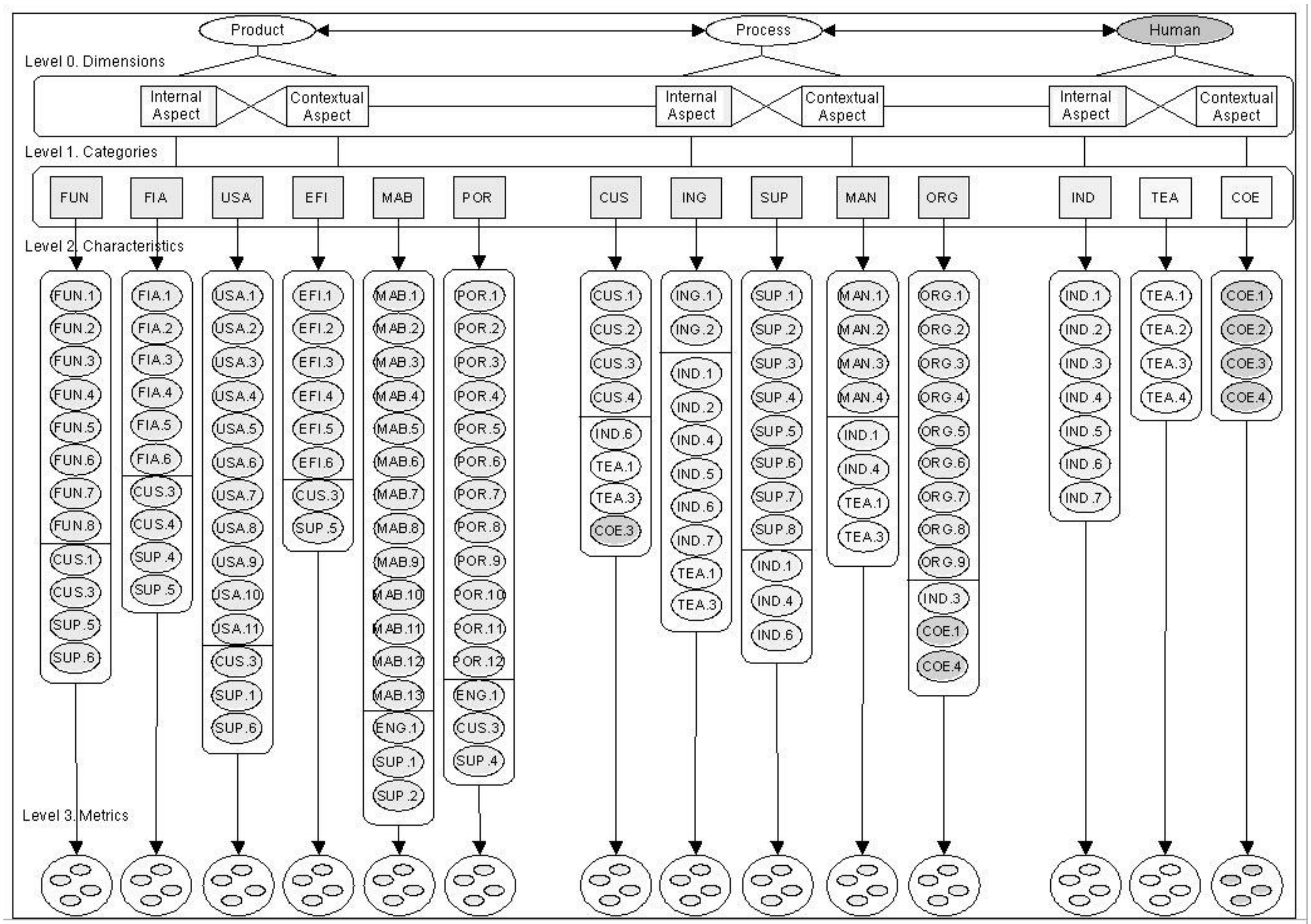

Figure 3. Systemic model for quality specification in Software Systems integrated in the Perspective

Two case studies on which the model was applied are presented in the following section. The pilot project and the results obtained are briefly described for each case study.

CASE STUDY: COMPANY A

The company belongs to the insurance services sector in Venezuela. A project was selected from the Automobile Claims Management, because this area is emblematic for the company. This pilot project had two objectives for MOSCA: the evaluation of the metrics proposed and the application of the whole model, including the 3 perspectives (Product, Process, and Human).

Results of the evaluation of the metrics proposed

Metrics proposed for Human Perspective were evaluated through a questionnaire applied among the development team. This questionnaire estimates Pertinence, Feasibility, Depth, and Scale of each Human Perspective metric.

Figure 4 shows the result of this evaluation according to specific characteristics of the MOSCA Human Perspective Categories. This result is calculated based on the average of all metrics employed in each category.

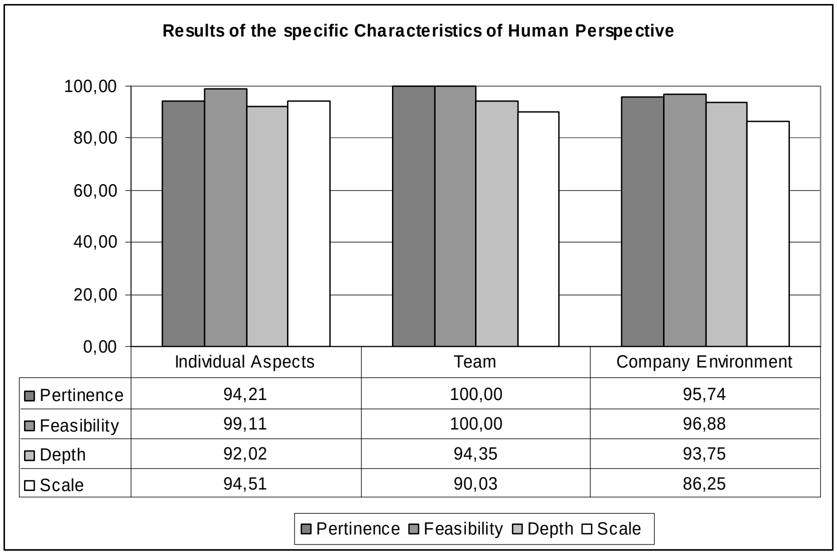

Figure 4. Results of the specific Characteristics of Human Perspective

Outstanding Elements:

According to Figure 4, 94.21% of the metrics in the Individual Aspects category were considered **Pertinent** within the context of the evaluation. The next in terms of metrics pertinence is Company Environment with 95.74%, followed by Team that obtained 100% pertinence for its metrics. According to the acceptance criterion, metrics averaged more than 75%, which is considered acceptable.

In the case of **Feasibility**, the evaluators considered that 96.88% of the metrics were feasible to be evaluated within the context where they were applied; the metrics related to Individual Aspects follow with 99.11% and finally, with 100%,appear the Team metric.

As regards Depth, according to Figure 4, evaluators found that 92.02% of the Individual Aspects metrics exhibited the proper **Depth**, followed by the Company Environment with an average of 93.75%. The metrics with the top depth value were Team metrics with 94.35%.

Figure 4 shows that the evaluators considered that 86.25% of the Company Environment metrics have the proper **Scale**. The scale of the metrics specifying team quality and individual aspects obtained an average of 90.03% and 94.01%, respectively. **Since the average for each characteristics widely exceeds the 75% ceiling established in the acceptance criterion, MOSCA Human Perspective is considered more than acceptable.**

Result of the MOSCA Application

For the Product Perspective, data were analyzed considering the characteristics and sub-characteristics of the software product selected according to the categories of Functionality, Usability, and Reliability, based on (Mendoza et al, 2002). Figure 5 shows the results in terms of Quality requirements established by the customer. Functionality achieved the minimum of characteristics required to be met. The remaining categories, i.e. Reliability and Usability, did not reach the minimum required; therefore, based on the MOSCA application algorithm, the **product quality is Basic**.

The organization is a large firm and its main business line is not the development of systems but insurance services, therefore, the field of system development is limited to a departmental unit. The MOSCA Process Perspective was used to evaluate all its categories. As a result of its application (see Figure 5), it can be concluded that the only Process category that was met was Management. **Therefore, Process Perspective has null quality**.

Then MOSCA Human Perspective was used to evaluate all of its categories. As a result of its application (see Figure 5), it can be concluded that the categories of Individual Aspects and Team exceeded the minimum levels established (75%). Accordingly, **Human Perspective has an Intermediate quality**.

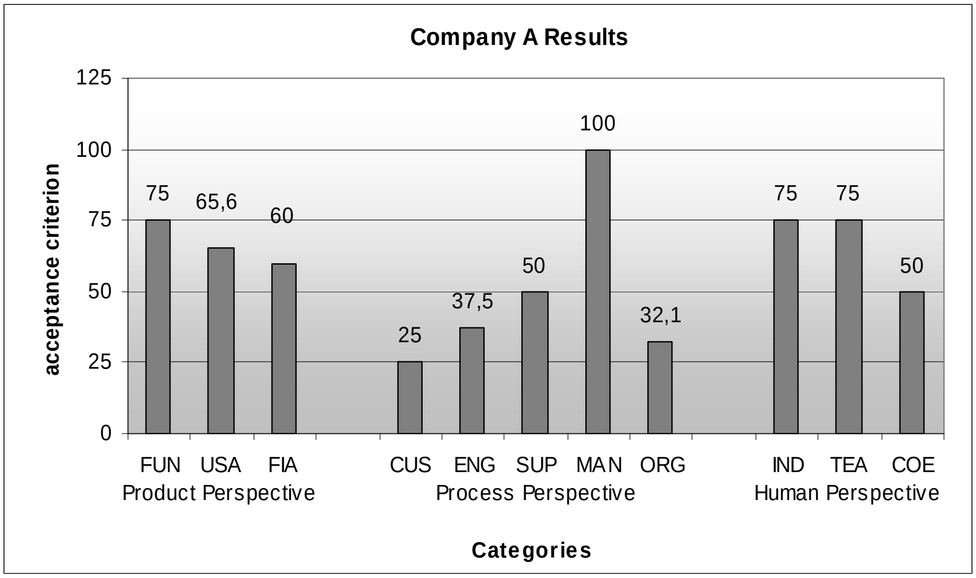

Figure 5. Company A Results

Since Product quality was Basic, Process quality was Null, and Human quality intermediate, the Systemic Quality of Company A is Null. However, it is worth mentioning that the results exhibited deficient values as far as Process quality is concerned; it can thus be inferred that people played a relevant role that had an impact on Product quality.

CASE STUDY: COMPANY B

The second Case Study was developed in a Venezuelan consultant firm that offers Web-based Services and Solutions, focusing mainly on the implementation and development of Corporate Portals. The objectives of this pilot project included the application of the whole model, including the 3 perspectives (Product, Process, and Human). The project selected corresponds to the Development of Bases, Systems, and Computer Networks, which is part of the Strategic Plan of the customer organization. The project selected is supported by an application for the management of Internet Contents, developed by the company being evaluated.

Like in the previous case study, data were analyzed for the Product Perspective, taking into account the characteristics and sub-characteristics of the software product selected, based on the categories of Functionality, Usability, and Reliability.

Figure 6 shows the results in terms of the Quality requirements established by the customer. Functionality reached the minimum characteristics that it required to be met. Usability considerably exceeded the minimum required, but Reliability did not reach the minimal level required. Therefore, based on the MOSCA application algorithm, the **product has Basic quality**.

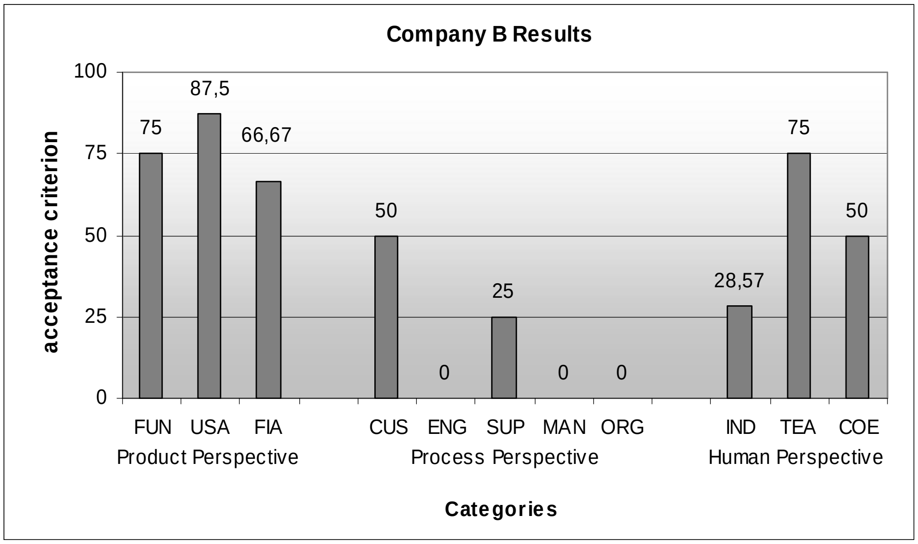

Figure 6. Company B results

Since a basic quality level was achieved, the remaining process and human perspectives were also evaluated. The MOSCA Process Perspective was used to evaluate all its Process Categories (see Figure 6), but since the Customer-Provider characteristic did not reach the minimum required, the **Process Perspective has Null quality**.

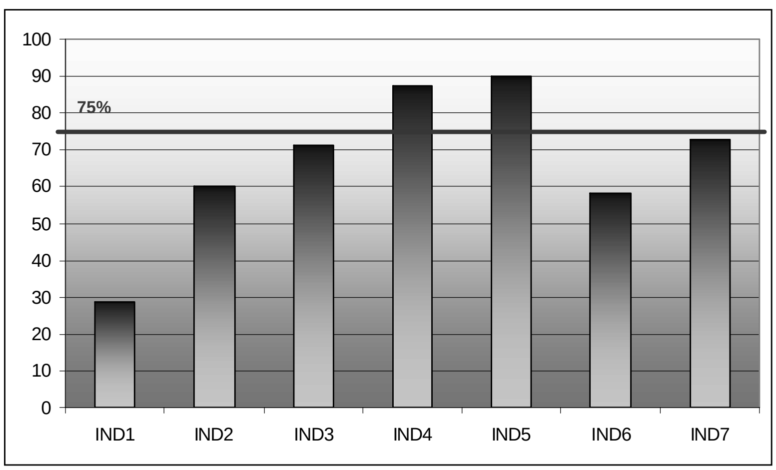

Figure 7. Evaluation of the Individual Aspects characteristic

Similarly to Company A, the Systemic Quality of Company B is Null, because Product quality was Basic, Process quality was Null, and Human quality was also Null. Notwithstanding, it is worth mentioning that, while not all characteristics of the "Individual Aspects" category obtained the minimum required, IND.4 (Self Management) and IND.5 (Team Work) reached more than 75%; this suggests that the responsibilities of a project fall on the developers, both at the individual as well as the group level, meaning that thanks to their contribution the company is able to meet its objectives.

This case study also showed that some aspects of human quality obtain values better than those of Product quality, in spite of which an acceptable product quality was obtained.

CONCLUSIONS

In this work, a human factor quality model in system development (Human Perspective) is integrated in the Systemic Model for the Specification of Software Systems Quality (MOSCA).

According to this perspective, the main categories are Individual Aspects, Team, and Company Environment. In addition, this model operationalizes categories and characteristics through 128 metrics.

The Systemic Model for the Specification of Software Quality was evaluated with the coverage of Human Perspective in two organizations in Venezuela, and the results obtained were widely satisfactory in terms of their effectiveness. In both case studies, it was evident that the quality of the development team is determining for system quality, because this counteracts the low process quality levels.

Further study of the relationship of Human Perspective with or its influence on the other perspectives, i.e. Process and Product, is advisable.

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