2005

A Model for Productivity and Systemic Quality for Systems Development Process

M. Perez
Simon Bolivar University, movalles@usb.ve

E. Mendez
Universidad Simon Bolivar - Venezuela, emendez@usb.ve

L. Mendoza
Universidad Simon Bolivar - Venezuela, lmendoza@usb.ve

A. Griman
Universidad Simon Bolivar, agriman@usb.ve

A Model for Productivity and Systemic Quality for Systems Development Process

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

Méndez, E.
Processes and Systems Department – LISI
Universidad Simón Bolívar
Caracas – Venezuela
emendez@usb.ve

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

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

ABSTRACT

Many authors in the manufacturing industry have affirmed that "high quality levels promote high productivity levels". How is it possible to verify this affirmation for the IT sector? How to relate both concepts for the IT sector in a systemic way?

The goal of this paper is to establish an initial version of a Characterization Model for the Systemic Quality and Productivity relationship in development systems; based on the Process Effectiveness and/or Efficiency, which is related to the Systemic Quality and Productivity concepts.

This model allows the IT sector to access a tool for indicating the expected balance between quality and productivity levels in the development systems process in order to achieve increased market competitiveness.

A model was the most important result of this research, which confirmed the initial premise: to offer a quality product with cost reduction it is necessary to increase productivity and strengthen the development process.

Keywords

Software Systemic Quality, Productivity, IT Projects, Systems Development Process.

INTRODUCTION

In systems development companies, productivity has been studied at product perspective as the capacity of the software product to ensure that users consume the appropriate quantity of resources (time, effort, materials or costs) in order to achieve effectiveness in a specified use context (ISO/IEC 25000, 2001). At process perspective, productivity has been studied in the context of code lines and in models that estimate effort (Pressman, 2002; Sommerville, 2002), it has not been conceived from a systemic view. In this respect, this study proposes to define the relationship between Systemic Quality and Productivity in systems development process. To do this, the Systemic Methodological Framework for IS Research was used. This Framework is based on the Action Research method and combined with DESMET methodology. This framework is systemic because: it considers the contextual conditions of the research, it is flexible respect to the studied object, and it is able to import or exclude techniques, instruments or relations in every instantiation. More than thirty case studies have been applied and five research areas have been consolidated (Pérez et al., 2004).

In the area of software quality, Systemic Quality was used as a reference because it works with a broader view of software quality: Product Efficiency/Effectiveness and/or Process Efficiency/Effectiveness.

The characterization of the relationship between Systemic Quality of the Development Process and Productivity is a modelling tool that will guide organizations in the actions that need to be taken to improve Quality and Productivity levels. After validating and applying this model in various IT contexts, a theory can be developed, thus, the first step is to formulate this characterization.

This article presents four sections, in addition to the introduction and conclusions. The first section describes Systemic Quality in the system development process, followed by issues of Productivity. The third section proposes the Characterization of the relationship between Systemic Quality and Productivity. Next, the Case Study is presented to obtain initial data on the proposition. Lastly, the Conclusions and Recommendations of this study are presented.

SYSTEMIC QUALITY IN SYSTEMS DEVELOPMENT PROCESS

In recent years, the use of quality standards has been justified to guarantee client-user satisfaction. Quality can be the most powerful channel for increasing productivity (Feigenbaum, 2002). According to ISO/IEC 25000 (2001), quality is "*the totality of characteristics of an entity that bear on its ability to satisfy stated and implied needs*."

The overall objective is not only to meet clients' needs but also to go beyond their expectations due to the competitiveness of the market. Thus, the quality of the product and/or service will be the total resulting from the characteristics that integrate it, and the *actions* taken to guarantee this, in the framework of Total Quality Management (TQM). This method's contribution to Human Resources is that quality is everyone's responsibility; to achieve this, there has to be mutual commitment and teamwork is needed to guarantee quality at all stages of the project, and at all levels of the company.

Quality Systems, according to Pressman (2002), is the "*compliance with explicitly stated functional and performance requirements, explicitly documented development standards, and implicit characteristics that are expected of all professionally developed software*." The importance of each quality characteristic varies according to the type of IT project and the context.

Nowadays, models and/or standards are created to measure or estimate the software systems quality. The relationship between these models and productivity was analyzed from a Development Process perspective.

Relationships between some Quality Standards and Productivity

ISO/IEC 15504 (SPICE)

This standard establishes that one of the benefits obtained by an organization by increasing its maturity process is *increased productivity and quality* as a result of the decrease in the *development costs and time*.

Capacity Maturity Model (CMM)

Currently, CMM provides two tools: one aimed at people (P-CMM) and the other fostering integration (CMM-I).

Recent studies consistently show that People-CMM provides guidance to improve productivity by increasing quality and reducing time cycles. These improvements take place through a process of continuous innovation which involves staff but does not address productivity concepts.

Within the seven categories of improvement benefits of CMM-I, the following are considered: time reduction, productivity increase, and quality improvement, the latter being measured by defects (CMM-I, 2002). It does not address a theoretical definition of productivity.

Personal Software Process

PSP is a tool to improve long-term efficiency and effectiveness of the software process, but it does not represent a panacea because it emerges within an individual and group concept of the project staff; therefore it needs to be supplemented with other practices with the purpose of improving quality and productivity within a wider context of the organization.

However, these models are focused on the quality of the process only. Given the complexity of the concept, a systemic quality approach was used.

This quality approach is put into effect in the Systemic Quality Model (MOdelo Sistémico de CAlidad - MOSCA) (Mendoza et al. 2001; 2002). A starting point for defining a relationship between software quality and productivity is by applying MOSCA to a project which is having its productivity evaluated to establish links between Systemic Quality and Productivity.

SYSTEMIC QUALITY MODEL (MODELO SISTÉMICO DE CALIDAD – MOSCA)

This model measures the Systemic Quality of software systems: taking into account the quality of the software product and its development process, based on the Callaos and Callaos systemic global quality matrix (1996). The first version of MOSCA has four (4) layers, as shown in Figure 1.

MOSCA was useful in this study because of its global view of the development process, and also because it was based on the "Efficiency and Effectiveness" Dimensions, establishing a relationship with the concept of productivity used here through the strategy of Integration of Shared Concepts. The concept of Productivity is dealt as below.

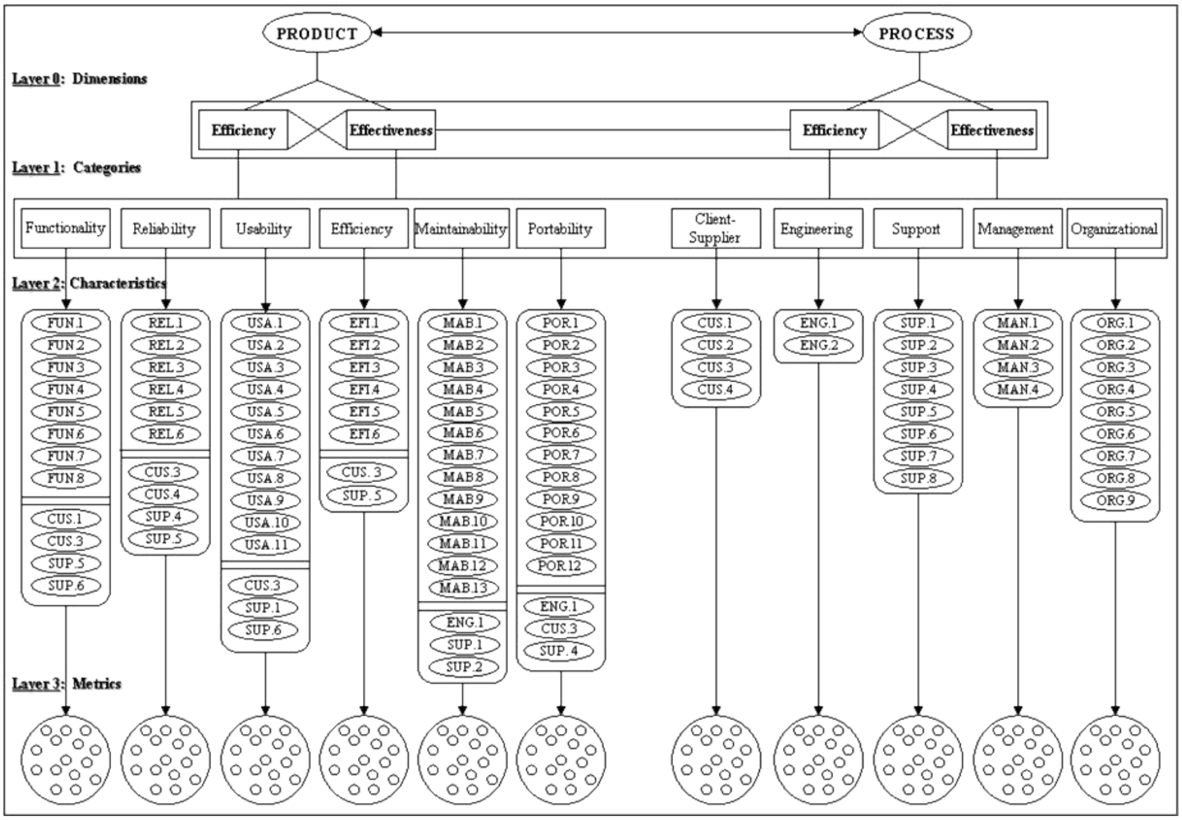

Figure 1. Modelo Sistémico de Calidad – MOSCA – Diagram (Mendoza et al., 2001; 2002).

PRODUCTIVITY

Sumanth (1996) states that Productivity *is a combination of effectiveness and efficiency*, because the former is related to performance and the latter to the utilization of resources. In other words, how the results are obtained reflects effectiveness and how the resources are used to achieve the results reflects efficiency.

The difference between Effectiveness and Productivity is long term because the former establishes a result in a single time period whereas the latter needs the values of prior periods to establish if there was any improvement in productivity.

From managements point of view, the concept of productivity is localized in the relationship between the administrative system and the specific organization of the activity. In this specific stage, the elements and the system that they form are organized for a specific purpose (Kurosawa, 1983). For this reason, the organization must have a higher level of knowledge with respect to the meaning of productivity and its implication (Guzmán, 1986). Knowing the procedures means that the most appropriate tools and techniques available will be used effectively and efficiently (Davis and Naumann, 1997).

This concept must be visualized from a systemic point of view, in which the sum of all the factors in their positive degree leads to an improvement in quality, and consequently an increase in productivity understood as the effectiveness of the products through the efficient use of the resources.

To estimate Productivity, the study uses as reference the FIMP Model, which has been applied in manufacturing companies in Venezuela (FIM-Productividad, 1999).

FIMP Model

In Venezuela, the Fund for Research and Productivity Improvement –FIMP- designed a model to meet the instrumental needs of manufacturing companies for an instrument to determine their general situation with respect to "*good management practices*" in productive systems, understanding that the results of high or low quality and productivity, as well as the possibility of future improvements, are directly dependent on them (FIM-Productividad, 1999).

The areas or factors to be evaluated in the organizations (see Table 1) include all the aspects of the company that affect quality and productivity (some more than others).

Area to be evaluated	Sub area
I. Management	I.1. Management and Environment (Strategic Planning). I.2. Management and Control.
II. Organization, Information and Functions	II.1. Functional Structure. II.2. Information Systems. II.3. Normalization.
III. Human Resources	III.1. Policies. III.2. Staff Administration Systems. III.3. Motivation Policies.
IV. Planning, Programming and Control of production	IV.1. Planning. IV.2. Programming. IV.3. Control.
V. Distribution in plant, storage and handling of materials	V.1. Distribution in plant. V.2. Warehouses. V.3. Materials Handling.
VI. Supplies	VI.1. Policy. VI.2. Planning and Programming. VI.3. Control.
VII. Research and Development	VII.1. Product Design. VII.2. Process Design. VII.3. Work Methods.
VIII. Maintenance	VIII.1. Policies and Organization. VIII.2. Planning and Programming VIII.3. Control.
IX. Finance	IX.1. Financial Policy. IX.2. Budgets and Cash flows. IX.3. Cost and General Accounting.
X. Marketing	X.1. Policies and Strategies. X.2. Execution and Control.
XI. Sales	XI.1. Policies and Strategies. XI.2. Execution and Control.
XII. Quality Control System	XII.1. System Organization. XII.2. Measurements and Information Systems. XII.3. Prevention and Corrections.
XIII. Health and Industrial Safety	XIII.1.Policy and Organization. XIII.2.Planning and Programming. XIII.3. Control.

Table 1. Areas of evaluation in the FIMP Model (Méndez et al., 2004).

This instrument was very useful in this study because it is a proven, documented and easy-to-access model. It uses the terms "efficiency and effectiveness" in the concept of productivity, and relates them to quality; consequently it was used as a guide to formulate the characterization after adapting it to the needs of system development companies.

For proposing a Characterization of the relationship between Systemic Quality and Productivity, the relationship between both concepts was initially established through the analysis of the MOSCA Characteristics and the FIMP sub areas in terms of the efficiency and effectiveness of the process; which is, everything that affects project productivity under a systemic approach not only in the Efficiency and Effectiveness dimension but also visualizing Productivity at different levels: individual, organizational and project team level.

PROPOSAL OF CHARACTERIZATION

The objective of this research is to characterize the relation between productivity and systems quality. However, FIMP model is an abstract representation of the productivity and MOSCA model is an abstract representation of the quality systemic of the software systems; both handle to concepts of efficiency and effectiveness. This coincidence was the beginning point to deepen in the strategic map (Figure 2) the relationship between "Training in Base Practice Quality" and "Training in Base Practice Productivity". Making use of these models it was possible to be arrived more at detailed levels of this relation and thus it was possible to be proposed causes - effect relations (Figure 4). Figure 5 shows the productivity level at which these point (causes - effect relations).

Table 2 shows the activities carried out and their respective products to formulate the characterization proposal. These activities are explained in more detail in this section.

ACTIVITY	PRODUCT
Analyze the elements that affect the IT company internally and externally	Link to Systemic Quality and Productivity in IT projects systemically from the organizational point of view.
Establish the behavior of Systemic Quality and Productivity, as well as the factors that influence them, and those influenced by these concepts.	Strategic map (High Level). See Figure 2.
Present an internal view of the behavior between the training in the quality practice bases and Productivity, through the relationship between the characteristics of the MOSCA development process and the FIMP sub areas, which were in turn located in an Efficiency and/or Effectiveness dimension of the IT development process.	Relation Map (Low Level). See Figures 3 and 4.
Use a nomenclature to indicate each relationship established in the low level, thus the indirect relationship of each MOSCA Process characteristic is shown over the various productivity levels (Individual Productivity, Project Team and Organizational) in line with the direct influence of the FIMP sub areas.	Location of the relationship at each productivity level (Middle level). See Figure 5.

Table 2. Activities and their products for the formulation of the Characterization Proposition.

Strategic Map - High-Level Characterization Proposal

To achieve a macro-view of the systems development organization as an open system related to the concepts of Quality and Productivity, Solano et al. (2002) is used as reference. This work presents a ***Strategic map with a dynamic systems approach for VeneSoft, C.A.,*** which works as a systemic model; this helps to transform the view and strategy of an organization into specific strategic objectives, controlled through a coherent set of action indicators, which are useful in this study. This model also integrates the quality strategy into the system development process.

According to Solano et al. (2002) this model proposes Productivity as an indicator from an organizational point of view, placing it in the financial perspective. For the purposes of characterization, this concept has to be extended, showing the different levels in the company, which results in three indicators: **Organizational Productivity** (Financial Perspective), **Project Productivity** (Internal Process Perspective), and **Individual Productivity** (Learning and Growth Perspective). Also, the **Base Practices** and **Training** are introduced **for Systemic Quality and Productivity** (Learning and Growth Perspective), which are an important part of the adoption and improvement of each of these concepts in the software development organization, since they represent the actions and policies adopted to generate the software product.

It is useful to explain two concepts that are also used as indicators:

- **Market**: includes both the market portion and the general conditions (economic, social, political and cultural).
- **Growth** can be associated with Profitability: according to FIM-Productividad (1991) it is represented by profitability over *sales* (degree of efficiency in the generation of income – establishes the degree of competitive advantage), *economic* (degree of profitability of the asset indicating the degree of efficiency of its utilization - in line with the measure of the potential to generate profits), and *financial* (ratio of company profits to net worth).

Figure 2 shows the adaptation for the Characterization of the relationship between Systemic Quality and Productivity in the Software Development Process (High or Macro Level). As observed, the **Base Practices of Systemic Quality** influence

Process Quality by providing the project team with the knowledge and tools needed to improve **Product Quality** (Systemic Quality). Process Quality reduces **Operating Costs** (according to the Deming chain reaction in the medium and long term, because the quality assurance is initially reflected as an increase in costs), thus **Project and Organizational Productivity** increase (the indicators related to Operating Costs maintain an inverse influence; that is, as one indicator increases, the other decreases).

Organizational Productivity improves **Competitiveness** and **Shareholder Value**, thus increasing the investment in the organization. **Competitiveness** influences **Market share** which influences **Growth**, allowing the Shareholders to increase their **Fixed Investment**, as well as the expansion of **Access to Technology** and **Training in Quality and Productivity Base Practices** by offering new training to staff as feedback from the learning process. The investment in new technology generates greater **Employee Satisfaction** which influences **Process Quality** and **Individual Productivity**. **Product Quality** results in an increase in **Client Satisfaction** which also leads to an increase in **Market share**.

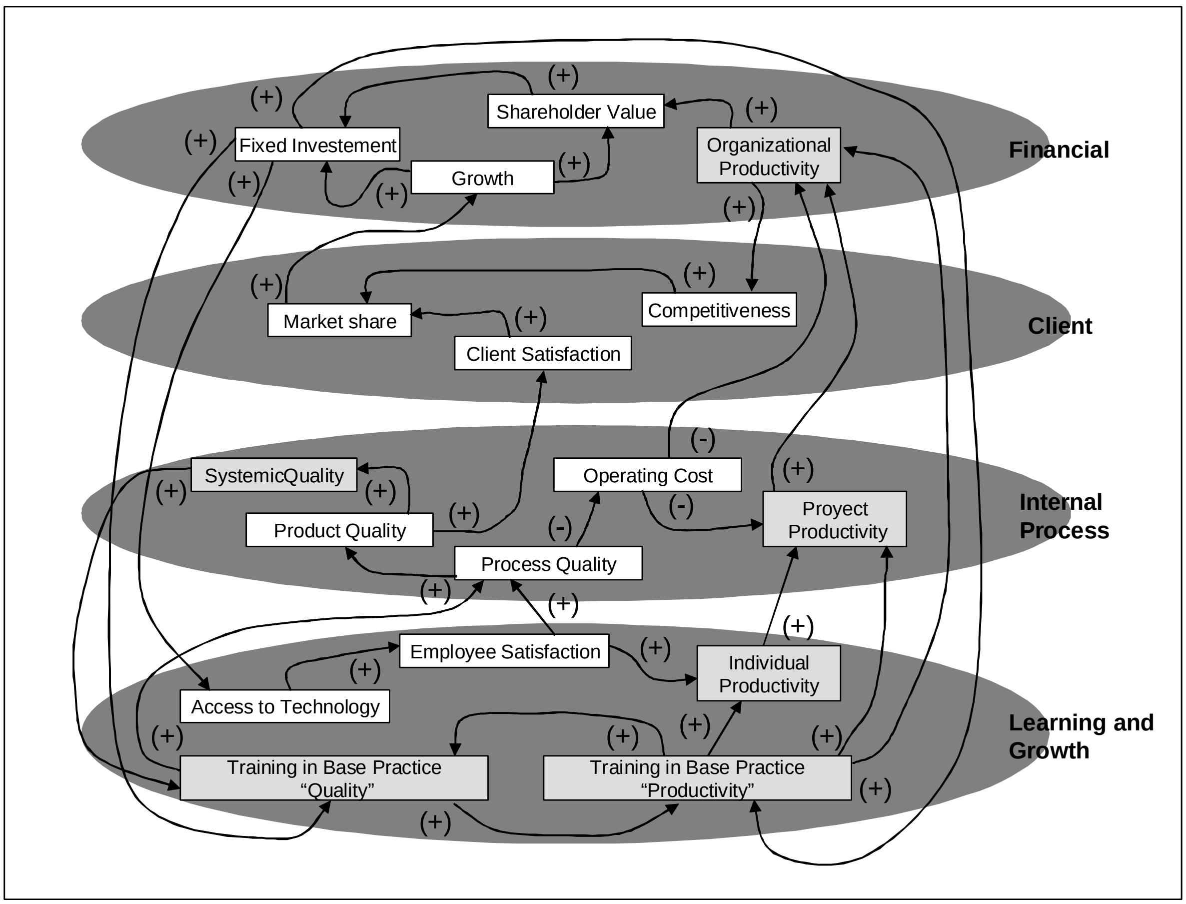

Figure 2. Characterization of the relationship between Systemic Quality and Productivity in Development Systems – High Level.

All productivities are affected by the **Training in Productivity Base Practices**. The learning process in the organization has an impact on **Training in Base Practices of Quality and vice versa** which need to be adapted as changes are generated which favor process quality and productivity at their various levels.

Improvements in Individual Productivity do not guarantee that Project Team Productivity will increase, or that if the team's Productivity improves, Organizational Productivity will also increase because other factors make this relation very particular. But it is useful to clarify that, if human resources management is effective for quality and productivity, it would be the first step to obtain a cohesive and effective project team which would facilitate, to some extent, the achievement of optimum productivity levels in the organization.

Distribution of the MOSCA Characteristics and FIMP Sub areas, by Efficiency and/or Effectiveness

Figure 3 groups the characteristics of the MOSCA Process Dimension and the FIMP Sub areas to give a global view of their inclination toward efficiency and/or effectiveness. It shows that 41% of the MOSCA Characteristics point to effectiveness, 37% to both, and 22% to efficiency. 50% of the FIMP Sub areas relate to efficiency, followed by 28% to efficiency/effectiveness, and the remaining 22% to effectiveness. This means that there is a balance between pursuit of efficiency and/or effectiveness in both models.

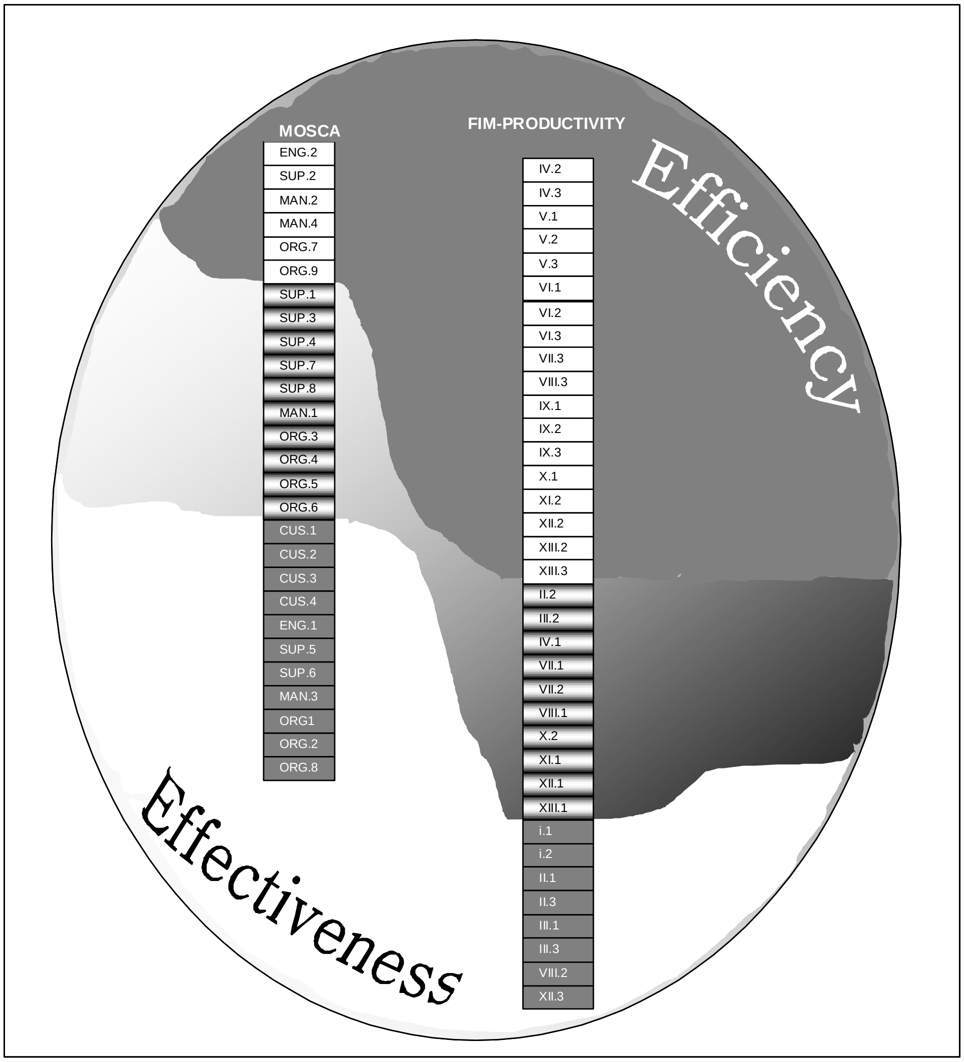

Figure 3. Distribution of the MOSCA Characteristics and the FIMP subareas in the Efficiency and Effectiveness dimension of the Process.

This distribution leads to the conclusion that productivity in the development process of an IT project is going to be influenced more by efficiency; but without neglecting its effectiveness. The latter is going to depend on the objectives of the Development Systems; for this a strategy has to be formulated to guarantee the best use of the inputs in order to perceive Productivity in terms of cost and time. That is, Productivity would not increase if there were only adequate management of resources; the requirements of the project must also be complied with. Productivity exists when a quality product is obtained through the best use of resources.

Relationship Map – Low Level Characterization Proposal

Figure 4 shows a Relationship Map between the Characteristics of the MOSCA Process Dimension and the FIMP sub areas. It shows the influences of more than one Quality Characteristic on a Productivity Sub area, which determines its relevance. Also, there is feedback from the Sub areas to the Characteristics, product of a systemic relationship. In short, this figure is an instantiation on a small scale of the Characterization between Systemic Quality and Productivity in the IT project.

It can be concluded that approximately 92% of the FIMP sub areas are related to the MOSCA Process Characteristics. This leads to the idea that Quality does influence Productivity. The most influential characteristics are: ***System or software product acquisition (CUS.1), Development (ENG.1), Project Management (MAN.2), Quality Management (MAN.3), Risk Management (MAN.4), Human Resources Management (ORG.6), Infrastructure (ORG.7), and Reuse (ORG.9)***. Quality Management (MAN.3) and Measurement (ORG.8) are implicitly present in each sub area of the FIMP Model because the quality and monitoring are taken into account in each one.

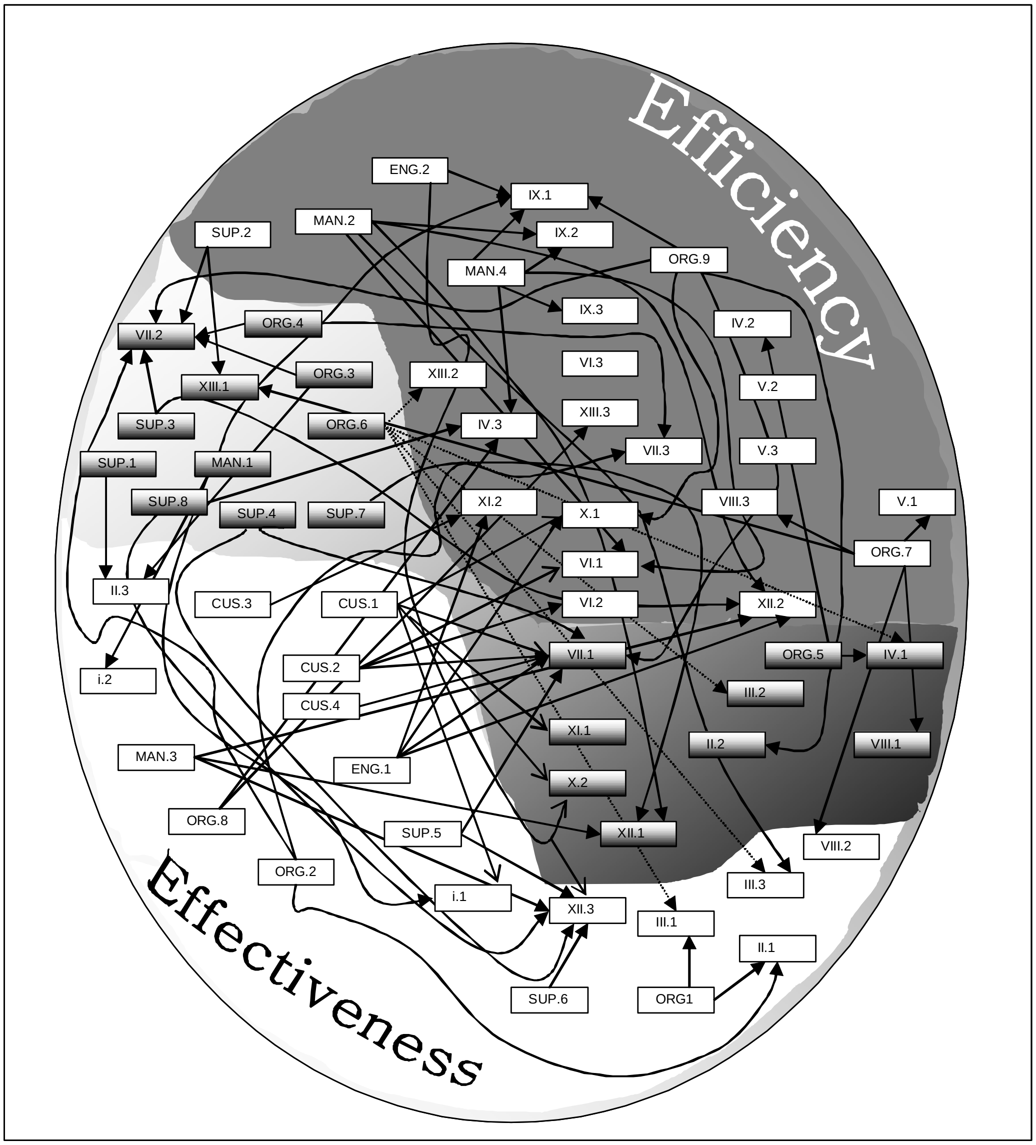

Figure 4. Relationship Map of the Characteristics of the MOSCA process dimension on the FIMP Sub areas – Low Level.

Location of Relationships in Productivity Levels: Mid Level Characterization Proposal

A nomenclature was used to synthesize relationships from the MOSCA Characteristics to the FIMP Sub areas and make Figure 3 into a much more explicable Chart through Figure 5. This figure shows that these relationships have been identified with a legend, placing them according to how they impact the FIMP Sub areas toward the levels of organizational productivity, project team productivity or individual productivity. Most of these relations point to three levels.

Figure 5 is a visualization of **Training of Productivity Base Practices** in relationship to the various productivity levels, such as: Organizational (O), Project (P) and Individual (I). It also shows the feedback from the **Characteristics-Sub areas** relationship to the **MOSCA Characteristics**; where it is observed that more than one of these relationships has an impact on a MOSCA Characteristic. *For example, E1-3 is the relationship between ENG.1 (Development) Characteristic and "Policies and Strategies-Market share" Sub area and it has an impact on SUP.5 (Verification) and ORG.8 (Measurement) Characteristics.*

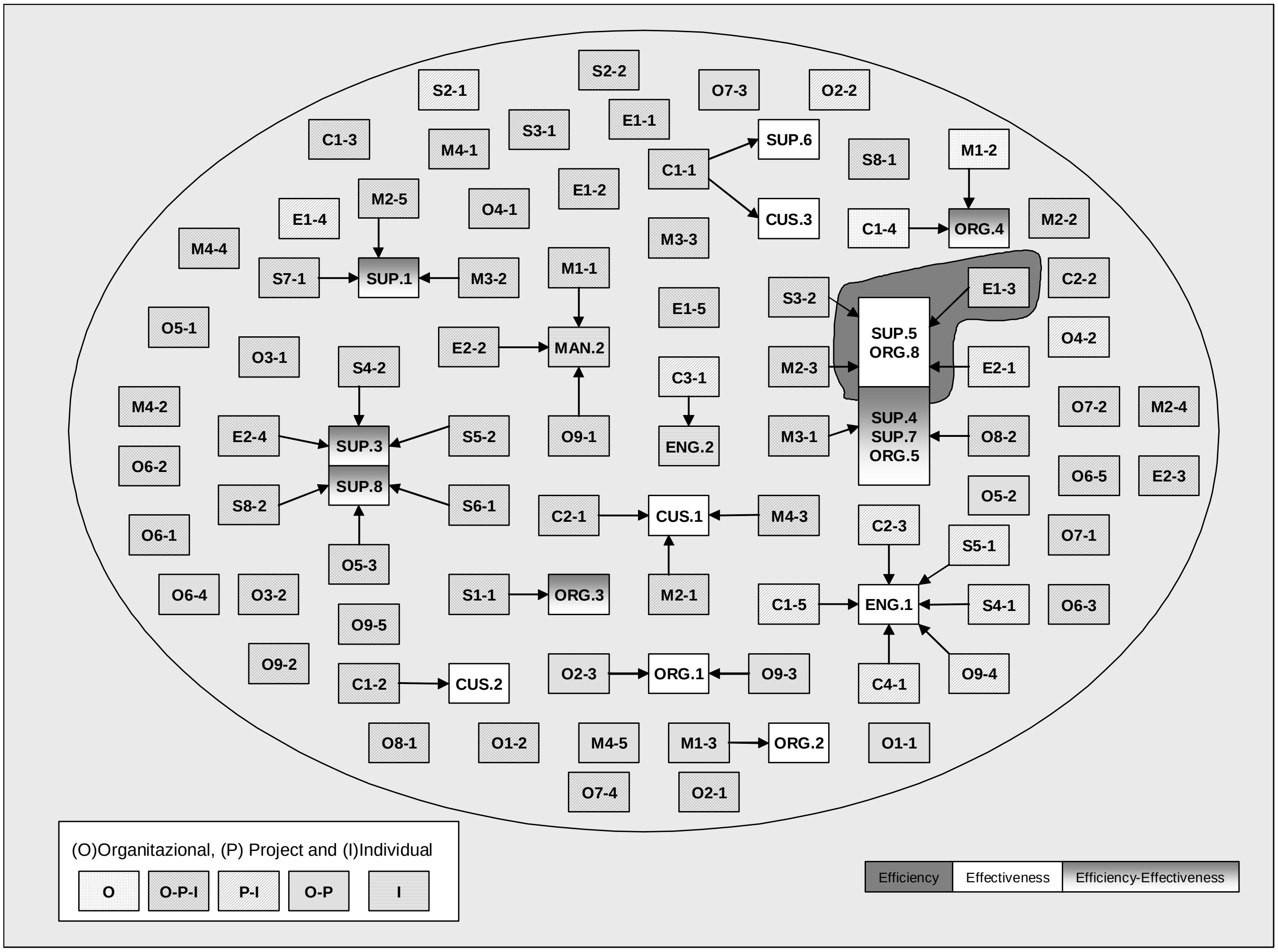

Figure 5. Location of relationships at various Productivity levels - Middle Level.

CASE STUDY OF AN SYSTEMS DEVELOPMENT PROCESS

For reasons of confidentiality, the name "Telecom" is used for the Venezuelan software development company where the study was made. The basic conditions for applying the study to an organization are that it must be a systems development company, the staff surveyed must have worked on the project to be evaluated, and it must have taken place recently. The "Telecom" company met these requirements.

This company provides Internet Mobile Solutions using private-label portals **-** portals that use a brand and name of a cellular operator **-** to meet the needs of cellular carriers and their market. It also specializes in management and development of applications that integrate appropriate content for Internet Mobile through the WAP, SMS, Voice and Web protocols.

For evaluating the proposition, a recent project was selected: the project was based on a CHAT SMS (Space Messaging Service) application which offered e-mail notifications, reminders, alerts, sports results, financial market closings, jokes, horoscopes, weather forecasts, traffic reports, among other messaging services.

The procedure consisted of: (1) checking that the organization met the basic conditions for executing the study; (2) applying MOSCA and the FIMP Model for the Development Systems and analyzing its results; (3) comparing the results of the MOSCA Characteristics and the FIMP Sub areas in order to analyze the relationships proposed in the characterization; and (4) presenting the conclusions and results of the case study.

The instruments used by both tools were based on questionnaires.

Analysis of the Case Study

For determining the Systemic Quality and Productivity evaluated, each tool used to estimate the quality and productivity had an algorithm that was used as a guide for the execution of the study.

Results of Systemic Quality

Following the MOSCA algorithm (Mendoza et al., 2002), the results of its application in the IT project is presented below (see Table 3).

PHASE	LEVEL	JUSTIFICATION
Results of Quality		
Phase 1: Software Product Quality	Quality level of the product was BASIC.	Only complies with the FUNCTIONALITY (FUN) category. The characteristics associated with the EFFICIENCY (EFI) and MAINTAINABILITY (MAB) categories did not achieve the established minimum. (see Figure 6).
Phase 2: Quality of the Software Development Process	Quality level of the process was NULL.	Since the categories Client – Supplier (CUS), Engineering (ENG), Support (SUP), Management (MAN) and Organizational (ORG) were not satisfied (see Figure 6), the "NULL" classification described in Mejías (2003), which is indicated for processes that do not meet the required minimum, was used again.
Phase 3: Systemic Quality in the Organization.	Systemic Quality was Null.	The classification of Mendoza et al (2001) was used to determine Systemic Quality, but since this does not take into account the "NULL" quality level, it was necessary to use the Mejías classification (2003) as a guide, which shows a classification adapted and expanded from Mendoza et al (2001), including the quality level mentioned earlier. Thus, the conclusion was that the level of Systemic Quality was Null because the product quality was BASIC and the Quality of the development process was NULL.
Results of Productivity		
Productivity Level	The Productivity level of the development process for the IT Project was Null	Continuing with the algorithm of the FIMP tool, the six (6) important areas for entering a Basic level were not satisfied, these were: **Management (I); Organization, Information and Normalization Functions (II); Planning, Programming and Control of Software Production (IV); Research and Development (VII); Quality Control System (XII),** see Figure 8. Most of the sub areas associated with the 13 areas of FIMP did not achieve 75% compliance. Figure 7 shows that only two (2) areas exceeded 70%: **Supplies** (VI), and **Finance** (IX), which indicated that all the areas needed to be strengthened because on average they did not reach 30% compliance.

Table 3. Results of Quality and Productivity Levels.

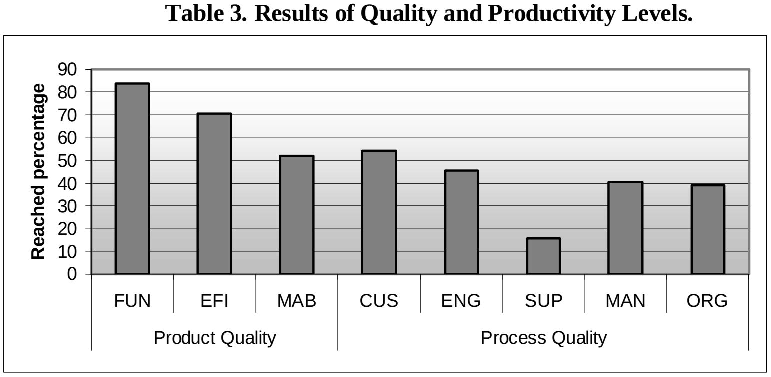

Figure 6. Quality Results in the project.

The results of this case study led to the conclusion that, according to the results of this case study, the effectiveness of the tools used - MOSCA and FIMP – was proven. The results were also taken as initial values for comparison with values after the improvement of the Training in the Quality and Productivity Base Practices.

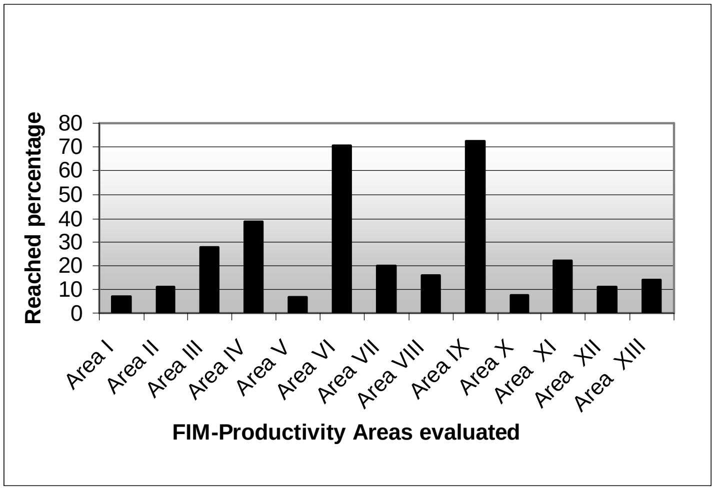

Figure 7. Productivity Results in the IT Project.

Attributes of the Characterization Proposition

After testing the effectiveness of the instruments and obtaining initial values to be used in a later evaluation, the model proposed through the Characterization proposal had the following attributes:

- Abstract: it presented the relationships accurately, which it showed at different levels to facilitate understanding.
- Not Ambiguous: the characterization proposition showed a clear interpretation of the results obtained in the evaluations.
- Complete: it was composed of the parts needed to form a whole in a particular context.
- Simple: the model was not difficult or understand.
- Based on principles: it was structured logically on theoretical bases that underscored its relationships.

CONCLUSIONS AND RECOMMENDATIONS

The characterization of the relationship between Systemic Quality of the Information Systems Development Process and Productivity is a modeling tool to guide organizations, development of software, in the actions they need to take to improve Quality and Productivity levels. The causal links between different could be used to diagnose the source of problems and suggest areas for system improvements. After testing and applying this model in various IT contexts it will be possible to develop a theory. The first step of this process is formulation of the characterization.

The Characterization proposal was established between the Systemic Quality and Productivity in a first version, which must be evaluated in a real project to test the proposed relationships in the model, as well as taking this proposition to a simulation model to visualize the sensitivity of the influences of the MOSCA Characteristics on the FIMP sub areas and vice versa.

We recommend that future researches analyze the Characterization Proposition in other software sector organizations in order to obtain additional references to refine or confirm the relationships established in this study. Since only one study was made in a single organization, it is not yet possible to generalize to all software development companies that the quality characteristics presented in this proposal are the only ones that have an impact on productivity.

REFERENCES

1. Callaos, N. and Callaos, B. (1996) Designing with a Systemic Total Quality, International Conference on Information System Analysis and Synthesis, Orlando – USA, Del 22 al 26 Julio de 1996.
2. CMM-I (2002) CMMISM for Systems Engineering, Software Engineering, Integrated Product and Process Development, and Supplier Sourcing (CMMI-SE/SW/IPPD/SS, V1.1) *Continuous Representation CMU/SEI-2002-TR-011*, *Improving processes for better products CMMI Product Team*. (Marzo, 2002). Recuperado el 25-11-2002. Disponible [On-Line]: www.sei.cmu.edu/cmmi/comm/pdf/ss-cont-v1.1_CMMI.pdf
3. Davis, G. and Naumann, D. (1997) Productivity with Information Technology, Mc Graw Hill, USA.
4. Feigenbaum, A. (2002) The Power Behind Consumer Buyind and Productivity, Revista Quality Progress, Abril 2002, 49-50.
5. FIM-Productividad (1991) Calidad y Productividad - Manual del Consultor, Fondo para la Investigación y Mejoramiento de la Productividad, Corporación Andina de Fomento, Segunda Edición, Venezuela.
6. FIM-Productividad (1999) Capacidad para mejorar la Calidad y la Productividad en las empresas, Fondo para la Investigación y Mejoramiento de la Productividad, Coordinado por: Ing. Francisco Rodríguez, Agosto de 1999, Caracas - Venezuela.
7. Guzmán, J. (1986) Aspectos Claves para el Mejoramiento de la Productividad en las empresas, Segunda Conferencia de Productividad de las Americas, Venezuela, (15-17/1986), 1-13.
8. ISO/IEC 25000 (2001) ISO/IEC 25000 *Software Engineering – Software Quality – General overview, reference models and guide to Software Product Quality Requirements and Evaluation (SQuaRE)*, International Standard ISO/IEC JTC1/SC7/WG6, Editor-Project: Prof. Motoei AZUMA, Fecha: 03-11-2001, Versión: 0.4.
9. Kurosawa, K. (1983) Medición y Análisis de la Productividad en la Empresa, Editorial Rigor, Comisión Venezolana para la Productividad / FIM – Productividad.
10. Méndez, E., Pérez, M., Grimán, A. and Mendoza L. (2004) Calidad Sistémica y Productividad en el Desarrollo de Sistemas de Software, 3ra Conferencia Iberoamericana en Sistemas, Cibernética e Informática - CISCI 2004. Orlando, Estados Unidos de América. Julio 2004. CD: *Memorias de la 3ra Conferencia Iberoamericana en Sistemas, Cibernética e Informática - CISCI 2004*, 2, 144-151.
11. Mendoza, L., Pérez, M. and Rojas, T. (2001) Modelo Sistémico para Estimar la Calidad de los Sistemas de Software (MOSCA), LI Convención Anual de Asovac 2001, San Cristóbal – Venezuela, 18 al 23 Noviembre de 2001, 52, 435.
12. Mendoza, L., Pérez, M., Grimán, A. and Rojas, T. (2002) Algoritmo para la Evaluación de la Calidad Sistémica del Software, 2das. Jornadas Iberoamericanas de Ingeniería del Software e Ingeniería del Conocimiento (JIISIC 2002), Salvador (Bahía) – Brasil, Noviembre 2002, 1, 1-11.
13. Mejías, A. (2003) Integración Formal de los Modelos de Calidad del Proceso Y del Producto con Enfoque Sistémico, Universidad Simón Bolívar, Caracas – Venezuela.
14. Pérez, M., Grimán, A., Mendoza, L. and Rojas, T. (2004) A Systemic Methodological Framework for IS Research, Proceedings of the Tenth Americas Conference on Information Systems, New York, New York, August 2004, 1, pp. 1-10.
15. Pressman, R. (2002) Ingeniería del Software - un enfoque práctico, Mc Graw Hill, Quinta Edición, España.
16. Solano, J., Pérez, M., Rojas, T., Grimán, A. and Mendoza, L. (2002) Integration of Systemic Quality and the Balanced Scorecard, *Information Systems Management*, 01/12/2002, 20, 1, 66 – 81.
17. Sommerville, I. (2002) Ingeniería del Software, Editorial Addison Wesley, Sexta Edición, México.
18. Sumanth, D. (1996) Ingeniería y Administración de la Productividad, Mc Graw Hill, México.