

How Quality Perceived by the Client Connect with Cmm Maturity and Quality of Six Sigma Processes

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Abstract

The present study intends to identify quality as perceived by users of information systems and the connection between the quality of the software development process as measured by CMM and the quality of the business process optimized by SIX SIGMA. The theoretical references used here are: the instrument to evaluate the quality of the service (SERVQUAL) by Valerie A. Zeithaml, A. Parasuraman and Leonard L. Berry, the "Lean Six Sigma" model by George, Michael L. and the Capability Maturity Model (CMM) for system development from the SEI (Software Engineering Institute), at Carnegie Mellon University. Using the existing literature on the subject as the starting point, survey processes and questionnaires, the goal of the present study is to evaluate users' perception of quality regarding system products generated by CMM-based projects, and business processes optimized by SIX SIGMA, and the way they perceive their system products developed with the CMM. The sample was extracted from XEROX Comércio e Indústria.

Key words: Quality perceived by customer, Six Sigma, CMM, software development.



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INTRODUCTION

Most companies struggle to become more and more competitive because markets everywhere are getting tougher and tougher these days. Such competition demands faster players, a fast pace that requires a lot from them; they have to put better quality products and services in the market, practice better prices, enjoy reduced costs and must have a great time-to-market as far as new products are concerned. Speed is of the essence for organizations to be prepared to survive and be successful in such a scenario. To open new markets up, they must be ready to take advantage of the opportunities generated by the development of new technologies, and. To be fast, they must have internal processes and information systems that support these processes that have been optimized to the utmost level of excellence, thus reducing possible variables to a minimum acceptable level. It is then possible to concentrate in the implementation of new marketing strategies without being caught off guard by operational problems in the administrative and customer service infrastructure.

The current scenario requires investment in quality methodologies such as CMM and SIX SIGMA, not simply to get adjusted to corporate guidelines and procedures, but above all to boost performance, aiming at achieving strategic goals!

Studies have demonstrated that companies capable of successfully implementing Six-Sigma present a better performance in virtually all business indicators, including sales increase, better ROI, increased job opportunities, and an increase in stock value.. ("A Tool in the Search for Zero Defect" (Thomas Pyzdek - HSM Management 38 - May/June 2003)

FORMULATING THE PROBLEM SITUATION AND SURVEY QUESTION

Today's global world is the one where competition gets tougher by the minute and where corporations discover on a daily basis that their segment/industry now counts with even one more competitor. These are competitors that corporations would not pay attention to before; in many cases they were not even considered competition. In this new environment, there is no space for trial-and-error strategies.

Corporations that have yet to solve infrastructure problems have no time to respond to these threats and/or, as stated by Michael Porter (1980), to newcomers or replacement products. They are not prepared to counterattack since their business processes are not yet optimized, allowing them to deal with the implementation of new strategies, and/or changes in the current ones.

The applicability of concepts and methods to software engineering is intrinsically linked to quality and to an increase in productivity concerning the delivery of solutions that optimize and add value to business

processes. This fact is naturally conducive to the use of methodologies and processes of quality management for projects related to information systems.

As a direct response to such a need, the following question emerges: What kind of relationship we can identify between the quality of software development processes based on CMM and the quality of business processes implemented or optimized by the Lean Six Sigma model?

HYPOTHESIS SURVEY QUESTIONS

Hypothesis I: Using CMM to develop software projects results in an improvement in quality that is noticed by the user.

Key Questions:

- a) Do software developed under CMM guidance have better chances to be ready within the established deadline?
- b) Do customers perceive an increase in quality on CMM-based software systems?

Hypothesis II: Business processes optimized by the use of the Six Sigma model whose modules/components have been developed using CMM excel in quality.

Key Questions:

- a) Are business processes optimized by Six Sigma that have had their modules/components developed by using CMM more effective, less susceptible to inconsistencies? Do they offer increased effectiveness?
- b) Do customers have a higher perception of quality regarding business processes that have been optimized by Six Sigma and have had their modules/components using CMM?

THEORETICAL BACKGROUND

The theoretical references used for the development and analysis of the core theme of the present study come from "Delivering Quality Service", a book by Zeithaml, Parasuraman & Berry (1990), "Lean Six Sigma" by George, Michael L. (2002) and from a variety of articles from other authors about the use of Six Sigma and CMM.

DELIVERING QUALITY SERVICES - PARASURAMAN

In 1983, A. Parasuraman, Valerie A. Zeithaml and Leonard L. Berry started a study on Quality Service sponsored by the Marketing Science Institute (MSI). They aim at answering the following questions:

- What is Quality Service?
- What are the causes of problems related to Quality Services?
- What can corporations do to solve these problems and offer better services?

Leadership in Service Has a Positive Effect on Profitability

Almost all companies compete to some extent in the service segment; it is hard to name one single industry where service issues are not essential.

Executives from the manufacturing industry are increasingly as enthusiastic about Quality Services as executives from segments like finance, health and transportation. Since executives from the manufacturing segment believe it is increasingly more difficult to establish a sustainable competitive edge based on technology alone, they will shift their attention and resources to services that add value and provide a real source of advantage.

Since the manufacturing industry is focusing more and more on services, there will be an even finer line separating the manufacturing industry from the service business. (Zeithaml et al, p.3).

It is a proven fact that providing superior quality is a successful competitive strategy. When we look at the service industry we see that all leading corporations in the segment are obsessed with excellence in the services they provide. They use the service rendered to distinguish them from the others, to increase productivity, to make sure theirs are loyal customers; they use the services provided to ensure a positive mouth-to-mouth marketing experience; they also use it to find a protection against price competition.

The Critical Need for Leadership in Services

A study carried out by a USA-based bank showed that three out of ten clients complained about one problem or another related to the service provided by their current or previous finance institution. More

than half of the reported problems were considered serious enough to make customers move to another company and/or close their accounts.

Managing is not enough

From the above study, Zeithaml et al were able to prove how the total commitment of the management team to quality energizes and stimulates the company to increase its performance. They could prove once and for all that the ambiguity of roles, poor teamwork and other negative issues contribute to an out-of-control environment that lacks leadership, depleting the Quality Service rendered by the company. To increase the performance, companies must invest more energy and pay more attention to the business and to business schools that focus on leadership values and capacities. Otherwise, the offering of mediocre services will keep defeating the promises of excellence.

How Customers see Quality Service

It is more difficult for customers to evaluate the quality of a service rendered than the quality of goods. The criteria they use to evaluate the quality of a service can be very difficult for the marketing team to understand. The way customers analyze services provided by a brokerage firm is far more complicated than the way they evaluate insulating material, for example. The evaluation of the Quality Services provided by companies in the health segment is definitely more complex than the evaluation of the quality of a car. (Zeithaml et al, p.16).

Customers don't weigh up the quality of a service received only by its end result (e.g.: the hair style after one gets a haircut); they also consider the delivery process (e.g.: how involved, sensitive and friendly the hairstylist is during the actual process of cutting hair).

The only criterion that counts when evaluating a service is the one defined by customers. Only customers can evaluate quality; any other evaluation is essentially irrelevant. The perception of quality is specifically determined by how well a supplier provides a service compared to the customer's expectations about that same service.

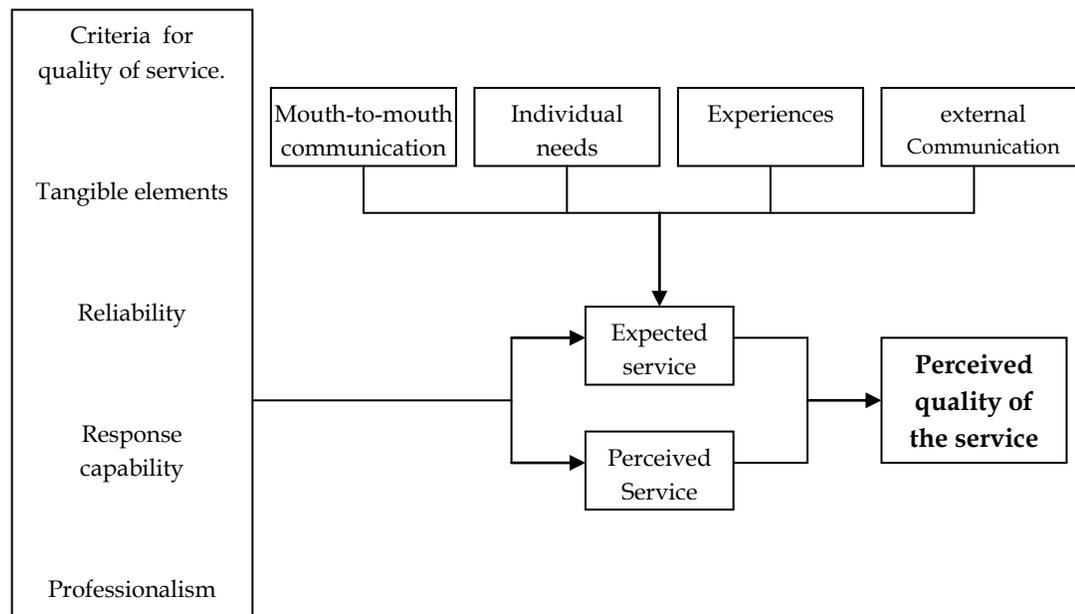


Figure 1: Customer Evaluation - Quality of Service

Source: Zeithaml, V. A.; Parasuraman, A.; Berry L. L. Delivering Quality Service.

New York: The Free Press, 1990

SERVQUAL - an instrument to measure Quality Service

Based on the conceptual definition of Quality Services and on the 10 criteria found in the exploratory investigation carried out, Zeithaml, V. A., Parasuraman, A., and Berry L. L started a phase of quantitative research to develop an instrument that would allow measuring different customers' perceptions

regarding the quality of the service. Their effort resulted in the development of a research tool called SERVQUAL.

SERVQUAL is divided in two sections: (1) An expectation section that includes 22 questions to determine general expectations on the part of the consumer, and (2) a perception section with another set of 22 questions to measure the evaluation of customers in the service segment within a specific organization. Matching SERVQUAL dimensions with the ten initial evaluation criteria for Quality Service:

	Tangible Elements	Reliability	Capacity to Respond	Safety	Empathy
Tangible elements					
Reliability					
Capacity to Respond					
Professionalism Courtesy Reliability Safety					
Accessibility Communication Understanding the Customer					

Table 1: Matching SERVQUAL dimensions and the ten initial evaluation criteria for Quality Service
 Source: Zeithaml, V. A.; Parasuraman, A.; Berry L. L. Delivering Quality Service.
 New York: The Free Press, 1990

Definition of SERVQUAL Dimensions

Evaluation Dimensions	Statements
Tangible Elements	State-of-the-art equipment (hardware and software). Facilities are visually attractive. Well-groomed employees – well dressed, clean and organized. Material elements related to the service (flyers, manual, etc) visually attractive.
Reliability	When a date is set for an action, they comply with it. When customers present a problem, they demonstrate sincere willingness to solve it. Make sure the first time they deliver a service to a client, the performance is great. Deadlines strictly observed. Keep accurate updated records of jobs.
Capacity Respond	to Employees alert clients on when service will be fully delivered. Employees provide customers with a faster service. Employees always ready and willing to help customers. Employees are never too busy to answer a customer’s question.
Safety	Employees’ behavior convey reliability to customers. Employees make sure customers are reassured when dealing with the organization. Employees are always kind and pleasant towards customers. Employees have the necessary knowledge to answer questions customers may ask.
Empathy	Customers are aware that they are unique for the company Working hours are convenient for all customers. Tailor-made support to customers available. Constantly worried about doing the best for customers. Employees understand specific customers needs

Table 2: Statements for each of the evaluation dimensions for Quality Service.

Source: Adapted from Zeithaml, V. A.; Parasuraman, A.; Berry L. L. Delivering Quality Service. New York: The Free Press, 1990

LEAN SIX SIGMA

“Total Quality Management” (TQM) was the major initiative that came right before the Six Sigma model; it strongly pushed the necessity to solve quality-related problems.

Six Sigma came to life at Motorola in the mid-80s. At that time, Motorola was spending from 10% to 20% of revenues with low quality – both direct and indirectly.

Since total cost of quality is frequently a hidden cost, the benefits resulting from improving quality may not be that easy to be seen. By analyzing what was linking the experience of external failure at their customers’ and the experience with internal failure at its plants, Motorola started to understand that low quality had a major impact on the profitability of its basic line of products.

From Motorola, the Six Sigma concept spread to such companies as Asea Brown Boveri (ABB), Allied Signal (now Honeywell), Kodak, IBM and GE – and soon it was being applied in many other companies worldwide.

According to Michael L. George, Six Sigma goal is to develop products and processes that deliver what is expected from them with a high reliability level. Six Sigma can be applied to all operations at a given corporation, including commercial transactions, services, development of products and processes in

manufacturing areas, etc. The expression Six Sigma refers to a product or process that generates only three faults¹ (or errors) within millions of opportunities.

Six Sigma speaks the CEO language; its concept is quite blunt as to the expected financial results expected from each employee and from all the efforts. Such expectations bring together all goals of an organization like no other methodology to boost processes has done before. (Michael L. George, p.19)

In general, the metrics Defects per Million of Opportunities (DPMO) is used to determine the Sigma performance level for a product or process. Since complex products like cars, airplanes or computers may present a much higher number of opportunities for defects than simple products like a pencil or a paper clip, the DPMO metrics was created to level off different areas thus providing a fair evaluation – a common problem for corporations working with different products and services.

The DPMO assumes the possibility of several defects per unit and it is based on determining the number of defect opportunities for a specific unit of product or service.

To calculate the sigma level, it is necessary to know how the DMPO is generated. To calculate the DPMO, three pieces of information are essential: the number of units produced, the number of defect opportunities per unit and the number of defects. The DPMO formula is as follows:

$$DPMO = (\text{Number of defects} \times 1.000.000) / ((\text{Number of defects}/\text{Unit}) \times \text{Number of Units})$$

Using the Six Sigma conversion table we can correlate the DPMO value found with the sigma level:

Production *	DPMO	Sigma Level
69.15%	308,500	2.0
84.13%	158,700	2.5
93.32%	66,800	3.0
97.73%	22,700	3.5
99.38%	6,200	4.0
99.87%	1,300	4.5
99.977%	230	5.0
99.997%	30	5.5
99.9997%	3.4	6.0

Table 3: Six Sigma Conversion Table - Source: Michael L. George

The process improvement and the tools associated with Six Sigma are quite powerful and generally divided in 5 phases for problem solution. The phases are referred to as DMAIC, an acronym for “DEFINE-MEASURE-ANALYZE-IMPROVE-CONTROL”.

Michael L. George (2002) says that Six Sigma does not directly address the speed process issue, which explains the lack of improvement regarding delivery deadlines in organizations using only the Six Sigma methods.

The goals behind the Lean process philosophy are:

Eliminate waste of time, effort and material.

Meet customers’ requirements and expectations.

Reduce cost while improving quality.

When a company simultaneously uses both Lean and Six Sigma methods, it achieves considerable improvements throughout the organization.

Merging Lean and Six Sigma is required because:

Lean can’t have a process under statistic control.

Six Sigma alone can’t dramatically improve process speed or reduce capital invested.

Lean Six Sigma is a methodology that maximizes business success, quickly improving customer satisfaction, cost ratio, quality, speed and capital invested.

Lean Six Sigma laws are: (Michael L. George, p.60)

Lean means speed; applicable to all processes;

Slow processes are expensive processes;

The Lean metrics is Process Cycle Efficiency;

Lot sizes must be calculated using flow variables;

95% of deadline for the majority of the processes is waiting time;

To increase speed, it is necessary to identify and eliminate major time wastage which is made possible by using Lean Six Sigma laws:

The Law of the Market: Critical quality problems from the customers' point of view must have the highest priority.

The Law of Flexibility: the speed of a process is proportional to the flexibility of the process.

The Law of Focus: 80% of delay in any process is caused by 20% of the activities.

The Law of Velocity: The average speed of any given process flow is inversely proportional to both the amount of "stuff" in the process and the average variation in order and stock.

CMM - Capability Maturity Model for software

According to Gregory H. Watson (2002), CMM goal is to ensure the quality of a software product through the implementation of a comprehensive product development infrastructure based on best practices of software projects practiced by several leading corporations.

CMM was developed by the Software Engineering Institute (SEI) at Carnegie Mellon University (CMU), Pittsburgh, Pennsylvania. (Fiorini, 1998, apud Rosana F. Osório, 2003).

CMM characteristic model works on 5 indexed maturity growth levels. These 5 levels take an organization from the initial performance level to a level where quality becomes a competitive advantage1:

Level 1: The initial level; a stage where quality is unstable and little controlled. Going beyond this level provides focus on using project management methodologies to add discipline to the software development process.

Level 2: The second maturity level introduces performance repetition as one of its characteristics. It happens when tasks previously under control are carried out confidently, consistent with previous performance. Going beyond this level requires an integrated engineering process to produce a standard and consistent software development process.

Level 3: The third maturity level results from a specific approach where the characteristics for the design process are well understood. Maturity beyond this level emphasizes product and process quality to provide predictable results in the design process.

Level 4: the fourth maturity level for software development quality is the stage where quality is managed through the use of performance assessment and controlled software development to achieve consistent results typical of predictable processes.

Level 5: the fifth maturity level optimizes the performance related to design and development of software products by improving the processes. At this maturity level, continuous improvements are impregnated in the organization, soon becoming a life style.

METHODOLOGY

THE APPROACH METHOD

The approach method used in this paper was the hypothetical/deductive one.

The hypothetical/deductive method according to Lakatos and Marconi (1991) starts by the perception of a knowledge gap about which the hypotheses are formulated and, through a process of deductive inference, tests the prediction of events covered by the hypothesis. On Figure 2 below, it is possible to see the correlation between the steps of the Hypothetical-Deductive Scientific Method and the elements of this study.

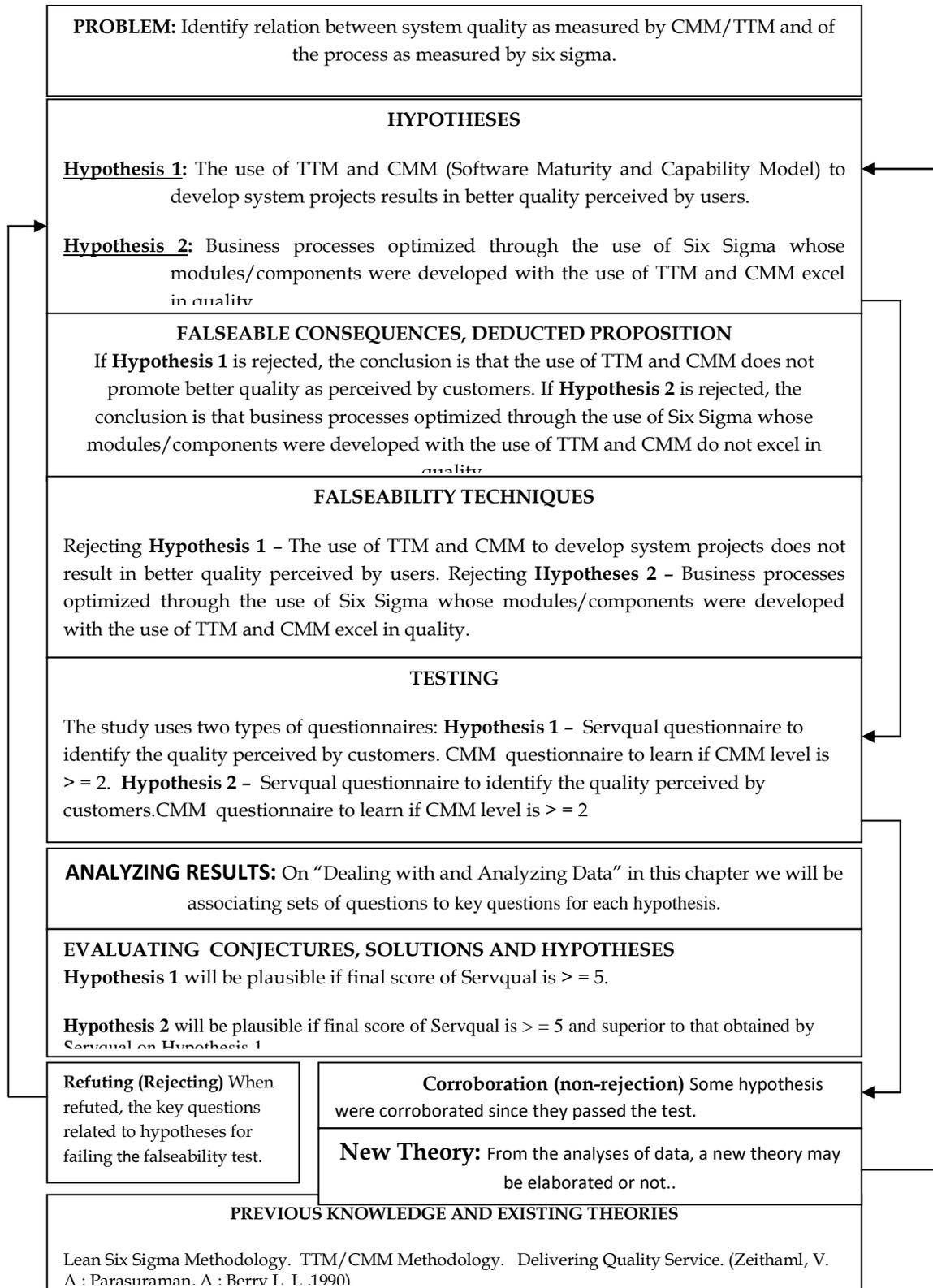


Figure 2 – Using the Hypothetic-Deductive Method to this study
 Source: adapted from Marconi and Lakatos, 2000 apud Popper

POPULATION / UNIVERSE AND SAMPLE

The problem of this research is represented by Xerox Comércio e Indústria. The company is present in the following states of Brazil: Rio de Janeiro, Brasília, Paraná, Rio Grande do Sul, Minas Gerais, São Paulo and Bahia; its headquarter is located in Rio de Janeiro. The study was carried out in Rio de Janeiro.

Two Xerox Comércio e Indústria system projects that met the requirements of the research were chosen:

A business process Optimized by Lean Six Sigma and a system project developed with CMM (called method 1)

A business process Not optimized by Lean Six Sigma and a system project developed with CMM (called method 2)

The expectation was to have a larger number of projects, but it was necessary for the system projects to have been developed through CMM and for the related business processes to have been optimized by the Lean Six Sigma model. Such requirements reduced a lot the sample possibility. Under these circumstances, we decided to use for our statistical assessment a process where Lean Six Sigma was used and one where it was not applied, which had, in both cases, the system projects developed through the use of CMM.

To carry out exploratory activities from hypothesis on something new and unknown such is the case here, commonly faces the lack of a large quantity of samples. For that reason, the study was complemented by a qualitative assessment.

COLLECTING DATA

Collecting data in the field was divided in two phases. The first one consisted of a survey via e-mail sent to each one of the project managers responsible for the development process. The goal here was to identify at what CMM level each system project is classified by using the CMM QUESTIONNAIRE.

The second phase consisted of an e-mail survey with four major users responsible for the systems, to evaluate their perception the quality of the system products generated by the projects developed through CMM. The business processes supported by such systems were measured/optimized by Lean Six Sigma, using the SERVQUAL questionnaire.

METHOD LIMITATIONS

Despite the size of the available sample, it reflects the population of system projects that meet the requirements stipulated for the assessment of this study hypotheses. However, no matter how adequate the planning and execution of the sampling process is, the results achieved from the samples are rarely the same as those of the population. There are no guarantees that the final result will present no distortions.

With that in mind, it was necessary to use a complementary qualitative analyses. Individual interviews were held to magnify the exploratory aspect with open questions, allowing users to be completely open, to make it possible to validate and/or confront the answers to the results of the statistical assessment.

To be as assertive as possible regarding the analyses of the hypotheses, we are applying the paraconsistent logic to a third analyses of the results, since conventional logic is not clearly applicable to the analyses.

ANALYZING AND DISCUSSING THE RESULTS

STATISTIC METHOD

The statistic analyses to substantiate any major difference between the methods was carried out through the Mann-Whitney non-parametric test, fixed at a 5% significant level. The statistic analyses was processed by SPSS®.

Two groups were defined for the statistic analyses:

Method 1: Project with Six Sigma & TTM/CMM;

Method 2: Project with TTM/CMM;

1) Because of the small amount of observations per method, the variables “Tangible Elements”, “Reliability”, “Response Capacity” , “Safety” and “Empathy”, as well as the General SERVQUAL indicator do not present a normal behavior.

Thus, the comparison between methods must be carried out by non-parametric methods – in this study, the Mann-Whitney test.

2) Establishing hypothesis : the null hypothesis (h0) would be the average scores associated to the SERVQUAL questionnaire of the set of answers related to method 1 is not considerably different from method 2. Nevertheless, since a normal condition of data is not possible because of the small amount of observations, the comparison carried out through the Mann-Whitney non-parametric test, which considers the score position in the value set, makes the hypothesis refer to the average positions of both methods. Therefore, the null hypothesis (H0) would be that the average position of the scores associated to the SERVQUAL questionnaire of the answer set related to method 1 is not notably different from that of the average position of scores of answer set related to method 2.

Mann-Whitney test analyze the average positions instead of the averages. The hypothesis are:

H0: The average positions of scores for both methods in the considered aspect are similar.

H1: Average positions of scores for both methods in the considered aspect are considerably different.

3) The Mann-Whitney test, fixed at a 5% significant level, indicates that major statistical differences between the two groups do not exist for all considered aspects.

ASSESSING THE RESULTS

Analyses of the CMM level of projects.

Both system projects analyzed are classified at a CMM level 2.

Analyses of the SERVQUAL aspects.

Table 4 provides the average, the standard error, smallest, highest, and standard deviation of the scores from the SERVQUAL aspects according to the method. The general aspect corresponds to the 19 questions of SERVQUAL.

Aspect	Method	Average	Standard Error	Smallest	Highest	Standard Deviation
Tangible Elements	1	5.875	.375	5.50	6.25	.530
	2	5.250	1.000	4.25	6.25	1.414
Reliability	1	5.800	.600	5.2	6.4	.849
	2	5.500	.300	5.2	5.8	.424
Capacity to Respond	1	6.333	.333	6.0	6.7	.471
	2	5.333	1.333	4.0	6.7	1.886
Safety	1	6.333	.667	5.7	7.0	.943
	2	5.833	1.167	4.7	7.0	1.650
Empathy	1	6.375	.125	6.3	6.5	.177
	2	6.000	.500	5.5	6.5	.707
General SERVQUAL	1	6.141	.125	5.8	6.4	.279
	2	5.582	.144	5.25	6.0	.323

Table 4. Descriptive and Statistical Analyses of the SERVQUAL Aspects, according to the Method.

Source: the authors

By analyzing the SERVQUAL aspects we observed that the average scores of all method 1 aspects were just a little higher than those of method 2. It becomes evident a regular tendency: in general, the expectations of method 1 users corroborates hypothesis II, as shown on figure 3 below.

The low statistical significance of such trend is related to the small number of projects available for study. Most probably, for a larger sample, such difference would be noteworthy.

AVERAGE SCORE FOR SERVQUAL ELEMENTS BY METHOD

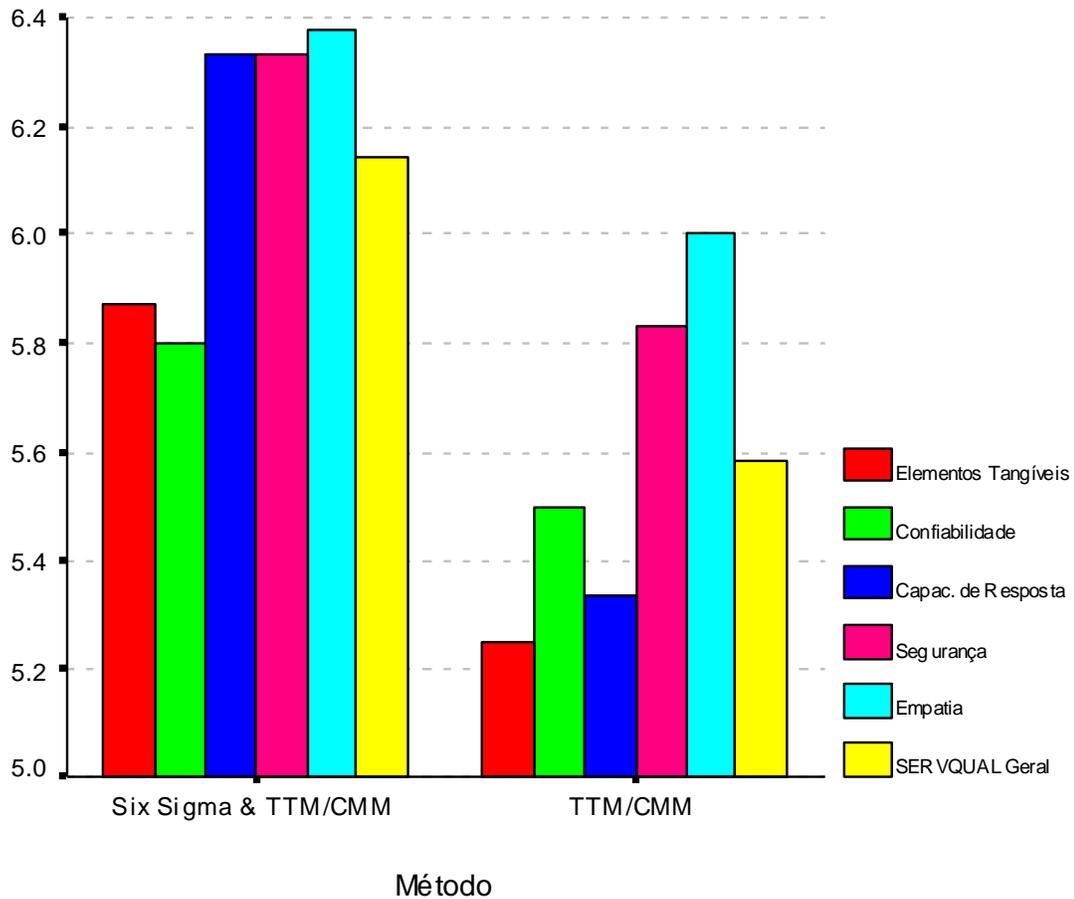


Figure 3 - Method x Average score for the SERVQUAL Elements
 Source: authors

Qualitative Analyses

Using the qualitative analyses, we come to the following positioning of users as to the reasons why a better quality is perceived in method 1 compared to method 2, as the result of this study shows:

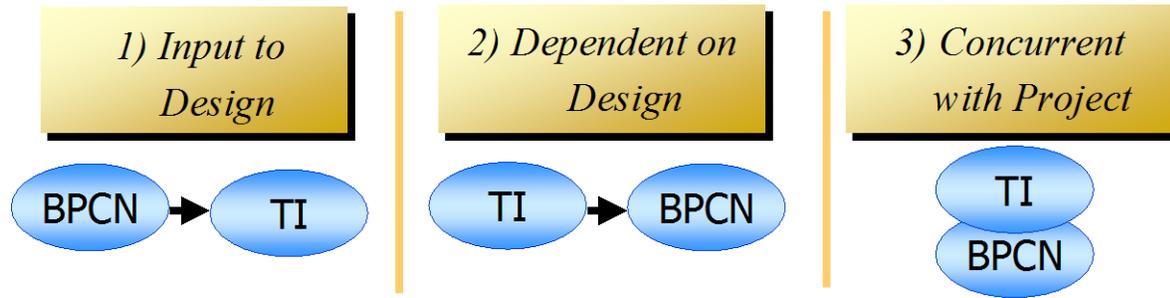
Losses/wastes and reworks were not considered when mapping the process and the sequential activities turned into parallel activities, generating increasing effectiveness and productivity, and reduction of total cost.

Lead time between tasks was reduced, bringing faster responses to the process.

The risk of new processes were identified during the Define and Analyze phases, making it easier to mitigate and prioritize them, reducing possible risks to the project.

Using "Lessons Learned" in previous projects increased productivity.

Organizational Processes and IT



A system project is developed in three major integration contexts involving IT and users, and the chain value:

- 1) It is a consequence of changes in the process required by the business.
 - 2) It is a pre-requirement for changes in the business process, remodeling it.
 - 3) As processes are remodeled or built, technological solutions to meet these processes are evaluated.
- “It becomes clear that option 3 above is the one allowing for better results, corroborating hypothesis II, and the CMM metrics must be the input for the “control” / DMAIC - Six Sigma metric phase.”

Analyses of Results using a Paraconsistent Logic

“The Paraconsistent Logic presents alternatives to propositions whose conclusions lead to values beyond True and False, such as Undetermined and Inconsistent.” (Maurício Correia Lemes Neto, NérioVenson, 2002).

A paraconsistent system works as follows:

- 1) If there is a high level of contradiction, there is no certainty yet as to the decision, therefore new evidences must be pursued.
- 2) If there is a low level of contradiction, a conclusion can be formulated as long as there is a high level of certainty.

Being μ_1 (belief rate) and μ_2 (disbelief rate) respectively, the values related to the SERVQUAL scale are listed below:

SCALE						
Completely disagrees				Completely agrees		
1	2	3	4	5	6	7
$\mu_2 = 1$	$\mu_2 = 0,8$	$\mu_2 = 0,7$	$\mu_2 = 0; \mu_1 = 0$	$\mu_1 = 0,7$	$\mu_1 = 0,8$	$\mu_1 = 1$
$\mu_1 = 0$	$\mu_1 = 0$	$\mu_1 = 0$		$\mu_2 = 0$	$\mu_2 = 0$	$\mu_2 = 0$

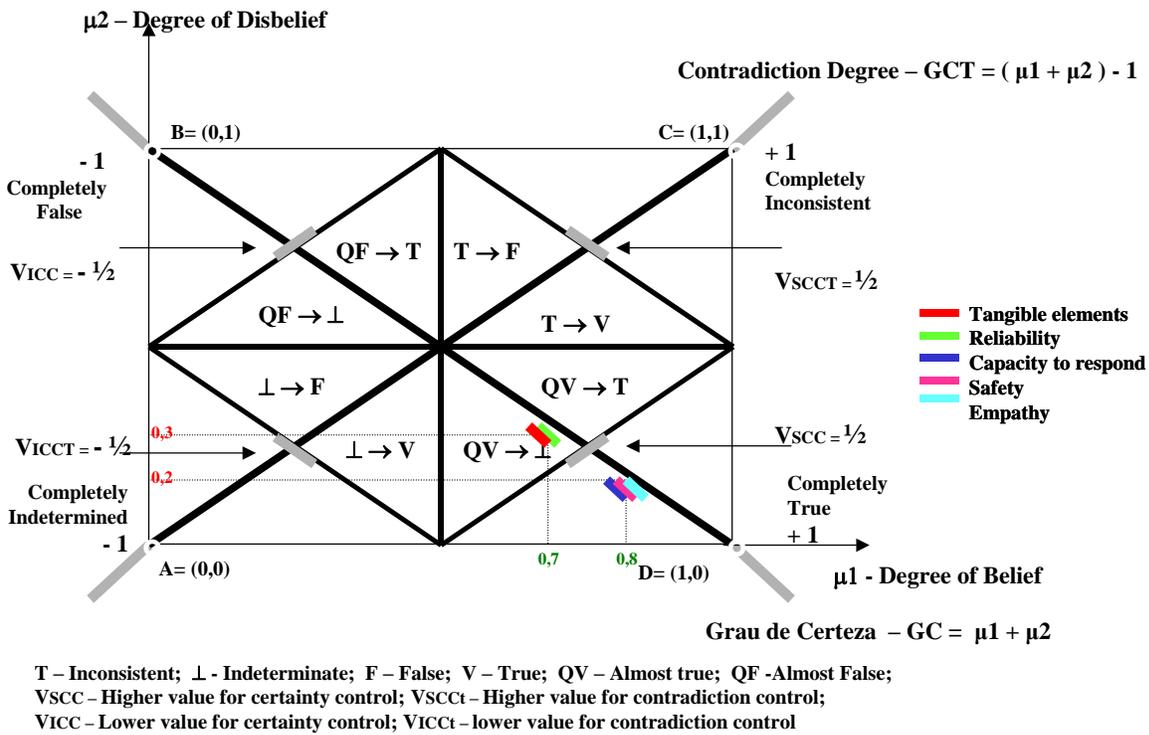


Figure 3 - Representation in the QUPC levels of certainty and contradiction for the SERVQUAL aspects
Source: Adapted from Neto, Maurício Correia Lemes; Venson Nério. Paraconsistent Logic. Santa Catarina: UFSC, 2002.

Based on the results of levels of certainty and contradiction calculated for the SERVQUAL aspects and represented in the Unitarian Square in the Cartesian Plan (QUPC) - we notice that: the Tangible Elements and Reliability aspects are in the Almost True quadrant, tending to Undetermined. The Capacity to Respond, Safety and Empathy aspects are in the Completely True quadrant. There is a low level of contradiction and a high level of certainty for hypothesis II.

CONCLUSIONS AND RECOMMENDATIONS

Based on the premises previously listed and on the results of the survey carried out, it is possible to establish the following assessment as to the problem of the study, the hypotheses used and the conclusions:

SOLVING THE PROBLEM

The problem of the study was to identify the existing relationship between the quality of the system development process using CMM and the quality of the business processes implemented or optimized by the Lean Six Sigma model.

After statistical analyses of the results for each question in the SERVQUAL questionnaire for the field survey, we came to the conclusion that there is a non-significant trend, due to the small size of the sample, but on the rise in all items analyzed, where clients notice an increase in quality when processes are optimized using the Lean Six Sigma model and when system projects associated to these processes are developed with CMM.

VERIFYING THE HYPOTHESIS

The methodology applied to this study is based on the falseability test of the hypothesis created through the null hypothesis method, that is to say, through the use of a statistical test that is adequate to the nature of the variables and of the sample so that it is possible to verify the weight of the results.

Each aspect of the SERVQUAL, as describe by Valerie A. Zeithaml, A. Parasuraman and Leonard L. Berry, was evaluated in connection with the methodology used.

Having the results collected in the field statistically tabulated and tested, each hypothesis was analyzed with the possibility of being validated – totally or partially – or refuted. In addition, the key questions were answered. Below, we find each hypothesis, its assessment with total or partial validation, or refutability, and the answer to each key-question.

Hypothesis I:

The use of TTM and CMM to develop systems further enhances the quality perceived by the user.

Key Questions:

Are Systems developed through TTM and CMM less susceptible to mistakes?

Do Systems developed through TTM and CMM present a more solid guarantee that they are to be conclude within the specified timeframe?

Answers to 1 and 2: Yes, since the projects are classified as CMM Level 2, there is a planning and a follow-up of the software process integrating all the areas involved in the process of project development. Do clients have a perception of better quality regarding systems developed through the use of TTM e CMM?

Answer: Yes, the average scores of all SERVQUAL aspects corroborate such perception on the part of the users.

From the results we conclude that hypothesis I is plausible.

Hypothesis II:

Business processes optimized through the use of the Six Sigma model whose system modules/components were developed using TTM and CMM present excellence in quality.

Key Questions:

Are Business processes optimized through the use of the Six Sigma model whose system modules/components were developed using TTM and CMM more effective, and less susceptible to inconsistency? Do they introduce performance gains?

Do clients have a perception of higher quality regarding business processes optimized through the use of the Six Sigma model whose system modules/components were developed using TTM and CMM?

Answer: Yes. Analyzing the average scores of all SERVQUAL aspects, we conclude that they corroborate the perception of quality on the part of users. It presents a non-significant but on the rise trend in all analyzed items on method 1 over method 2, possibly, as the implementation of the methodology matures in a larger number of companies, this trend will increase.

From the results of the statistical, qualitative and paraconsistent analysis, we may conclude that hypothesis II is undetermined, tending to plausible.

CONCLUSIONS

After verifying each hypothesis and each answer to the key questions, an analysis of the results can be made regarding the contextualization of the problem and, from such analysis, we can infer the following on customers perception related to information systems:

It was noticed that the use of the CMM methodology to develop systems promotes a perception of quality on the part of clients..

It is possible to affirm that implementation of the Lean Six Sigma methodology to optimize business processes and CMM to develop systems is on the rise, becoming a priority in several companies, and yet it is a new subject matter for most people.

As the implementation of these methodologies matures, it will be easier to obtain more substantial samples to corroborate the perception of superior quality on the part of the client who have had its

business processes optimized by the Six Sigma methodology and whose systems' components/modules were developed through CMM.

SUGGESTION FOR FUTURE STUDIES

The present study does not exhaust the subject matter in any way. Despite the fact that the methodology is now adopted by many companies, it still is a new subject matter for most. As of today, the number of samples available does not allow us to go deeper into the subject to precisely corroborate the hypotheses studied here.

For future studies, that will be able to complement and go deeper into the work we present here, we suggest that historical basis for projects and processes be created to be used in research works to try to identify in the Brazilian companies actually using these methodologies, how they are dealing with the integration between business processes and system projects and what the perception of quality on the part of customers is.

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