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Lean six sigmas in academic processes

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Abstract. The objective of the research was to analyse the influence of the Lean Six Sigma management strategy on the process management of the master in mathematical education of the Universidad Francisco de Paula Santander, San José de Cúcuta, Colombia. The research follows a quantitative approach of field type correlational level. For the analysis and interpretation of the information, tools of diagramming, process mapping, descriptive and multivariate analysis, hierarchical, capacity studies, analysis of measurement systems, design of experiments, error tests and control charts were used. Once the lean six sigma philosophy is implemented, continuous improvement is observed, improvements in process capacity, 99.9% effectiveness in measurement variables, improvement in perceptions of the academic and administrative community, and process standardization, the impact of the application of Lean six sigma in a program is evaluated, demonstrating an efficient flow of its products and processes.

1. Introduction

In response to the demands of competitiveness in a context of openness and internationalization of the economy, have assumed the implementation of models and quality strategies as they have done companies and companies continuous improvement in their processes. The institutionalization of process of define, measure, analyze, implement, control (DMAIC) in institutions develops a staff focused on all process improvement [1]. Educational institutions not alien to these organizational phenomena, also face in an environment of competition and supply of high quality services, face efficiently and effectively the search for their vision, to meet objectives and indicators of research and innovation in their programs offered. This, without losing sight of the importance of the impact on educational processes and on the development of the country, which implies the application and development of management strategies that maximize achievements and costs, leads to the redesign and improvement of organizational processes of academic units.

This internalization of modern management philosophies has not been an easy process and the Universidad Francisco de Paula Santander not alien to this phenomenon, aware of the need to modernize management styles and advance improvement processes in the work of their area implemented quality management systems and strategies through Lean six sigma. The objective of the research involved implementing the lean six Sigma management strategy in the management of the Mathematics Education program. Its importance lay in the continuous improvement of management processes [2], in administering and operating the unit effectively [3]. The specific objectives sought to diagnose the situation of process management, determine feasibility to facilitate continuous improvement and evaluate the impact of the application and development of the methodology. In this way, the research



was pioneering in implementing this managerial philosophy within a process of impact in a postgraduate program in research, in the educational community which would allow it to serve as a model for other processes in educational institutions in the country.

2. Methodology

The study was framed in the quantitative approach, supported by a field study, documentary following a correlational level [4], which, based on different conceptions, is developed through stages such as diagnosis of needs, approach and theoretical foundation of proposals, methodological procedure, activities and resources necessary for its execution and analysis of economic, financial and social viability, and its implementation [5]. The tools and approach according to Lean Six Sigma [6] focus on quality, efficiency, service levels, and the behavior of processes to identify improvements in a short time. They were used as instruments, surveys, interviews, checklists, administrative staff, teachers and 120 students. The reliability of the instruments was 0.79, 0.89 and kappa index equal to 0.9, 0.7, 0.83 and 0.78. In the diagnostic stage, Kaufman's type C model was used to establish priorities [7]; the possible projects to be evaluated are identified. The second phase of the methodology, comprising measurement, consists of characterizing the process by identifying key needs of the academic community, the characteristics of the services (or outcome variables) and the parameters (input variables) that affect the functioning of the process. The results, the documentary and economic-financial analysis, led to the identification and selection of priority problems to solve in processes, as well as to measure the performance of management units adopting the model of lean six sigma in management [8]. In the third stage, analysis, the team analyzes current and historical results data. Hypotheses about possible cause-effect relationships are developed and tested using relevant statistical tools.

The capacity of the processes is determined according to the quotient between the difference between the upper and lower limits and six times the deviation [9], and the upper limit through the probability of success, range and reliability [10]. Process Compliance Analysis determines the number of defects per million opportunities to solve problems for compliance with process quality and efficiency parameters [11]. Parameters established in the methodology are followed, and a scale is stipulated to determine whether the process is in a satisfactory, adequate or inadequate state [12]. The formation of improvement teams and the selection of projects to be executed requires a cause-effect analysis and estimation of times to begin the planning stage and execute projects [13], using a logical framework matrix, evaluated indicators and brainstorming.

On the other hand, comparative analyses after the philosophy has been implemented allow the evaluation of the results of its application and development. Taking into account guidelines on quality policy, we assume as guidelines a competent human capital, compliance with legal requirements, compliance with the purposes of the institution, dynamic organizational structure, development of efficient, effective and efficient processes, continuous improvement, user satisfaction, compliance with rules and parameters established by the state. In the improvement phase, actions are established to comply with the quality objectives, strategic plan and action plan to be implemented in less than six months, in order to compare results before and after the methodology used has been implemented. It also outlines the perspectives to be taken into account in the control, financial perspectives, clients, processes and potential human resources perspective [14]. The final phase, control, consists of designing and documenting the necessary controls to ensure that the improvement in process capacity is maintained once improvements are implemented [15].

3. Results

The analysis (Table 1) shows critical impact indicators in the dimension leadership with defect, in the dimension communication indicators external communication channel has defects. In the control dimension the indicators evaluation, document control, internal audit, risk map, corrective actions are critical. Regarding personnel management, five indicators were considered critical, one unacceptable and three acceptable. In the process of marketing and welfare services, indicators are considered critical

and unacceptable. Six indicators were evaluated as critical in the planning dimension, namely, tasks, norms, decision making ($z = 0$ to $z = -1.72$; significant impact, attribute: meets), control, competence, mission, advisory criterion ($z = 0$ to $z = -0.5$; significant impact, acceptable attribute), strategy, compliance to 2018 of the plan, plan, compliance mission, improvement plan ($z > 2$; critical); execution time (defect). Leadership dimension shows in type of leader (average compliance, profile, goals, decision making, delegation of authority with significant impact, acceptable), delegation of transcendent authority.

Table 1. Fulfillment by dimensions.

Dimension	Indicators	%	variance	Impact	Attribute
Leadership	Leader profile	70	0.8	Substitute	Acceptable
	Compliance plan	50	1	Critical	Defect
Communication	External communication	20	1	Critical	Defect
	Internal communication	70	0.3	Suitable	Acceptable
Planning	Tasks, rules, decision making	90	0.8	Significant	Complies
	Improvement plan	60	0.5	Critical	Defect
Training	Profile, Availability time, development skills, achievements, contribution to integral formation	100	0	Significant	Complies
	Satisfaction of service, Staffing, infrastructure	80	0.4	Substitute	Acceptable
	Satisfaction of service, Staffing, infrastructure	70	0.7	Substitute	Acceptable
	Research projects Research groups	90	1	Significant	Complies
	Number of incentives	100	0	Significant	Complies
	Lunch access, beneficiary by stratum, condition, participation in events	80	0.3	Substitute	Acceptable
Social	Medical service use, hours of operation, % according to service	30	0.48	Critical	Defect
	Access to services, medical service	20	0.4	Critical	Unacceptable
Control	Process control	25	0.36	Critical	Unacceptable

On the other hand, there are more defects per million opportunities, in processes of resource management, training, social management, services whose sigma is less than one, appreciating that all dimensions require improvement (Table 2). Successes and failures were attributed to social aspects ignored during the implementation phase, aspects such as context, competitive market, leadership and management style, resources, and skills, organizational priorities, socio-economic status.

Table 2. Defects per million opportunities and z sigma 2017-2019 value.

Dimensions	Defect per million opportunities 2017	Sigma store	Average defect rate % 2019	Sigma store
Planning, social, services	0.718	0.5	0.005	5
Leadership	0.2918	2	0.0004	6
Training, financial	0.961	1	1	3.9
Resources	0.918	1	1	3.9
Staff	0.66	0.5	0.005	5
Communication, control, marketing	1	2	20	2.4

The improvement team considered that the central problem corresponded to the low score obtained in the management (3.5) referring to welfare addressed to postgraduate students, deficiencies in records, grades, external communication. 190.2 defects were found per million opportunities. Implemented lean six sigma, the decrease in the variability of the planning, control, and research processes is highlighted, which indicates a tendency to maintain compliance rates within the normal range, with quality higher

than 95%. There was a need to establish channels for the dissemination of truthful information on existing problems. With 99.9% reliability, the average management score rating improved the philosophy, obtaining scores between 4.5 and 5 in 2019. Improved response time to needs and achievement of six sigma reach. In acceptability of the management system, the community showed advantages when working through processes, taking into account systemic vision, there was improvement in the process, organization and agility, standardization, integration to the processes of the University, monitoring, evaluation, continuous improvement, quality in the provision of services and appropriation of these, better coverage of the population, offer of welfare services, agreements and implementation of information systems, improvement and publication of events, communication plan, card, extension of schedules, offer courses, web improvement, social networks and services and incentives for graduates.

4. Discussion

Lean six sigma is a management approach that measures and improves quality [16]. It has become a reference method to meet the needs of students and achieve improvement with levels close to perfection, the research showed that the approach can be implemented in a graduate education program, in its processes, units, and products, responding to the needs of the academic community. Design, communication, training, production, administration, losses can be improved through this philosophy, where the possibilities of improvement and cost savings are enormous, but requires the commitment of time, talent, dedication, persistence and, of course, investment [17]; in the program, increase indicators and implement information systems did not have rejection, controls improved and evidenced community satisfaction, implementation of socialization practices of research initially presented rejection but in the end achievements and acceptance. There was improvement in the satisfaction of teachers, students and administrative staff in the effectiveness of services.

The determination of the capacity of the processes demonstrates that it can meet the estimation of the demand for services and needs of the community [18]. The main problem in external causes generally in production is the lack of computer equipment audio-visual's own program, which in many cases is the result of the procedures required to award a purchase product high process; in the case of university welfare processes the main problem focuses on response times to needs, procedures especially around schedules and postgraduate supply. The perception of service quality improved for the leader, managers, processes and services. Costs decreased and the number of beneficiaries increased. However, six sigma improvement is not achieved in all processes, but five sigma is obtained which indicates that there is still room for improvement in terms of process efficiency.

5. Conclusions

The implementation of six sigma in an academic program of a university institution allows to improve the capacity of the planning process, and cost reduction process, as well as to reduce the variability of the same and shows high correlation between customer satisfaction and the qualification of the management, as well as the achievements in the quality management system to reduce times, there was a significant increase of stimuli aimed at low-income students, areas of Catatumbo, Norte de Santander, Colombia, graduates, teachers of articles and participation in events, increased the capacity of the process in each of its indicators, observing tendency to stability of the same. Six Sigma intervenes in the culture of an educational organization and an academic program of a university institution. Control tools allow monitoring 99% of the achievements, transparency and progress in improving a process.

Implementing lean six sigma, improved response times, credibility in leadership, increased the capacity from 0.5 to 1.67, that is, the process goes from an inappropriate state to a satisfactory state. In the same way, the variability of the process decreased, showing efficiency in managing quality indexes within the normal, fostered the culture of continuous improvement of processes promotes competitiveness, more efficient processes, effective decisions, developing advantages and differentiation.

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