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Professional Competencies of Civil Engineers Through the QHS-Six Sigma Methodology

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ABSTRACT

The QHS-Six Sigma Methodology is used to promote the development of civil engineer professional competencies, encouraging comprehensive skills to ensure performance with knowledge, skills, and attitudes for systemic development with a focus on continuous improvement and innovation in the quality of professional services projects to clients in the construction industry. The provision of services of civil engineering professionals involves knowing aspects of the context of business, government, academia, associations, and consulting, as well as specific skills of teamwork, quality controls, project management and monitoring of key performance indicators (KPIs). Key aspects in the training of civil engineers, for the field of the construction industry with quality tools based are used to supervise and optimize the management of materials in projects. The contribution of the QHS-Six Sigma methodology in civil works projects is to improve critical thinking and problem-solving skills. Collaboration between students, faculty, and industry experts supports the teaching process and enables students to perform effectively in workplace work teams.

Keywords: Professional competencies, QHS methodology, Six sigma, Civil engineers, Engineer training

INTRODUCTION

There are materials on the market with different levels of quality, of course quality is implicit in the price, but buying cheaper material does not necessarily lower the cost of the work under construction (Suarez, 2002). There are two types of materials: natural and man-made. Natural materials used on site, e.g. sand, gravel, water, wood which are found in nature. On the one hand, these materials require a process which is made by man, so that they meet the necessary characteristics for which they will be used. In the field of construction, there are materials used generically, which are the following: cement, gypsum (ready mix), rod, profiles, paints, wiring, aluminium. The materials must have good quality and comply with the standards established according to each product. The control of the materials in the field must be given from their request, until the use of the material on site. It is important that all departments are in constant communication, to carry out the control of materials, from the moment of quantification to the request and the

departure of the material from the supplier to the delivery to the warehouse (Schmelkes, 2010).

Professional Competencies of Civil Engineers through the QHS-Six Sigma Methodology; its purpose is to create an eclectic proposal for an intervention model in the businesses of the construction industry, considering the different aspects of the different sectors of society from the systemic approach; Business, Academia, Government, Associations and Consultants. Likewise, the focus on continuous improvement in processes in the business units of companies specialized in the construction sector through civil engineering (Jiménez et al., 2014). This research is derived from a Master's Thesis project in Administration (TecNM, 2024), entitled "Control and Improvement of the supply of materials in civil works through the Six Sigma methodology" with a Case Study focused on the construction company Mareba. Following the scientific method of scientific research (Sampieri, 2008), the actions developed in each stage of the research are described below:

a) In Chapter I: the context of the construction company subject of the case study is analyed, the problem statement, the definition of the problem, the general objective specific objectives, as well as the hypothesis, the variables, the justification and limitations and delimitations.
b) Chapter II addressed the state of the art, the theoretical support, and articles of relevance to the research topic, enriching the research, analysis of the theories for the development of the research, in addition to describing in detail the methodology used: Six Sigma with a systemic approach of the QHS Methodology.
c) For the development of Chapter III, the analysis of the methodological design as a guide, describing the steps and form to carry out the research, as well as the definition of the subject, as well as the methods and techniques used in the development of instruments that were designed. Finally, the tabulation of the data is presented.
d) Chapter IV was oriented to the analysis and interpretation of the results of the research through the table that presents the analysis of material supply control, including percentages of loss, cost and time.
e) Finally, in Chapter V, the conclusion of the research and the recommendations to the construction company case study are presented, as well as the description of the proposed model as a guide for the analysis of Control and improvement of the supply of materials in civil works through the Six Sigma Methodology.

Nowadays, the challenges of systematizing good practices in the management of civil engineering businesses are of utmost importance to acquire new methods and tools that allow the development and optimization of the control of materials that are used in the development of civil works. The company, Case Study Constructor Mareba. It has developed and executed the construction of ponds with a dimension of 25 meters, 4 meters deep, and the laying of 6-foot pipes with a length of 3 kilometers. The project is located on the old Transpeninsular highway, Ejido Nueva Odisea in the San Quintín Valley of Baja California, Mexico.

RESEARCH MATERIAL AND METHODS

Alignment in physical flows and information must occur at the same time, to minimize errors, missing information, failed data entries that can cause delays in other activities and total blockage in subsequent activities. Alignment of objectives throughout supply chain management (SCM) all organizations have their objectives established, therefore, the objectives of the different projects, improvement plans, restructuring, growth, must lead to the achievement of three objectives of the company (Sánchez and Mantilla, 2012).

1. Focus elements: they are considered the basis for the development of projects with initiatives of expansion, change for improvement and exploration of opportunities.
2. Developmental elements: This is where the tools and principles of lean thinking, six sigma and logistics are integrated.
3. Outcome elements: Findings are expected to be obtained with the application of the proposed model to reduce process variability and defects through this six-Sigma objective it is intended to control the factors that generate variation to reduce defects.

QHS and Six Sigma Methodology Analysis

The alignment of the QHS Methodology of a systemic approach with the Six Sigma Methodology generates a new eclectic approach methodology that is presented in Figure 1. The QHS Methodology seeks sectoral integration and develops cross-cutting actions in the different sectors of society for growth (Martinez, 2020). And the approach of the Six Sigma Methodology is to achieve a level of quality (Inoco & Felix, 2013), where there are no more than 3.4 defects per million opportunities. The Six Sigma Methodology is a fundamental tool in continuous process improvement. Its name comes from the five phases:

1. Define: Clearly identify the problem or opportunity for improvement. This includes crafting a project charter, analysing stakeholders, and collecting the voice of the customer (VOC) to understand their needs and expectations.
2. Measure: Establish the current performance of the process by collecting relevant data. Data collection plans and process maps are created to visualize the status.
3. Analyze: Identify the root causes of problems using tools such as the fishbone diagram (Ishikawa), the 5 Whys, and Pareto analysis.
4. Improve: Develop and implement solutions to address identified root causes. This may include piloting and implementing improvements on a larger scale.
5. Control: Establish control measures to maintain the improvements achieved. This includes the creation of control plans, the standardization of processes and the continuous training of personnel.

Table 1. QHS-six sigma methodology in the civil engineering industry.

QHS Elements	6 SIGMA Elements	Description and Management Indicators
BUSINESS Sector; Civil engineering	DEFINE Civil Works needs	• Customers: Their needs and expectations • Processes: Executive Project and Roadmap
ACADEMIA Sector; Civil Engineer Training	MEASURE quantifies project information	• Application of Business Unit Principles • Development of tools by type of project • Management of Business Indicators
GOVERNMENT Sector; Construction Labor Standards Regulation	ANALYZE generate continuous improvement initiatives	• Compliance with Legal Requirements • Good Labor Practices in Employee Safety and Benefits
ASSOCIATIONS Sector; Construction Industry	CONTROL Project monitoring	• Quality of the service or product of the project • Service with qualifying attributes of care • Costs linked to competitiveness vs. competition • Taking care of the environment
CONSULTANTS Sector; Civil Engineering	IMPROVEMENT in projects	• Waste reduction (KPIs) • Improvements through innovation

The QHS Methodology is a strategic approach used primarily in the context of supply chain and logistics management. It focuses on integrating various levels of authority and management to develop standards of good practices, particularly in specialized talent management and competency certification. Here are some key aspects of the QHS Methodology (Martinez, 2021, 2022):

Systemic Integration: It involves a comprehensive approach to integrating different levels of management and operational practices to ensure consistency and efficiency across the supply chain.

Talent Management: Emphasizes the development and management of specialized talent within the organization. This includes training and certifying employees to ensure they meet the required competencies.

Business Intelligence: Utilizes business intelligence tools to analyse data from various sources, helping to improve decision-making processes and operational performance.

Innovation and Competitiveness: Focuses on innovation and the systematization of competitive practices through regulatory operation management models.

Customer Satisfaction: Aims to enhance customer satisfaction by ensuring high standards in quality, service, cost, and delivery time. The academic research conducted by experts in technical higher education at the Tijuana Institute of Technology focuses on developing strategies to enhance the competitiveness of the sector. This is done in consideration of the learning curve that has been generated in the strategic sectors of Mexico. The objective is to build the technique for Dictionaries of Sectorial Competencies (DSC) using the QHS approach (Martinez, 2020, 2021) as a systematic contribution to bridge the disparity in professional skill knowledge across occupational positions in important regional sectors, the goal is to build the DSC methodology. Table 2 includes the description of activities in each methodological phase of the QHS-Six Sigma Model Proposal for Civil Works Project. In addition, this will help to increase the relevance of graduates in professional employment as well as the competitiveness of higher education in scientific and technical fields.

Table 2. Six sigma methodology in project development.

Methodological Phase	Description of Project Activities
DEFINE Civil Works needs	Data collection with all staff in the field and office
	Definition of the universe and population
	Cuestionario Serv Qual (19 reactivos)
MEASURE quantifies project information	Detection of needs for improvement opportunity
	Information Mining Development and Graphing
ANALYZE generate continuous improvement initiatives	Apply the methodological tool of Cause-and-Effect Diagram: Applying an analysis of the 5M's + 1M
	Workforce (Man-employee profile)
	Working Methods (Staff Skills)
	Measurements (project management indicators)
	Machinery (equipment and tools needed)
	Raw Material (everything needed for the Project)
	Working Environment (project area)
CONTROL Project monitoring	Evaluation of the Questionnaire (Serv Qual)
	Analysis of preliminary results
	Control and improvement in material supply
IMPROVEMENT in projects	Development of learning curves
	Project phase monitoring and feedback
	Development of decision-making phases for effectiveness, efficiency, effectiveness, productivity and installed capacity (competitiveness level)

This methodology is very effective in solving complex problems and improving the quality and efficiency of processes in various industries. In Mexico, the National Council for Standardization and Certification

(CONOCER, 2024) establishes Competency Standards to certify the knowledge, skills, and abilities to perform specific functions in the civil works construction sector. The EC1024 Competency Standard, entitled: Supervision of the building, modification, extension of works in the house, has the purpose of serving as a reference for the evaluation and certification of the people who work as supervisors of the building, modification, extension of works in the house and perform the following functions: supervise the masonry work the building, modification, extension in the house, supervise the execution of electrical installations of the building, modification, extension in each room and supervise the installation of the hydraulic and sanitary network of the building, modification, extension in each room. The EC1024 is structured with three elements to obtain certification:

1. Supervise the masonry work of the building/modification/extension in each room
2. Verify the realization of electrical installations of the building, modification, extension in each room
3. Inspect the installation works of the hydraulic and sanitary network of the building, modification/extension in each room.

CONCLUSION

The QHS-Six Sigma model is representative of the proposal that integrates the elements and components, input of material to be used and the output of each of them. In the first element, the entrances and needs of civil works material Alga Marina were located. The second element is development to research refers to the Six Sigma methodology which is based as follows, define, measure, analyse, improve, control. These are the stages implemented in this research.

Description of the stages.

Define: Carry out data collection through Case, where everything from company director to warehouse personnel are involved.

Measure: The Mareba company holds a meeting Friday of each week to determine the causes that generate the untimely delivery of some material, and it is analysed by means of a Pareto diagram and the company's opportunities are detected.

Analyse: Field visits, management, purchases, are carried out to gather information with the resident of the site and warehouse of the most prosperous materials to be used. To get an upgrade and Ishikawa tool is used.

Improvement: Refers to the population of improvement by using a flowchart and obtaining the most relevant information.

Control: The evaluation of reagents that were obtained through field research, Case methodology, is carried out.

Recommendations

The following two elements are recommended for future research to obtain greater control in the supply of materials:

1. Proposal for the implementation of Six Sigma in civil works.
2. Factors of delivery times of completed civil works

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