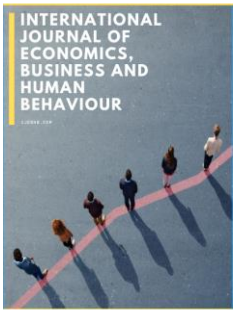
International Journal of Economics, Business and Human Behaviour (IJEBHB)

Volume 1, Issue 2, 2020-10-01, pp. 80-87,
Available at: https://ijebhb.com/ijebhb-issues/
ISSN Online:2693-1478 DOI: 10.5281/zenodo.4060778



Feasibility Study on the effectives of Total Quality Management model in Engineering Projects

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Abstract

TQM can be considered as a broad system method that "horizontally works" across an organization and involves every single employee as well as departments and extends back and forth to embrace both customers and suppliers. However, there has been a series of setbacks regarding many engineering project due to lack of sound Total Quality Management model that can be employed by key stakeholders. For that reason, the TQM framework in this feasibility study consisted of two levels and comprised of all TQM philosophical management elements. In particular, level 1 comprises TQM soft factors, while level 2 encompasses the underlying details of each soft factor. The survey consisted of about 14 experts in the field of engineering as well as seven from management levels from governmental the hotel industry and 7 form universities. To ascertain the consistency of the respondents (experts in the field of engineering), a binomial test was conducted to evaluate the null hypothesis, which states that "There are no differences among experts' opinions." From the results, it was identified that soft factors of TQM have a close relationship with each other. There was a positive correlation between four items, which were "committed leadership, closer customer relationship, benchmarking and process improvement". Using Columbia Basin Project (CBP) as a case company, it was realized that that leaders of Odessa Ground Water Management Subarea in CBP needs to consider implementing the TQM framework to improve their project viability and consequently reduce costs.

Keywords: Total Quality Management, Engineering project, Cost Reduction, and Soft Factors.

Introduction

Background

Columbia Basin Project (CBP) has been undergoing continual development to replace the underground water for irrigation with surface water in the "Odessa Ground Water Management Subarea," USA. Regarding civil engineering services, TQM is very vital because it is the system that maintains the engineering mission and takes care of the public health such as the supply of clean water to hotels. It has also been argued that hotel industry has been seriously affected by the pervasive use of TQM globally and it is increasingly being "identified as the key issue in

Received : 20.09.2020

Revised : 29.09.2020

Accepted : 01.10-2020

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differentiating service products and building competitive advantage in tourism" (Sin Kit, Muhammad Shahar, and Noormaizatul Akmar, 2018, p.1). Consequently, hotel industries can experience a diverse range of "of saturated and uncertain TQM practices" that are currently used in the tourism industry. However, the hotel industry is separate from engineering projects. Since there is the absence of widespread knowledge concerning issues in TQM in the engineering projects, there is the need for implementing a process that will assist various engineering firms in the USA in the evaluation of TQM practices and identify the most suitable so that ultimate organizational management practices can be provided in engineering projects. Nevertheless, there have been concerns about the widespread gaps in TQM as far as the Engineering Education is concerned. Some studies have established that these gaps does not only negatively affect the "employer dissatisfaction", but also unemployment (Sapra, 2017).

At present, there has been significant depletion of groundwater in the Odessa Subarea to the degree that needs pumping of water from very great depths. In some places, water pumping goes past 750 feet underground, and wells can go as deep as 2101-2401 feet below the ground. Drilling of wells and water pumping mechanisms from such depths have resulted into costly power consumption as well as declining quality of water due to high concentrations of sodium and increased temperatures. The surrounding hotels, restaurants, commercial, domestic, industries, and municipal authorities are exposed to the use of poor water quality. Moreover, the irrigation wells with low water intake are exposed to a shorter lifespan and reduced water production in future. The prolonged sustenance of these wells can be achieved by using a sound water drilling mechanisms and proper management of such projects through the incorporation of a better TQM framework.

What is TQM in Engineering Management?

Some scholars had tried to give various definitions of TQM. Some have referred to TQM as the method of managing an organization to improve the productivity and quality in such organizations, especially large multinational corporations and business (Shweta, Ruchi, and Monika, 2018). From the perspective of Engineering Management, Total quality management (TQM) can be defined as "a process of continuous improvement in its efforts to manage expectations are met, clients or customers efficiently" (Jamei, Shahamat, and Fani, 2013, p.301). From this perspective TQM can be seen as a philosophy of management whose primary objective is to fulfil "the needs and requirements of internal and external customers" (Jamei et al.,2013) through the creation of organizational culture that involves all stakeholders at each "stage of creating product and services" (Shweta et al., 2018).

This current study defines TQM based on the definition that was given by Ismyrlis and Moschidis (2015). According to Ismyrlis and Moschidis (2015), "TQM is a management based approach with the participation of all members of an organization in improving processes, products, services and the culture to achieve a higher level of satisfaction of customers and other associated stakeholders" (p.498).

Why TQM in Engineering Projects?

Total Quality Management, Engineering project, Cost Reduction, and Soft Factors.

Sin Kit et al., (2018) suggests that "TQM is a suitable way to relatively achieve efficiency and effectiveness which in turn leads to achievements such as success in long-term, meeting the workers', customers' and other interested parties' needs in the society. It is what can, as a key and efficient means, give a practical aspect to the total quality management and change it from being merely theoretical "(p.232). The primary role of quality managers in ensuring effective TQM is very vital. Managers, therefore, need to be at the forefront of improving the quality of their organization, identifying both common and distinctive sources and distinguish them from one another. As argued by Sin Kit et al., (2018), TQM principles are "focusing on clients, leadership in management, workers' contribution, procedural approaches, systematic approach to management, continuous improvement, decision making based on facts and beneficial and mutual relationship to the providers" (p. 232). Implementing TQM in engineering projects' management is therefore very essential as it can lead to several positive results. According to Jamei et al. (2013), the results of TQM is an increase in "employee engagement, improve relationships, increase production, improve quality, reduce rework, and increase customer satisfaction, reduce costs and improve competitive advantage is of poor quality" (p.301).

TQM in Engineering Management

In service sectors such as ICT, TQM aims at accomplishing the "effectiveness of the system such as production, design, planning, quality tools, techniques involvement as well as customer satisfaction as it has potential not only to reinforce competitiveness but also to strengthen firm effectiveness and produce more satisfied customers" (Khanam, Talib and Siddiqui, 2015, p .21)". Concerning engineering services, an effective TQM definition that links both stakeholders and customers need to incorporate "the meaning of conformance to internal specifications" that customers tend to require as well as fulfilling the endlessly changing stakeholders' and customers' requirements within the organization (Fotopoulos and Psomas, 2010).

Research Methods and Evaluation Criteria

Method of Analysis

This feasibility study utilized a sample statistical method that is based upon TQM soft factors framework. These soft factors were then used to design the questionnaire for the field study. For that reason, the TQM framework in this feasibility study consisted of two levels and comprised of all TQM philosophical management elements. In particular, level 1 comprises TQM soft factors, while level 2 encompasses the underlying details of each soft factor. It is this second level that was used to determine the strategies of measuring each soft factor and the way in which such TQM soft factors can be implemented effectively. The categorization of these soft factors is presented in figure 1 in the appendix below.

It is worth noting that the proposed framework is derived from a mixed research method, which involved semi-structured questionnaire and surveys. The survey consisted of about 14 experts in the field of engineering as well as seven from management levels from governmental the hotel industry and 7 form universities. To ascertain the consistency of the respondents (experts in the field of engineering), a binomial test was conducted to evaluate the null hypothesis, which states that “There are no differences among experts’ opinions.” Each expert was required to indicate his/her expert opinion by choosing either letter “1=Agree” or “2=Disagree”. It was assumed that about 50% of Engineering Experts participated in the survey and for that reason, agreed with the model, representing about 0.50. The binomial test result is shown in the table below.

Table 1: Binomial test Results

Soft Factor	Percentage inAgreement	Percentage in Disagreement	Test Proportion	Exact Significance level(2tailed)
1	0.81	0.19	0.50	0.021
2	0.81	0.19	0.50	0.021
3	0.81	0.19	0.50	0.021
4	0.81	0.19	0.50	0.021
5	0.88	0.13	0.50	0.004
6	0.81	0.19	0.50	0.021
7	0.88	0.13	0.50	0.004
8	1.00	1.00	0.50	0.000
9	0.88	0.13	0.50	0.004
10	1.00	1.00	0.50	0.000

From table 1, it was clear that the null hypothesis was rejected and for that reason, a conclusion was drawn that “there is a difference among the experts’ opinions.” Based on the ‘Percentage in agreement’, which are above 0.80, it can be contended that, at 0.95 confidence level, the majority of Engineering Experts agreed with the proposed framework of TQM in an organization.

The Results of the Study

The main research findings are presented in the table below

Table 2: TQM soft factors’ Results

Soft Factor	Item	Mean	Std.Dev.
1	“Committed Leadership”	4.1970	0.58760
2	“Adoption and Communication”	3.6820	0.63630
3	“Closer Customer Relationship”	3.7580	0.78570
4	“Closer Supplier Relationship”	3.6820	0.63630
5	“Benchmarking”	3.3940	0.72660

6	"Increased Training"	3.3940	0.69900
7	"Open Organization"	3.6210	0.73930
8	"Employee Empowerment"	3.7120	0.57550
9	"Zero Defect Mentality"	3.5760	0.58340
10	"Process Improvement"	3.7420	0.61550

Total Quality Management, Engineering project, Cost Reduction, and Soft Factors.

In table 2 above, it is evident that the highest soft factor is 'Committed Leadership,' while 'Benchmarking and Training' denote the least soft factors' values. The calculated value of the Cronbach's Alpha was found to be 0.8330. This value depicts a satisfactory level of reliability.

Table 3 A Two-tailed Person Correlations Test of "TQM soft factors."

No.	TQM Soft Factors	1	2	3	4	5	6	7	8	9	10
1	Committed Leadership	1	0.458**	0.572	0.499**	0.509**	0.445**	0.422**	0.352**	0.517**	0.483**
2	Adoption and Communication		1	0.490**	0.392**	0.543**	0.321**	0.590**	0.418**	0.501**	0.652**
3	Closer Customer Relationship			1	0.336**	0.510**	0.401**	0.449**	0.354**	0.578**	0.537**
4	Closer Supplier Relationship				1	0.310*	0.286**	0.329**	0.376**	0.252*	0.377**
5	Benchmarking					1	0.372**	0.402**	0.477**	0.366**	0.502**
6	Increased Training						1	0.353**	0.401**	0.416**	0.490**
7	Open Organization							1	0.427**	0.406**	0.628**
8	Employee Empowerment								1	0.410**	0.352**
9	Zero Defect Mentality									1	0.462**
10	Process Improvement										1

*Significant at 0.05, **Significant at 0.01

From table 3, it can be seen that the highest correlations are denoted by "committed leadership, closer customer relationship, Benchmarking" and "process improvement," whereas "Training" does not represent any significant relationship with other soft factors of TQM.

Implementation of TQM in Engineering Project

Resources Needed

1) *Civil Requirements:* During the feasibility study, the main materials that were identified, from the perspective of civil engineering requirements, are sand and gravel pits. These were estimated to be approximately "10-mile haul" from the Moses Lake region. This region will provide the required sand, gravel, as well as cobbles for various drains and filters.

2) *Mechanical Equipment:* By adopting a proper TQM framework, it was realized that 8-centrifugal pumps at about 102 feet total head, each with a rating of "r 91.9 ft^3/s (41,240 gpm)" will be required to pump the water. By applying TQM, it was realized that the pumping plant would minimize the requirement of spare parts by about 40% of the initial construction design without using TQM.

Other mechanical pumps required were Synchronous motors, with 1250Hp and 506 RPM to drive the pump, Steel Piping, and Valves, and Auxiliary Mechanical Systems such as "gravity drainage system, fire suppression system, compressed air system, non-potable service water system, sanitary waste system, cooling water system, and HVAC system."

3) *Electrical Requirements:* the electrical systems will be responsible for the constant supply of power to the lightning as well as the equipment. These will include the SCADA system, a 16MVA, 115-4.18kV oil-filled power transformer, 115kV Substation and Transmission Line, SF6 gas-filled CB, and other switch gears.

Costs

The total estimated cost of the underground irrigation water pumping includes both Field Costs and Noncontract costs. These costs are primarily based on the water supply and delivery alternatives that can be realized using the TQM model. Besides, other costs such as annual Power Consumption and "Operation, Maintenance, and Replacement (OM&R) costs" for different alternatives are also involved.

Field estimates: when using the new TQM model, the field cost estimates that are associated with this feasibility study included the following:

- Mobilization. These costs comprise of costs of mobilizing employees such as contractor personnel and materials to the project construction site at the early phases of project development.
- Design Emergencies. These are meant to cater for risks such as alterations in design and scope, expenses associated with estimating refinements, and unlisted items
- Construction Contingencies. These are the funds that are needed to be spent, should there be a need for, after the completion of the project.
- Allowance for Procurement Strategies (APS). These comprise of solicitations that are set aside "under socioeconomic programs" as well as those that may hinder competitions or proposal allowance for the lowest bid.

Noncontract Costs: these costs will be classified as categorized below:

- *Service Facilities.* These are items that are required in the process of construction of permanent property such as an underground pumping plant.
- *Land Cost, Rights, and Realty.* These are items that are necessary in the initial "construction of the project".
- *Engineering Design.* These involve the review and the preparation of various construction estimates, specifications, final designs, and engineering drawings.

Discussion and Evaluation of Feasibility Criteria

From the results, it can be seen that soft factors of TQM have a close relationship with each other. There was a positive correlation between four items, which were "committed leadership, closer customer relationship, benchmarking and process improvement." Based on these results, any Engineering Company or service Industry manager is thus encouraged to put more focus on the four factors to come up with the most appropriate model for implementing TQM. In this feasibility study, the lowest value was denoted by "closer supplier relationship and zero defect mentality." Thus manufacturing companies may need more factors such as 'supplier relationship' than required by other service industries. Because the feasibility study involved even those managers from companies that provide engineering services to customers, "internal activities" of the workers could be the central explanations for providing proper services and not suppliers.

Total Quality Management, Engineering project, Cost Reduction, and Soft Factors.

To evaluate the effectiveness of implementing TQM models in Engineering Project management and ascertain its feasibility, one matrix was processed to identify key benefits of TQM framework. For that reason, the TQM model was required to meet at least three of the four general criteria: Technological Feasibility, Economic Practicality, Social Desirability, and Ecological Soundness as shown below.

Table 4: Assessment Matrix for TQM model in the Improvements of Engineering Project Objectives

TQM Model Benefit	**Technically feasible**	**Economic Practicability**	**Social Desirability**	**Ecological Soundness**
Site design Specifications	Yes	Yes	No	Yes
Power Consumption	Yes	Yes	Yes	Yes
Project-pre planning	Yes	Yes	No	Yes
Identification of Hazardous materials	Yes	No	Yes	No
Incident Modelling	Yes	Yes	Yes	Yes
Committed Leadership	N/A	No	Yes	N/A
Project Improvement	Yes	Yes	Yes	Yes

Conclusions and Recommendations

Conclusions

There is a great potential of addressing the problems that are pertinent to engineering-quality that are associated with Total quality management (TQM) in several manufacturing industries, including health centers, as well as improving the performance of the organizations. In this feasibility study on the effectiveness of adopting TQM in the underground pumping plant, it has been established that organizations can enhance the effectiveness of their Engineering projects by focusing on leadership. At least three factors were met by the TQM benefits of Site design Specifications, Power Consumption, Project-pre planning, Identification of

Hazardous materials, Incident Modelling, Committed Leadership, Project Improvement. In general, the specific functions of the TQM in engineering projects successfully "passed" the matrix and, through effective leadership skills, this framework can be implemented in most capital-intensive projects to reduce expenses.

Recommendations

Concerning the conclusions are drawn from the feasibility analysis, it is recommended that leaders of Odessa Ground Water Management Subarea in CBP needs to consider implementing the TQM framework to improve their project viability and consequently reduce costs. It can also be argued that "senior management and employee involvement "in a capital-intensive project are key to TQM implementation in engineering.

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