Assessment of ISO 9001 and TQM implementation in Construction Projects [1]

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Abstract

The effects of a quality management system or its effectiveness towards projects and organizational performance have remained questionable in the minds of many engineering and project management professionals. The high cost of implementing the management system requires that the results bear fruit to the organization**.** An ISO 9001 accredited organization is expected to implement quality management system requirements for all its area of business including projects, facilities, people, training, services, and equipment.

This research focused on ISO 9001 used as a tool to continually improving engineering project deliverables performance (product) to streamline operations while reducing costs. Barriers to total quality management (TQM) implementation in projects were also evaluated. A case study, a survey questionnaire was divided into two categories: ISO 9001 implementation and barriers of TQM implementation. The purpose of this paper is to demonstrate how implementing ISO 9001 and TQM can address the project process continuous improvement, combining both a project-level and an organizational-level perspective as well as sustaining organizational continuous improvement of project management processes and capabilities.

Keywords: Project quality management, ISO 9001, total quality management (TQM)

Introduction

Adams, McQueen & Seawright (1999-563) indicated that ISO 9001 family of standards has been developed to assist in all organizational sectors irrespective of size, type, and activity to implement and operate an effective project quality management system. Aarts & Vos (2001-181) said that the solicitation of quality international standards is beneficial to plant owners, service providers, regulators, and users. The standard is widely adopted to improve competitiveness around the world, but with mixed success according to Anderson & Sohal (1999-871). There is much criticism of ISO 9001 certification because it is not a risk-free undertaking and that it does not guarantee improved performance due to the high cost associated with its implementation, said Beaumont, Sohal & Terziovski (1997-8). Varies studies confirmed that ISO 9001 certification is too expensive, resource-consuming, time-consuming, neutral, formalized and that cost far exceeds the benefits derived according to Brah, Wong, Madhu & Rao (2000-11).

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On the other hand, organizations are increasingly dependent on each other for business, and standardization needs to meet the changing expectations of regulatory authorities, stakeholders, and society. Taylor (1995-41) assumed that the risks of doing wrong are high today requiring that the management system have to be carefully positioned according to international standards because customers and manufacturer distance has increased due to globalisations. Sun (2000-168) supposed that the project quality management system needs to be supported by the organization's strategy, policies, and goals to enjoy more benefits from this certification. Zhang (2000-10) specified that quality may be considered as a strategic competitive tool, and organizations cannot afford to ignore the strategic implications of quality for their competitive position and that ISO 9001 has capabilities of generating a competitive advantage only if management is committed to program implementation from a strategic perspective. Easton& Jarrell (1998-258) proposed five ISO 9001 performance perspectives are financial, Customer perspective, process perspective, growth perspective, corporate mission perspective.

Singels, Rüel & Van der Water (2001-66) whispered that quality management is a philosophy of continuous organizational success through customer satisfaction, based on the participation of all employees in continuously improving processes, services, and products. It is also evident that willingness and the ability to change and to improve, based on innovation lessons learned and benchmarking, are necessary components within the quality management approach. Deming classifies 14 points summarising and operationalizing his philosophy (Known as Deming 14 points). Goetsch and Davis (2013-12)

According to Goetsch and Davis (2013-18), total quality management (TQM) is an approach to doing business that attempts to maximize the competitiveness of an organization through the continual improvement of the quality of its products, services, people, processes and environment. Foster (2010-25) alleged that the total quality approach targets everything in a project that affects quality for continuous improvement. The results of effective application of total quality include superior value, global competitiveness, and organizational excellence focusing on:

- Measurements – this approach believes that measurements determine the actions to be taken.
- People – empowering employees to drive business performance.
- Processes – continuous improvements of process directly yield product or service improvement. (Stamatis, 2003-43)

The Deming cycle is used as a continuous improvement tool that focuses on customer needs and on organizational resources for cooperative efforts to meet those needs, according to Goetsch and Davis (2013-11). The main contents of TQM are market advantage, process efficiency, reliability, and design efficiency (Jurca, 1999-22).

Research hypothesis

The logic of hypothesis testing is based on the formulation of mutually exclusive hypothesis statements that, together, exhaust all possible outcomes and testing of these so that one is necessarily accepted and the other rejected. The following hypotheses were deduced:

Hypothesis 1

In this research hypothesis one, the independent variable is ISO 9001 certification while the dependent variables are the project performance. The figure below the certification conceptual framework.

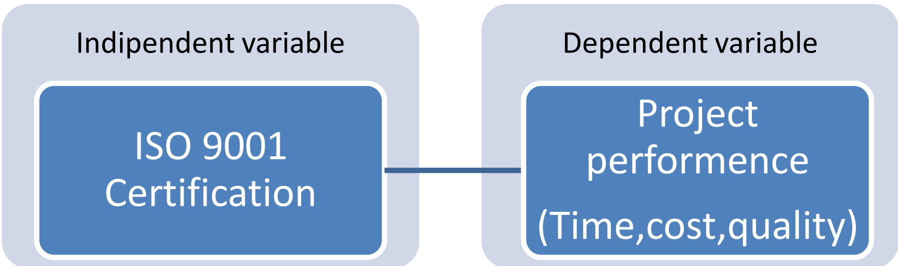

Figure 1 ISO 9001 certification conceptual framework

H1: There is a relationship between PMO ISO 9001 certification and project performance

Hypothesis 2

In this research hypothesis two, the independent variable is TQM implementation while the dependent variables are the barriers to TQM implementation. The figure below the certification conceptual framework.

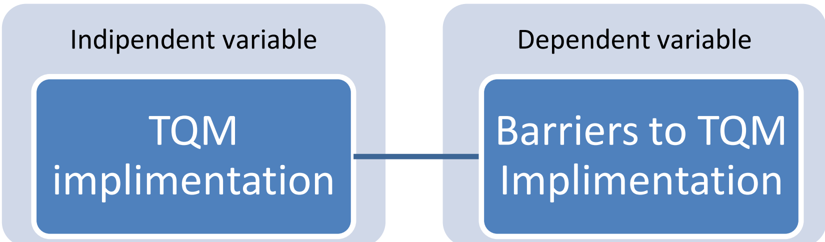

Figure 2 TQM implementation conceptual framework

H2: There are common barriers that affect TQM implementation in engineering projects.

Literature review

Evolution of quality management

Goetsch and Davis (2013-38) point out that quality management can provide a clearly defined structural framework in which all organizational activity occurs. Employees must be empowered through self-directed or cross-functional workplace teams, multi-skilled flexible workforces, or dynamic workplace environments to ensure that they contribute maximally to organizational performance. Table 1 below shows five major phases of quality evolution.

Table 1: Phases of project quality evolution (Goetsch and Davis, 2013-30)

Identifying characteristics	**Inspection**	**Statistical quality control**	**Quality assurance**	**Strategic quality management**	**Competitive continuous improvement**
Scope	Product quality	Process quality	Total quality		Excellent-sustainable organization
Action	Reactive to quality problems		Proactive or preventing quality failure		Flexible, responsive, adapt quickly to changes
Focus	Conformance to specifications	Conformance to Customer	Total customer satisfaction	Customer comes first	Continuously add value to the organization's stakeholders
Orientation	Inspect quality	Control quality	Build-in quality	Manage quality	
Methods and concepts	Gauging and measurement	Statistics: SPC sampling plan	Management practice	Integrating management practice	
Measure	Finished goods	In-process measurement	Entire production chain	Quality management system	Stakeholder satisfaction
Primary concern	Inspection	Detection	Coordination	Strategic impact	Continuous improvement
Quality target in production	No standard			Zero defect	
Key responsibilities	Inspector	Quality department	Active involvement of the entire organization		

Operating philosophy	Craftsman to mass production	Mass customization	Flexible specialization

How is total quality different?

Hatala & Maras (1997-18) indicated that total quality is different from the traditional ways of doing business, and it can be found on how it is accomplished. Easton & Jarrell (1998-254) thought that the three-legged stool of total quality are measurements (statistical process control, people (quality is built-in, quality is expected not inspected, employees are empowered) and processes (continual improvement). Goetsch and Davis (2013-25) whispered that TQM is different from traditional management which views management as a commodity and is passive contributors with little autonomy. In TQM practice, people are active contributors and are recognized for their creativity and intelligence. In traditional management, there is no innovation in this regard because quality is the adherence to internal specifications and standards. Evans & Lindsay (2014-21) pronounced that inspection is required to control defects. Cali (1993-34) point out that TQM defined quality as products and services that go beyond the present needs and expectations of customers which required innovation for improving quality continuously.

How is total quality achieved?

Dhillon (2002-45) indicated that the total quality approach has the following characteristics: Customer focus (internal and external), obsession with quality, use a scientific approach to decision making, teamwork, continual process improvement (people, processes, products, services, and environment), education and training, freedom through control, unity of purpose, employee involvement and peak performance as a top priority (Goetsch and Davis, 2013-289). The QMS must be continuously evaluated for its effectiveness against the objectives (elements of QMS). The evaluation of the effectiveness of the QMS will be carried out in four stages:

- Performance assessment in functioning level – evaluate processes, efficiency of the process criteria, expenses of quality, and effectiveness of quality.
- Quality-centered assessment of the ashplant – evaluate quality culture and the requirements of ISO 9001.
- The principles of management for sustainable success – evaluate the management of financial flows, development of staff proficiency, risk management, and the evaluation of the work environment.
- Generalized index – focus on all aspects of the QMS.

TQM implementation process

The 20-step TQM implementation processes shown in Table 2 below, provides a framework for any organization, with only a little adjustment here and there to accommodate organization-specific requirements understanding that no two TQM implementations will be the same. The three phases of the implementation model are preparation, planning and execution (Goetsch and Davis, 2013-21)

Table 2: TQM implementation process (Goetsch and Davis,2013))

Phase	Action by	Steps
Preparation	Top executive	1. Commitment to total quality
		2. Form total quality steering committee
	Consultation	3. Team building
		4. Total quality training for the steering committee
	Total quality steering committee	5. Create a vision, guiding principle
		6. Set broad strategic objectives
		7. Communicate and publicise
		8. Identify organisation strength and weaknesses
		9. Identify advocates and resistors
	Steering committee augmented	10. Baseline employee satisfaction/attitudes
		11. Baseline customer satisfaction
Planning	Steering committee	12. Plan implementation approach (Plan, do check , act)
		13. Identify projects
		14. Establish team composition
		15. Provide team training
Execution	Project teams	16. Team activation and direction
		17. Team feedback loop with steering committee
		18. Customer satisfaction feedback loop
		19. Employee satisfaction feedback loop
	Steering committee	20. Modify infrastructure as necessary

Comparison ISO 9000 and total quality management (TQM)

Goetsch and Davis, (2013-27) pronounced that the two main quality initiatives in the world today are ISO 9001 and total quality management. It is important to understand the similarities and differences between the two. The following statement outlines the relationship:

1. ISO 9001 is compatible with and can be viewed as a subset of TQM - TQM and ISO 9001 is not the same thing. TQM embraces all characteristics of ISO 9001, but ISO 9001 is not obsessed with quality, partially long-term commitment, partially employees' involvement as TQM does.

2. ISO 9001 and TQM are related not interchangeable – by definition, ISO is concerned only with management systems for design, development, purchasing, production, installation, and servicing of products and services. Total quality encompasses every aspect of the business including systems, processes, and all support systems (human resources, finance, and marketing) and involves every function and level of the organization from top to bottom.

3. ISO 9001 is frequently implemented in a non-TQM environment – TQM is not a prerequisite of ISO 9001 implementation. Most ISO 9001 registered organizations are not compliant with TQM requirements.

4. ISO 9001 can improve operations in a traditional environment – when ISO 9001 is implemented in an organization, it should be better for it. This means that if the commitment from top management is not there, the system will end up being a marketing tool, while the organization's functional department might develop even more problems than they had before ISO 9001.

5. ISO 9001 can be redundant in a mature TQM – all ISO 9001 requirements should be achieved in a mature TQM environment (above 600 on a scale of 1000 points). Registration with ISO 9001 can only assist with marketing if the company products are not yet considered world-class.

6. ISO 9001 and TQM are not in competition – organizations can adopt either TQM or ISO 9001, or both because the two concepts fit well with each other and have similar aims.

Research design

Montgomery (2005-346) points out that planning an experiment requires decisions to be made on what measurements to make (the responses), what conditions to study (the treatments), and what experimental material to use (the units). A survey questionnaire was designed to address the process, management, or leadership. This section focused mainly on perceptions of the research populations towards a QMS (ISO 9001) and its effectiveness in the power plant performance. This survey questionnaire also focused on identifying barriers of TQM implementation in power plants, which will be used to measure the possibility and practicality of implementing TQM successfully.

Questionnaire design

This survey questionnaire was designed to investigate the South African quality problems in the construction industry and analyze them in the context of ISO 9001 and TQM requirements. The main purpose was to investigate whether the construction industry complied fully with the ISO 9001 requirement or complied partially with the requirements so that the elements of non-conformance could be attended first. The second point was about the stage and step of the construction companies in the TQM implementation process. The third point was about identifying critical factors that could lead to the successful implementation of ISO 9001 in construction firms and addressing barriers encountered in the implementation process. The fourth point was about investigating the level of knowledge about both ISO 9001 and TQM among construction firms management and staff to determine the integration level between ISO 9001 and TQM. A good research method must specify a data-collection process, an instrument development process, and a sampling process.

The questionnaire was designed to measure elements of a QMS and its requirements based on ISO 9001 and TQM literature reviews. The following steps were followed during this research project:

1. A pilot study was conducted to verify and validate the need for a research plan. The aim was to establish whether the questionnaire was correctly structured and how people could relate quality to different elements or aspects of the QMS.

2. A conceptual framework was developed based on the information gathered during the pilot study including criteria for the target participants.

3. A literature study was conducted to gain knowledge about quality management systems mostly ISO 9001 and TQM which are also viewed as the current best practices in terms of quality management.

4. During the pilot study, queries were made regarding some questions, and clarity was provided, which resulted in some amendments to the questionnaire. Some participants also noted that the questionnaire was straight forward.

5. The final research design was based on the pilot study and literature review results.

6. The survey was sent to participants by email and the period to complete was stipulated.

Data received was collected, captured, and assigned correctly. Data was analyzed to determine the research findings, which were used to formulate conclusions and recommendations.

Research population

A research population is generally a large collection of individuals or objects that is the main focus of a scientific query. It is for the benefit of the population that research is done. The identified research target population for this study was the South African construction industry. The following characteristics were considered in selecting the participants: occupation, years of experience, age, highest qualification, and discipline.

Pilot survey

The questionnaire was tested with five individuals who were also part of the sampling population. The aim was to detect any problems with the questionnaire so that they could be corrected before the main/real survey. Four open-ended questions were converted into rated scale questions after identifying the range of possible answers from participants. A trial analysis was also performed during the pilot survey to test the analysis procedure. All amendments were made to the main questionnaire to maximize the respondent rate and minimize the error rate on answers.

Validity of the test instrument

According to Kothari (2004:81), research test instrument validity refers to the degree to which the instrument represents a concept of the measured research. Validity is concerned with the extent to which an instrument measures what it is intended to measure. Quantifying research variables measurement involves the operationalization of contrasts in defined variables and the development and application of instruments or tests. A measure is said to have content validity only if there is general agreement among experts that the instrument covers all aspects of the item being measured.

Reliability of the test instrument

Cronbach's coefficient is the most widely used objective measure of reliability (internal consistency). The generally agreed-upon lower limit for Cronbach's alpha is 0.70. An internal consistency analysis was performed to assess the reliability aspects of Likert Scale variables. The Cronbach's alpha range was between 0.715 and 0.837. The summary of the reliability analysis is given in Table 3 below. The alpha values indicate that the test instrument of this study is a sufficiently reliable measure.

Table 3: Cronbach's alpha range

Construct	No of Items	Alpha Value
Management Leadership	6	0.756
Measurement and Feedback	5	0.837
Continuous Improvement	4	0.778
Supplier Quality Management	5	0.832
Systems and Processes	4	0.715
Education and Training	4	0.794
Work Environment and Culture	4	0.745
Barriers to TQM implementation	15	0.764

Response rate

Thirty-seven (37) questionnaires were sent out project quality management professionals who are professional members. The response rate is summarised in Table 4 below:

Table 4: Questionnaire response rate summary

Column 1	Column 2	Column 3
Description	**Number**	**Percent**
Distributed questionnaires	37	100%
Received questionnaires	33	93%
Usable questionnaires	2	1%

Data analysis techniques

Statistical methods were used to analyze interpreted data collected through the survey questionnaires, including factor analysis, measuring variation, measuring association, and descriptive statistics.

1. The descriptive design was chosen due to its ability to analyze single variables and rank measured variables within each concept, indicating the current context of ISO 9001 implementation in construction projects.

2. Correlation tests purpose is to find out if there is a relationship and the extent of the relationship. Correlations close to +1.0 (or -1.0) designate strong positive (or negative). Correlations close to 0 designate little or no relationship between two variables.

3. Factor analysis was used to detect the structure of the relationships between variables and find underlying categories that best describe the construct.

4. The Chi-Square test was used to measure variations mainly to test any significant differences between groups or variables. It is useful as a general test to check whether significant differences exist between groups in contingency tables; only when the distance is less or equal to 0.05, is considered significant.

Results

Management system requirements survey results

All questions in this section were shortened to fit in the results table below, the questionnaire addressed two requirements which were:

1. The level of perceived importance of the QMS elements on a five-point Likert scale ranging from 1 = not important at all, 2 = not important, 3 = neutral important, 4 = important and 5 = very important.

2. The extent or degree of practice the particular elements receive in a day to day ash plant operation. This was also ranked on a Likert scale ranging from 1 = very low, 2 = low, 3 = moderate, 4 = high, and 5 = very high.

Management and leadership

Calculated

Importance chi-square value = 5.328, df = 5, P= 0.377. The p-value is 0.377175. The result is not significant at $p < 0.05$.

Practiced chi-square value = 5.286, df = 5, P=0.382). The p-value is 0.381982. The result is not significant at $p < 0.05$

Table value

At 5% chi-square value =11.070, df = 5, P=.0.05. The p-value is 0.05001. The result is not significant at $p < 0.05$.

At 1% chi-square value =15.086, df = 5, P=0.01. The p-value is 0.010001. The result is not significant at $p < 0.01$.

Table 5: Management and leadership results

	Important				Practised			
F1: Management Leadership	Mean	SD	Variance	P_SD	Mean	SD	Variance	P_SD
Q1:Business objectives known	4.44	0.73	0.53	0.68	2.92	1.12	1.25	**1.05**
Q2:Staff involvement	4.67	0.50	0.25	0.47	2.89	0.93	0.86	**0.87**
Q3:Employees empowered	4.11	0.78	0.61	0.74	3.00	0.50	0.25	**0.47**
Q4:Communication links	4.78	0.67	0.44	0.63	3.44	0.53	0.28	**0.50**
Q5:Management care	4.56	0.53	0.28	0.50	3.33	0.50	0.25	**0.47**
Q6: Social responsibility	4.67	0.71	0.50	0.67	3.67	0.87	0.75	**0.82**
Average	**4.54**	**0.65**	**0.44**	**0.61**	**3.21**	**0.74**	**0.61**	**0.70**

Resource management

Calculated

Importance chi-square value = 4.260, df = 4, P=.0.372 . The p-value is 0.371961. The result is not significant at p < 0.05.

Practiced chi-square value = 4.230, df = 4, P=0.376. The p-value is 0.375773. The result is not significant at p < 0.05

Table

At 5% chi-square value =9.488, df = 4, P= 0.049. The p-value is 0.049994. The result is significant at p < 0.05.

At 1% chi-square value =13.277, df = 4, P= 0.009. The p-value is 0.009999. The result is significant at p < 0.01.

Table 6: Resource management results

	Important				Practised			
F2: Resource Management	**Mean**	**SD**	**Variance**	**P_SD**	**Mean**	**SD**	**Variance**	**P_SD**
Q1:Human resource ability	4.56	0.53	0.28	**0.50**	4.11	1.17	1.36	**1.10**
Q2:Training provided	4.67	0.50	0.25	**0.47**	4.11	0.93	0.86	**0.87**
Q3:Employees given tools	4.67	0.50	0.25	**0.47**	3.78	0.97	0.94	**0.92**
Q4:Sufficient Finance	4.38	0.74	0.55	**0.70**	4.22	0.67	0.44	**0.63**
Q5: Effective material management	4.44	0.73	0.53	**0.68**	2.78	0.83	0.69	**0.79**
Average	4.54	0.60	0.37	0.56	3.80	0.91	0.86	0.86

Measurement and feedback

Calculated

Importance chi-square value = 4.235, df = 4, P=0.375. The p-value is 0.375135. The result is not significant at $p < 0.05$

Practiced chi-square value = 4.242, df = 4, P=.00. The p-value is 0.374244. The result is not significant at $p < 0.05$.

Table

At 5% chi-square value = 9.488, df = 4, P=0.049. The p-value is 0.049994. The result is significant at $p < 0.05$

At 1% chi-square value =13.277, df = 4, P= 0.01). The p-value is 0.009999. The result is significant at $p < 0.01$.

Table 7: Measurement and feedback results

	Important				Practised			
F3: Measurement and Feedback	**Mean**	**SD**	**Variance**	**P_SD**	**Mean**	**SD**	**Variance**	**P_SD**
Q1:Customer satisfaction	4.56	0.73	0.53	**0.68**	3.22	0.44	0.19	**0.42**
Q2:Quality data collected	4.33	0.71	0.50	**0.67**	3.44	0.73	0.53	**0.68**
Q3: Financial performance	4.44	0.73	0.53	**0.68**	4.33	0.71	0.50	**0.67**
Q4:Employees views	4.56	0.73	0.53	**0.68**	3.22	1.20	1.44	**1.13**
Q5:Employee performance	4.44	0.73	0.53	**0.68**	4.22	0.44	0.19	**0.42**
Average	4.47	0.72	0.52	0.68	3.69	0.70	0.57	0.66

Continuous improvement

Calculated

Importance chi-square value = 3.720, df = 3, P=0.29. The p-value is 0.29333. The result is not significant at $p < 0.05$.

Practiced chi-square value = 3.179, df = 3, P= 0.365. The p-value is 0.364842. The result is not significant at $p < 0.05$.

Table

At 5% chi-square value = 7.815, df = 3, P= 0.049. The p-value is 0.049994. The result is significant at $p < 0.05$

At 1% Chi-Square value = 11.345, df = 3, P=.00). The p-value is 0.009999. The result is significant at $p < 0.01$.

Table 8: Continuous improvement results

	Important				Practiced			
F4:Continuous Improvement	**Mean**	**SD**	**Variance**	**P_SD**	**Mean**	**SD**	**Variance**	**P_SD**
Q1:Improment coordination	4.22	0.67	0.44	0.63	3.44	0.88	0.78	0.83
Q2:Improvement teams	4.56	0.53	0.28	0.50	2.67	0.50	0.25	0.47
Q3:. Quality tools used	4.56	0.73	0.53	0.50	2.89	1.05	1.11	0.99
Q4: Process improvements	4.22	0.97	0.94	0.68	3.00	1.12	1.25	1.05
Average	4.39	0.72	0.55	0.58	3.00	0.89	0.85	0.84

Suppliers quality management

Calculated

Importance chi-square value = 4.238, df = 4, P= 0.375. The p-value is 0.374753. The result is not significant at $p < 0.05$.

Practiced Chi-Square value = 4.138, df = 4, P= 0.39. The p-value is 0.387652. The result is not significant at $p < 0.05$.

Table

At 5% chi-square value = 9.488, df = 4, P=.049. The p-value is 0.049994. The result is significant at $p < 0.05$

At 1% chi-square value = 13.279, df = 4, P= 0.009. The P-Value is 0.00999. The result is significant at $p < 0.01$

Table 9: Suppliers quality management results

	Important				Practiced			
F5:Supplier Quality Management	Mean	SD	Variance	P_SD	Mean	SD	Variance	P_SD
Q1:Quality base for selection	4.44	0.53	0.28	0.50	2.22	0.67	0.44	0.63
Q2:Meet quality specification	4.11	0.93	0.86	0.87	2.33	0.50	0.25	0.47
Q3:Suppliers' quality audits	4.00	1.32	1.75	1.25	1.67	0.87	0.75	0.82
Q4:Supplier relationship	3.89	0.93	0.86	0.87	2.56	0.53	0.28	0.50
Q5:Quality records	4.56	0.73	0.53	0.68	2.78	0.44	0.19	0.42
Average	**4.20**	**0.89**	**0.86**	**0.84**	**2.31**	**0.60**	**0.38**	**0.57**

Systems and processes

Calculated

Importance chi-square value = 3.155, df = 3, P= 0.37. The p-value is 0.368339. The result is not significant at $p < 0.05$.

Practiced chi-square value = 3.158, df = 3, P= 0.37 . The p-value is 0.3679. The result is not significant at $p < 0.05$.

Table

At 5% chi-square value = 7.815, df = 3, P=.0.049. The p-value is 0.049994. The result is significant at $p < 0.05$.

At 1% chi-square value = 11.345, df = 3, P=.00). The p-value is 0.009999. The result is significant at $p < 0.01$.

Table 10: Systems and processes results

	Important				Practiced			
F6:Systems and Processes	Mean	SD	Variance	P_SD	Mean	SD	Variance	P_SD
Q1:System procedures	4.56	0.73	0.53	**0.68**	3.44	0.53	0.28	**0.50**
Q2:Internal data collection	4.67	0.50	0.25	**0.47**	3.78	0.44	0.19	**0.42**
Q3:Feedback system exist	4.56	0.73	0.53	**0.68**	2.33	1.12	1.25	**1.05**
Q4:Employees evaluation	4.67	0.50	0.25	**0.47**	3.11	0.33	0.11	**0.31**
Average	4.61	0.61	0.39	0.58	3.17	0.60	0.46	0.57

Education and training

Calculated

Importance chi-square value = 2.836, df = 3, P= 0.42). The p-value is 0.417608. The result is not significant at $p < 0.05$.

Practiced chi-square value = 3.206, df = 3, P= 0.36. The p-value is 0.360941. The result is not significant at $p < 0.05$.

Table

At 5% chi-square value = 7.815, df = 3, P=.0.049. The p-value is 0.049994. The result is significant at $p < 0.05$.

At 1% chi-square value = 11.345, df = 3, P= 0.01. The p-value is 0.009999. The result is significant at $p < 0.01$.

Table 11: Education and training results

	Important				Practiced			
F7:Education and Training	**Mean**	**SD**	**Variance**	**P_SD**	**Mean**	**SD**	**Variance**	**P_SD**
Q1:Always update knowledge	4.67	0.71	0.50	**0.67**	3.44	0.53	0.28	**0.50**
Q2: On job training	4.56	1.01	1.03	**0.96**	2.56	0.53	0.28	**0.50**
Q3: Total quality training	4.56	0.53	0.28	**0.50**	1.22	0.44	0.19	**0.42**
Q4:Continous learn	4.78	0.67	0.44	**0.63**	2.22	0.97	0.94	**0.92**
Average	4.64	0.73	0.56	0.69	2.36	0.62	0.42	0.58

Work environment and culture results

Calculated

Importance chi-square value = 3.184, df = 3, P= 0.36. The p-value is 0.364117. The result is not significant at $p < 0.05$.

Practiced chi-square value = 3.188, df = 3, P= 0.36. The p-value is 0.363538. The result is not significant at $p < 0.05$.

Table

At 5% chi-square value = 7.815, df = 3, P=.0.049. The p-value is 0.049994. The result is significant at $p < 0.05$.

At 1% chi-square value = 11.345, df = 3, P= 0.01. The p-value is 0.009999. The result is significant at $p < 0.01$.

Table 12: Work environment and culture results

	Important				Practiced			
F8:Work Environment and Culture	Mean	SD	Variance	P_SD	Mean	SD	Variance	P_SD
Q1: Good work environment	4.78	0.44	0.19	**0.42**	2.67	0.71	0.50	**0.67**
Q2:Positive values	4.67	0.50	0.25	**0.47**	3.00	0.71	0.50	**0.67**
Q3:Teamwork practiced	4.67	0.71	0.50	**0.67**	4.11	0.78	0.61	**0.74**
Q4: Satisfaction initiatives	4.78	0.44	0.19	**0.42**	3.44	0.53	0.28	**0.50**
Average	4.72	0.52	0.28	0.49	3.31	0.68	0.47	0.64

Overall questionnaire results

The following were the final questionnaire results:

Table 13: Questionnaire results priority by importance and practice

Elements of QMS	Importance	Practiced
F1: Management Leadership	4.54	3.11
F2: Resource Management	4.44	3.80
F3: Measurement and Feedback	4.47	3.69
F4:Continuous Improvement	4.39	3.00
F5:Supplier Quality Management	4.20	2.31
F6:Systems and Processes	4.53	3.17
F7:Education and Training	4.89	2.36
F8:Work Environment and Culture	4.81	3.31
Overal QMS average value	4.53	3.09

TQM implementation survey results

Calculated

Chi-square value management = 17.43, df = 13, P= 0.18. The p-value is 0.180. The result is not significant at $p < 0.05$.

Chi-square value employee = 16.345, df = 13, P= 0.231. The p-value is 0.231. The result is not significant at $p < 0.05$.

Chi-square value QMS elements = 16.986, df = 13, P= 0.199. The p-value is 0.199. The result is not significant at $p < 0.05$.

Table

At 5% chi-square value = 22.362, df = 3, P=.0.05. The p-value is 0.05. The result is not significant at $p < 0.05$.

At 1% chi-square value = 27.688, df = 3, P= 0.01. The p-value is 0.01. The result is significant at $p < 0.01$.

The following where perceived barriers to TQM by employees:

Table 14: Barriers to TQM by employee

Barriers to TQM implimentation employees	Mean	SD
1. Lack of understanding.	3.02	0.74
2. Lack of preparation (No budget, no sponsor).	3.93	0.78
3. Resistance to change (Too busy)	2.40	0.76
4. Lack of vision.	2.97	0.73
5. Lack of top management commitment.	2.11	0.72
6. Lack of customer focus.	2.47	1.03
8. Lack of resources.	2.73	1.10
9. Lack of systems and structures for TQM activities.	2.27	0.70
10. Availability to training.	1.98	0.57
11. Training with no purpose.	3.07	0.97
12. Costly consultancies, training programs.	3.33	0.43
13. Lack of rewards and recognition.	3.85	0.98
14. Lack of effective measurement criteria.	2.81	0.70
15. Lack of evaluation procedures and benchmark indices	3.33	1.12
Avearage per dessignation	3.36	0.81

The following where perceived barriers to TQM by management:

Table 15: Barriers to TQM by management

Barriers to TQM implimentation (managerial employees)	Mean	SD
1. Lack of understanding.	3.02	0.53
2. Lack of preparation (No budget, no sponsor).	3.93	0.88
3. Resistance to change (Too busy)	2.40	0.45
4. Lack of vision.	2.97	0.61
5. Lack of top management commitment.	2.11	0.38
6. Lack of customer focus.	2.47	0.64
8. Lack of resources.	2.73	0.65
9. Lack of systems and structures for TQM activities.	2.27	0.35
10. Availability to training.	1.98	0.27
11. Training with no purpose.	3.07	0.85
12. Costly consultancies, training programs.	3.33	0.87
13. Lack of rewards and recognition.	3.85	0.90
14. Lack of effective measurement criteria.	2.81	0.64
15. Lack of evaluation procedures and benchmark indices	3.33	0.67
Average Score per dessignation	3.36	0.72

The following were the results of barriers to TQM implementation in the ashplant:

Table 16: Barriers to TQM implementation in construction projects

Barriers to TQM implimentation (overal avearage)	Mean	SD
1. Lack of understanding.	2.58	0.53
2. Lack of preparation (No budget, no sponsor).	2.68	0.88
3. Resistance to change (Too busy)	2.50	0.45
4. Lack of vision.	2.31	0.61
5. Lack of top management commitment.	2.02	0.38
6. Lack of customer focus.	2.46	0.64
8. Lack of resources.	2.29	0.65
9. Lack of systems and structures for TQM activities.	2.60	0.35
10. Availability to training.	1.95	0.27
11. Training with no purpose.	2.04	0.85
12. Costly consultancies, training programs.	2.52	0.87
13. Lack of rewards and recognition.	2.19	0.90
14. Lack of effective measurement criteria.	2.31	0.64
15. Lack of evaluation procedures and benchmark indices	2.59	0.67
Overal average	2.36	0.72

Discussions and interpretations

The survey participants were asked to rate the level of importance and level of practice of the eight elements of QMS. These were:

1. The level of perceived importance of the QMS elements on a five-point Likert scale ranging from 1 = not important at all, 2 = not important, 3 = neutral important, 4 = important and 5 = very important.

2. The extent or degree of practice the particular elements receive in a day to day ash plant operation. This was also ranked on a Likert scale ranging from 1 = very low, 2 = low, 3 = moderate, 4 = high, and 5 = very high.

The mean and standard deviation values were calculated for each QMS element to determine the elements of priority from high to low so that attention could be given to the highest element priority first, then to the next most important priority. This is based on the theory of constraint (TOC) that addressing a lower priority element before addressing the higher priority elements can be a wasteful exercise

Table 17 below shows the priority by importance (mean values), practice (mean values), and standard deviation. This summary was achieved by determining the mean and standard deviation values per QMS element.

Table 17: ISO 9001 elements based on perceived importance, practice and standard deviation

Priority	Importance	Practiced	SD
1	F7: Education and Training	F5: Supplier Quality Management	F7: Education and Training
2	F8: Work Environment and Culture	F7: Education and Training	F5: Supplier Quality Management
3	F1: Management Leadership	F4: Continuous Improvement	F8: Work Environment and Culture
4	F6: Systems and Processes	F1: Management Leadership	F1: Management Leadership
5	F3: Measurement and Feedback	F6: Systems and Processes	F4: Continuous Improvement
6	F2: Resource Management	F8: Work Environment and Culture	F6: Systems and Processes
7	F4: Continuous Improvement	F3: Measurement and Feedback	F3: Measurement and Feedback
8	F5: Supplier Quality Management	F2: Resource Management	F2: Resource Management

Figure 3 below shows how each QMS element has performed using a Likert scale.

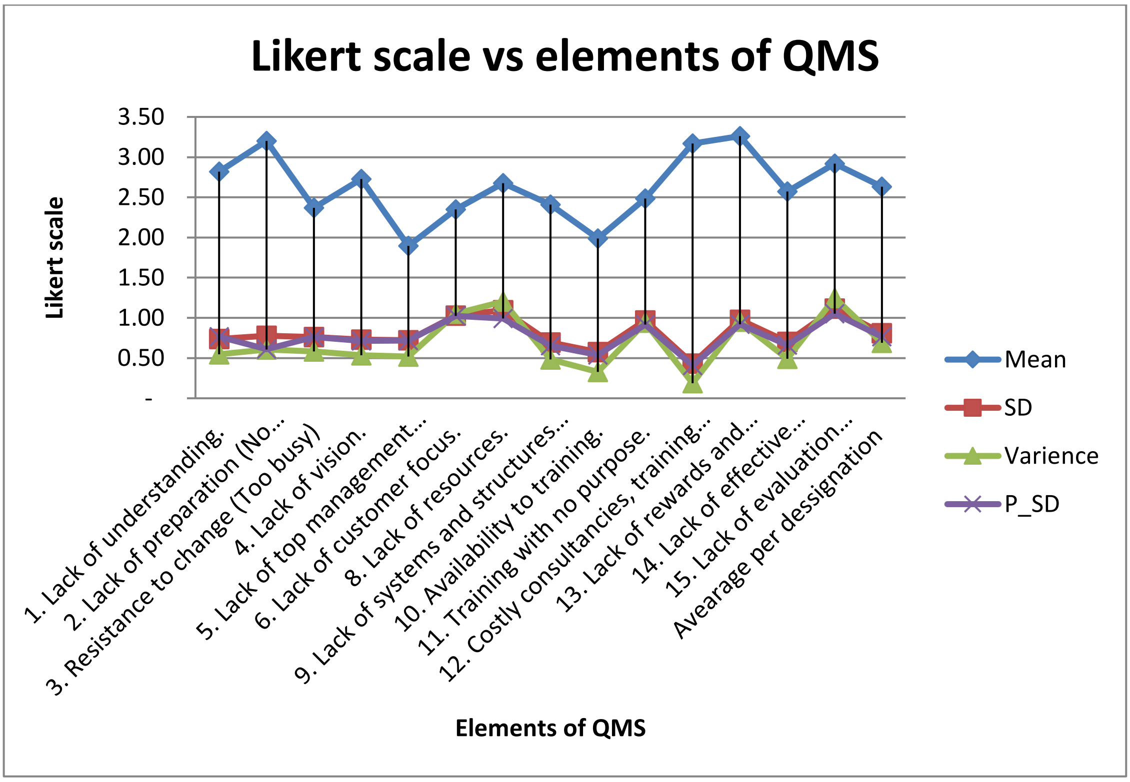

Figure 3: QMS elements performance measured by using a Likert scale

The final survey priority list of QMS elements was derived from the total score which included importance, practiced, and deviation per QMS element using a Likert scale. Table 18 below shows the final QMS elements priority list as part of the survey findings:

Table 18: Final QMS elements priority

Priority	ISO 9001 elements
1	**F5: Supplier Quality Management**
2	**F7: Education and Training**
3	**F4: Continuous Improvement**
4	**F1: Management Leadership**
5	**F6: Systems and Processes**
6	**F8: Work Environment and Culture**
7	**F3: Measurement and Feedback**
8	**F2: Resource Management**

The table above indicates that more attention has to be given to priority one in sequence up to priority 8 because all were measured to be less than 4 (important and high) using the Likert scale.

Findings

The following findings were deduced:

1. Despite projects being an ISO 9001 certified, there is a serious non-compliance regarding the eight elements of QMS (ISO 9001) at the operational level.
2. Lack of a proper ISO 9001 implementation plan for the sections to comply with the requirements of the system. The cost of implementing the system and consultants' fees may be a contributing reason for the PMO not fully adopting the system operationally.
3. Lack of clear vision regarding quality management in the construction resulted in objectives that weren't specific, measurable, attainable, realistic, or time-bound (SMART). ISO 9001 certified companies must continuously measure, collect, record, and analyze data for continuous improvement.
4. Policy problems of not aligning procurement to the requirements of ISO 9001 have resulted in major quality problems from suppliers.
5. It was deduced that TQM implementation favors ISO 9001 and brings more benefits but ISO9001 can be used as a first step towards TQM implementation and certification.

Hypothesis 1

The null hypothesis and alternative hypothesis:

- H_0 : There is no relationship between PMO ISO 9001 certification and project performance.
- H_1 : There is a relationship between PMO ISO 9001 certification and project performance.

ISO 9001 certification requires the PMO to possess more than just a project methodology and ensures that at a minimum, PMO must establish a quality policy and have a quality manual that interfaces with major HR and procurement processes. It also requires that PMO continuously solicit customer feedback and constantly measure customer satisfaction. In addition to project management culture, the PMO must be orientated towards a service culture and imbue its staff to be service driven.

This study establishes that with ISO-certification, the performance of PMO can be improved which will result in more project success. Results of correlation tests describe that the PMO performance of ISO-certified is better than a Non-certified construction company. It was also discovered that ISO 9001 certification generally has a significantly high positive influence on construction project success. It also positively affects construction significantly projects and programs quality performance assisting organizations to deliver projects on time, within cost, and acceptable to all stakeholders. It was also evident that ISO 9001 certification reduces rework significantly which will minimize the expenses of the project at completion and that projects achieve their objectives successfully. The study also observed that the cost of projects can be affected moderately by ISO 9001 certification at a 5% level of significance.

From the above results $\mathbf{H_1}$: Is accepted - There is a relationship between PMO ISO 9001 certification and project performance

<u>Hypothesis 2</u>

<u>The null hypothesis and alternative hypothesis:</u>

- H_0 : There are no common barriers that affect TQM implementation in engineering projects.
- H_1 : There are common barriers that affect TQM implementation in engineering projects.

In the project management office (PMO), the improvement method of TQM requires using PDCA (Plan–Do–Check–Act) for planning and monitoring the quality of a product or service. The result of the survey indicated that TQM continuous improvement cycle will significantly increase the likelihood of quality improvement success because it allows PMO to avoid common project management mistakes. It gives the project manager a set of tools for planning, monitoring and solving potential issues that may arise during the entire project management process.

The research survey results indicated that PMO management must identify the core values and principles that they intend to use and communicate them throughout the PM organization. This can include a revised PMO mission statement followed by devising a master plan. The PMO will then identify and prioritize stakeholders demands and make sure its products and services align with these. The results statistical correlation test indicated that there is a strong negative correlation of TQM implementation and barriers of TQM but effective implementation of the management system will reduce the impact of barriers while minimizing the overall risks. Figure 3 summarizes the common TQWM implementation barriers.

From the above results $\mathbf{H_1}$: Is accepted - There are common barriers that affect TQM implementation in engineering projects

Conclusion

ISO 9001 certification can only deliver desired results if managers of organizations carefully design the ISO 9001 and TQM implementation strategy to realize the necessity to align quality programs with business strategies to ensure that efforts reflect the long-term goals of an organization. There is a relationship between the values and requirements that underpin the ISO 9001 standard and important strategic and organizational dimensions. TQM requires continuous improvement of processes; people and system, the reward system, teamwork, the measurement of performance, and communication are all critical success factors for the sustainable quality management system and successful results of ISO 9001 certification.

The implementation of an ISO 9001 and total quality management culture within an organization pivots on several key enablers including building an infrastructure and technologies which support project planning, tracking, progress reporting, and change management. The implementation of TQM and ISO 9001 in projects ensures that project management philosophy is communicated at all levels of organizational structure because of its increasing application to processes of organizational development and strategic change consequently with immense and immediate strategic implications for the parent organization.

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