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Development of an Integrated Quality Management Conceptual Framework for Manufacturing Organisations

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Abstract

In the last couple of decades manufacturing management models such as Six-Sigma, Lean Manufacturing and TQM have been implemented by many organizations to facilitate the production lines, hence improving the quality performance. However, none of these models have been able to solve all organisation problems when implemented alone; on the other hand, integrated management models such as Lean-Six Sigma, have empowered organisations to exceed the improvement rates and achieve as competitive advantage. This paper attempts to develop an integrated quality management conceptual frame-work for Six-Sigma, Lean manufacturing and TQM; to eliminate the quality issues in order to improve and modernize the quality system for manufacturing organisations. The aim is to simplify the implementation process, improve the operation performances and provide imputes and guidance for manufacturing organisations; thus attaining sustainable improvement and performance excellence. The paper reviews the literature relevance to the topic and the required tools to carry out this research. Furthermore, a questionnaire survey is designed to collect the required data and to validate the proposed framework. The research results concluded that the framework developed is applicable for manufacturing organisations and can assist to achieve competitive advantages if adopted and applied correctly.

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Keywords: Lean manufacturing, Six-Sigma, TQM, Integrated quality management

1. Introduction

Quality management becomes increasingly important for manufacturing and industrial services This is due to the significant role of quality management methods, in which enabled the organisations to achieve high quality performances. Johannsen [3] stated that quality management can improve the organisation's performance in numerous aspects such as enhancing the employees' culture, improving the operation performance and satisfying the customer's requirements. However, the integration approach in quality management has recently become a significant means, in terms of modifying and optimising the quality management methods. In this regard, [3] said

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that integration of quality management methods is the parallel use of the proper quality management methods; in order to remove the weakness and enhance the strengths of quality management systems. The paper at hand is based on two previous papers published by the authors; one is the development of the Lean Six-Sigma (LSS) integrated model [5] and the other is the Six-Sigma TQM integrated model [6]. This paper intends to develop an integrated quality management conceptual framework for manufacturing organisations, by integrating the LSS model and the Six-Sigma TQM integrated model, in order to eliminate the quality critical issue and to improve and modernize the quality system. Additionally, the significant literature of the topic will be presented including the critical success factors (CSFs) for successful implementation of the framework and the methodology that ultimately lead to the desired results. Furthermore, the steps that should be followed to validate the proposed model are provided.

1.1. Literature review

Several studies in the literature discuss how the integration approaches; in quality management; are being developed. Conversely, Johannsen [3] summarised the key steps of deriving the integration approach in quality management which are as follows:

- Identify the appropriate quality management methods.
- Find out the similarity and differences between the methods selected.
- Plan and determine the integration strategy.

With respect to this, [3] argued that integrated quality management methods will be the key development in today's business environment. Therefore, and according to [2], many academics and practitioners are in agreement that Six-Sigma is one of the superior quality initiatives, in terms of decreasing the defects and variations of the system.

Andersson [1] declared that Six-Sigma is the greatest complete strategy, while [9] argued that TQM is also classified as one of the best initiatives, in terms of continuous improvement and quality commitment. In this context, Andersson [1] stated that TQM is the prime component of Six-Sigma. Although, Antony et al. [2] said that Lean manufacturing is another effective method for simplifying the production lines and achieving the process performance; Lean is also focused on achieving cost reduction through the elimination of waste and fully utilising the workers and their capabilities. Finally, many critical factors of Six-Sigma, Lean and TQM can lead to the formulation of a successful quality management framework [1]. Henceforth, this research focuses to develop an integrated quality management framework to provide inputs and guides for the manufacturing organisation; in which an effective and sustainable improvement performance is achieved.

1.2. Lean -Six-Sigma integrated model

This integrated model developed with the aim to simplify (LSS) implementation, enables manufacturing organisations to overcome the fear of high cost and the complexity associated with LSS implementation. The model seeks to utilise the knowledge within the organisation and break down the barriers hindering individuals from using statistical problem-solving methods via a step-by-step guide. The proposed model is based on the DMAIC approach a main strategy, which enables the implementation processes to identify opportunities for quality improvement, an increase in process performance and a reduction in variability and waste of a product or process using statistical tools. Nevertheless, DMAIC phases, in this model, are integrated with each other to facilitate the implementation process and streamline the operating system. Consequently, the model developed in Figure 1(1) consists of two main components: Firstly, the *Strategic elements;* that encompass the key drivers required for successful implementation of the business process. *Secondly, the Operation elements;* which incorporate the key factors for the successful implementation of the operation system to obtain high quality performance. The implementation process of the model consists of four stages; the Planning and Organisation stage, the Enhancement and Stimulation stage, the Evaluation and Activation stage and finally the Improvement and Verification stage (see [5] for details).

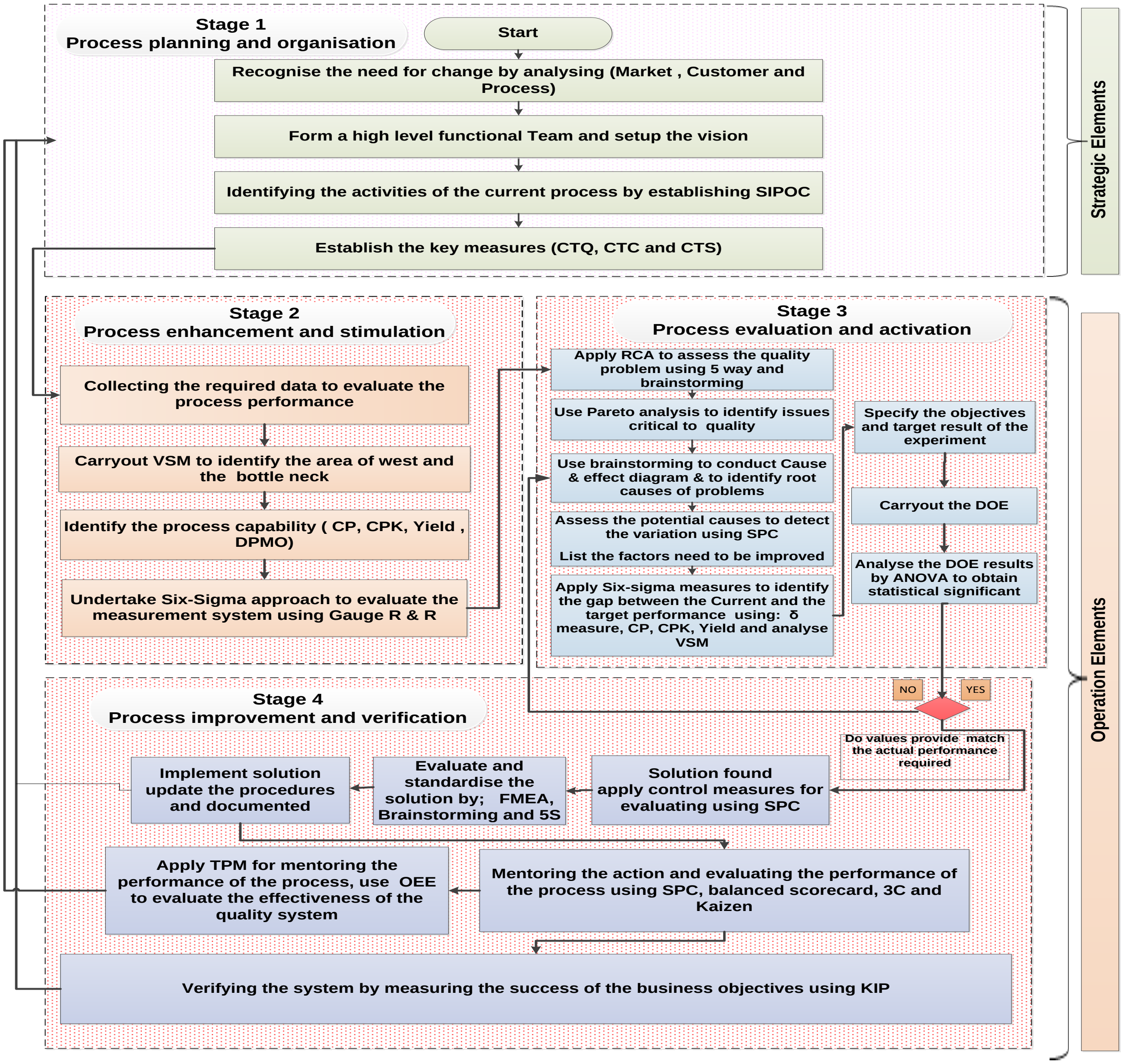

Fig. 1. LSS conceptual integrated model adopted from [5]

1.3. Six-Sigma and total Quality management integrated model

This model was developed to unify the management system by cultivating a culture of quality and a realisation of the innovation environment, the model is based on the improvement methodology of Six-Sigma (DMAIC) and the improvement activity of TQM, which are integrated to merge the management system and facilitate the implementation process in order to obtain an improved performance. Where DMAIC is the key strategy of Six-Sigma for achieving process improvement, the process activity of TQM is represented by the Quality Control Circle and Quality Improve Team (QCC and QIT). The purpose is to enable manufacturing organisations to present opportunities for quality improvement by involving everyone in the organisation, streamlining the operation process and hence, attaining business excellence. Therefore, the model developed in Figure (2) consists of three main elements; Strategic elements, Implementation elements and Performance excellence elements. Strategic elements are the essential components of the model to combine the business process and success in the implementation procedures. Implementation elements are the crucial drivers of the model for smoothing out the operation process, eliminating quality problems and attaining high quality performance. Performance excellence elements are the fundamental measures of the model for sustaining continuous improvement and accomplishing performance excellence. The steps towards implementation of the conceptual model are summarized into seven steps and reported in detail in [6].

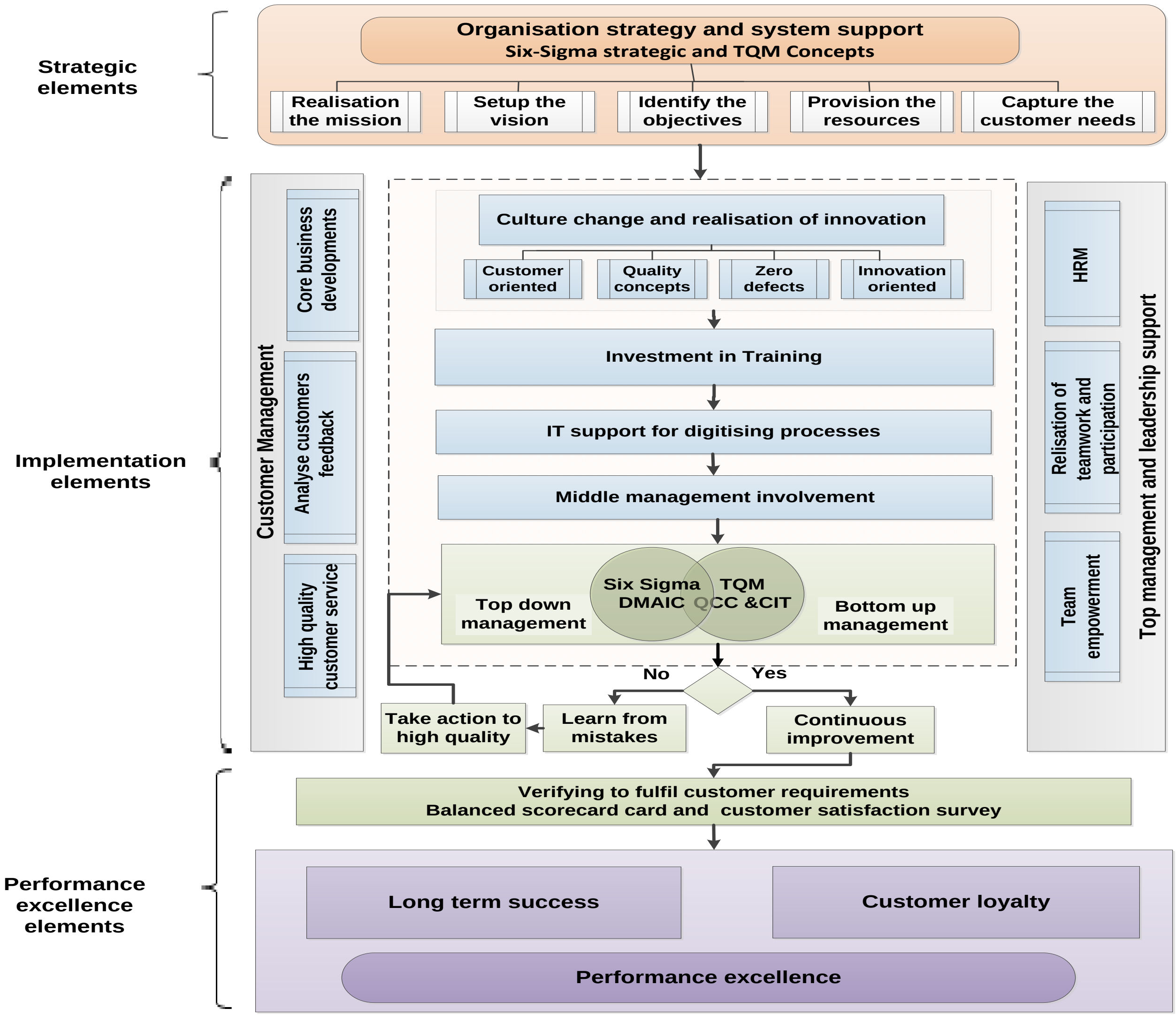

Fig. 2. Six-Sigma TQM integrated conceptual model adopted from [6]

2. Development of the Proposed integrated quality management Conceptual Framework

Quality management framework should be simple, logical and, yet, comprehensive enough to be successful in the implementation process and be able to reach a high operation performance [9]. The process of developing the proposed framework is a result of integrating the LSS model and SS-TQM model (discussed briefly earlier in section 1.2 and 1.3), in which the strategic element of both models is integrated, to formulate an effective platform for planning the operation system and facilitating the implementation procedures of the framework. The operational elements of the LSS model is integrated with both the implementation elements and the business excellence elements of SS-TQM model providing impetus and guidance for quality improvement, thus, attaining performance excellence in the manufacturing organisations. Although, the existing contradiction between of Six-Sigma and TQM, in terms of the operating system, in which Six-Sigma is top down management and TQM is bottom up. However, the framework suggested dealing with this; conflicts by employing two critical success factors; middle management involvement and top leadership support to provide better coordination between employees and to enable complete participation whilst relying on empowerment and self-control as supported by [9]. However, Six-Sigma DMAIC improvement is adopted as the key strategy of the framework to identify opportunities for quality improvement. Accordingly, the framework consists of:

2.1. The main body of the framework

The structure of the framework is represented by flowchart diagram in Figure (3), which displays the framework's activities and their integrated functions. The development of the flowchart is mainly based on the literature review of experienced authors in this field. The components of the framework were evaluated and prioritized using the Analytical Hierarchy Process technique (AHP). The main elements of the framework include a set of quality tools, statistical tools and global tools employed to formulate the stages of the framework. These are prioritized and organised based on the DMAIC strategy to deliver the tasks step-by-step in order to provide the opportunity for quality improvement and to overcome any quality issues. The development of these elements is based on the strategy of the black belt and green belt [4].

2.2. The operational mechanism of the framework

The work activities and functions of the framework are organised based on the trend of DMAIC methodology, where the stages, processes and steps of the framework are incorporated together in the interest of simplifying the operational process and enhancing the quality of performance. This mechanism is designed as an integrated and consolidated system to operate the framework; the development of these integrated functions and mechanisms are based on the literature review and the application of the black belt and green belt [4].

2.3. The implementation procedures of the framework

The components of the framework were gradually devised and were based on what was learnt from integrating the LSS model and SS-TQM model developed by the authors as detailed in [5] and [6]. It was also evaluated and prioritised using the AHP technique. The implementation processes of the framework have been designed sequentially, to be implemented in five phases, each phase concerned with the completion of its tasks across a number of stages. The development of the implementation procedures of the framework was adopted based on the sequences of DMAIC procedures; in which: Phase 1 - Strategic planning, Phase 2 - Measurement and evaluation, Phase 3 - Analysis and activation and Phase 4 - Verification and continuous improvement. Due to space limitation, the implementation procedures of the framework will be presented at the conference.

2.4. The CSFs for successful implementation of the framework

There are no clear CSFs mentioned in the literature for successful implementation of the integrated quality management approach. However, the factors that were ranked by [1], [2], [3] and [9] as effective CSFs for Six-Sigma, Lean and TQM are considered for the proposed framework. Some of these factors are specified in the study as soft factors for the success of the strategic phase; others defined as soft factors, for success of the implementation process, the rest are ranked as CSFs for the overall framework. The considered CSFs are:

1. Organisational structures
2. The focus on the customer
3. Linking to Suppliers
4. Training and education
5. Leadership support

6. Effective communication
7. Quality commitment
8. Middle management involvement
9. Reviews and tracking of performance

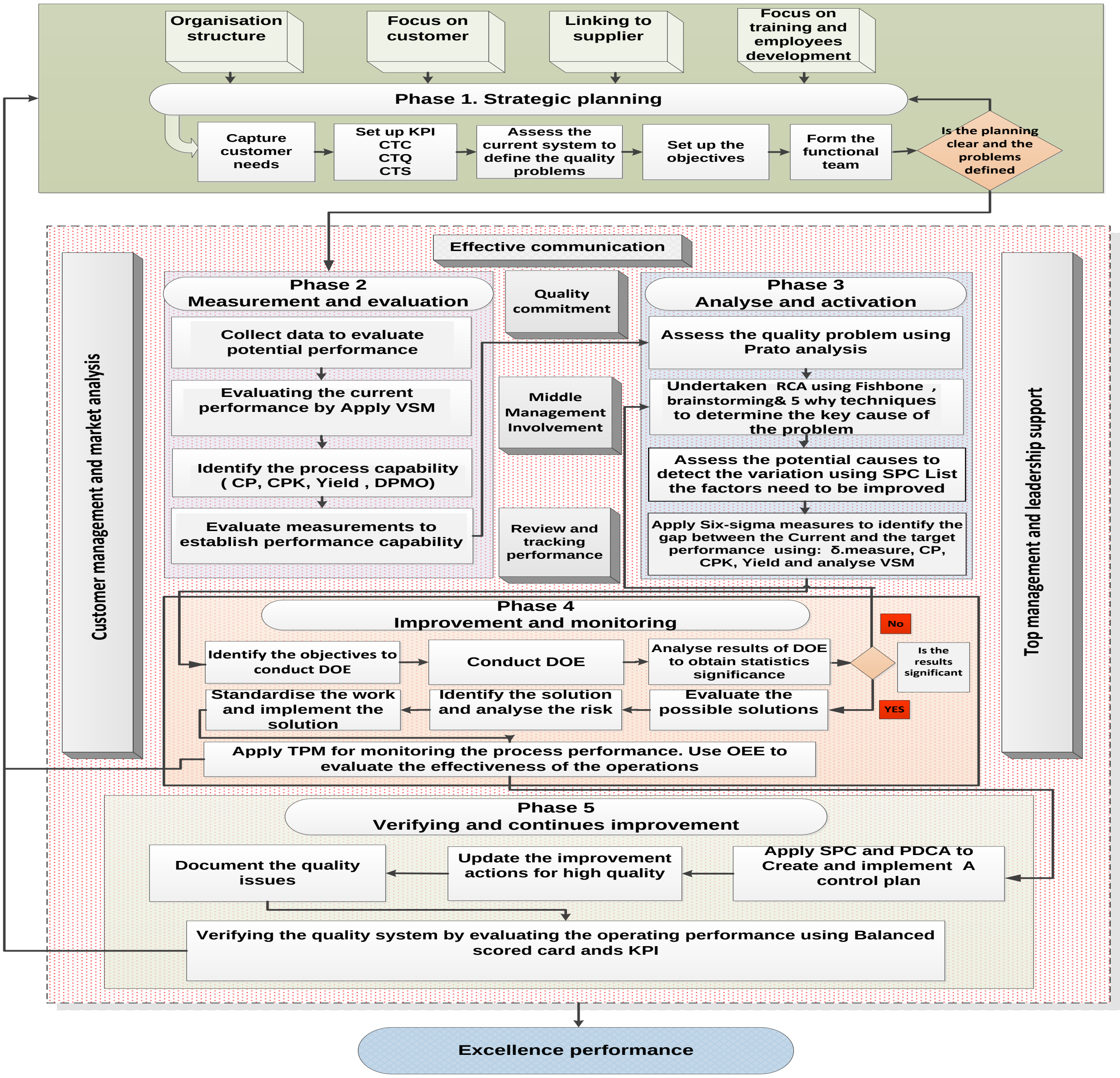

Fig. 3. The proposed integrated quality management framework

3. Research methodology

Questionnaire surveys were used to collect the required data and to validate the proposed framework, the questionnaire was designed to gather data from different professionals and experienced employees in the available manufacturing organisations and from academics related to the research topic. The questionnaire was structured in three sections with thirty main questions; the aim of which was to investigate the suitability of the framework and to improve and modernise the quality system within manufacturing organisations. The first section was about the participant's information; it aimed to present a clear picture of the respondent's background and understand the awareness level of the existing quality program in their organisation. The final section was to evaluate the CSF's and the potential barriers that can impede the implementation process.

4. Data collection and analysis

Seventy research surveys were sent out to a host of management employees, spread across different manufacturing organisations, 62 questionnaires were completed and returned within a given time frame, which can then be considered as a relatively high percentage of completed questionnaires [7]. SPSS 23 software was used to analyse the data collected which is an appropriate method to provide robust and structured analysis [7]. Therefore, these 62 valid completed questionnaires were coded and entered into a (SPSS 23) software program, where basic statistical analysis were carried out for the observation of frequencies, percentage, mean and standard deviation to assess the data. The respondents encompass mainly operational and quality managers from some selected industrial organisations around the world. The organisations of the respondents that are involved in the survey belong to three industrial sectors: manufacturing sector, automotive sector, oil and gas sector and higher education institutions; the results in Figure (4) show the respondent's position and their industrial sector.

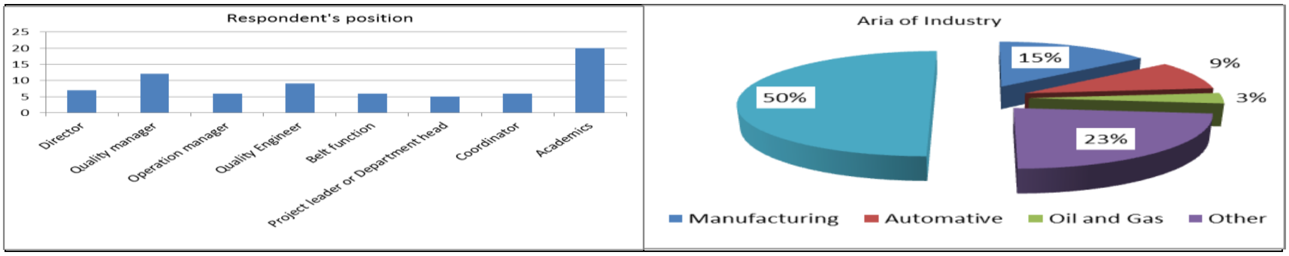

Fig. 4. Overview on the respondent's background

5. Validation of the Proposed Framework

Empirical study and the literature review were employed to propose the conceptual framework and questionnaire survey in furtherance of assessing and validating the framework. Validation was obtained from various practitioners, academics and experts in the manufacturing field whom are either currently using or yet to adopt the Lean, Six Sigma and the TQM approach, Figure 4 above demonstrates the results of both the position of the participants involved in the survey and the area of industry within their organisations. The study evaluated the current trend of the quality management implementation focusing on LSS and TQM in the manufacturing organisation, its methodologies, perceived benefits, critical success factors and barriers for successful implementation. Henceforth, fixating on the reliability and validity of the proposed framework and the CSFs .Therefore, the proposed framework was evaluated based on its suitability and applicability for manufacturing organisations; the ability to boost competitiveness and the capability of the implantation in practice. The respondents were asked to indicate to what extent they agree with the mentioned criteria based on five Likert scales, where one is strongly disagree and five is strongly agree. The results showed that the highest rates for the entire criteria fall respectively in favour of Agree, Moderate and Strongly Agree. Consequently, the results clearly increased the authors' confidence to consider that the framework is valid and applicable for manufacturing organisations and can assist to achieve competitive long-term advantages; if adopted or applied correctly. In addition, the results established that the awareness level with quality management methods is very high. However, the usage in an integrated fashion is rather low among manufacturers. Moreover, almost all the quality management tools and techniques listed in the survey are familiar among practitioners; nonetheless, a majority of the practitioners haven't utilized these tools and techniques effectively.

6. Reliability and Validity Analysis

Reliability and validity tests determined the accuracy and truthfulness of the results and instruments used in the survey. Cronbach Alpha was used to measure the internal consistency of the instruments as used to evaluate the proposed framework. Thereby, the results in table (1) below indicated that Cronbach alpha is 0.865, which is greater than 0.7; thus, this can be considered as an indication that all the instruments used to evaluate the framework have high internal consistencies and reliabilities [7]. Chi square goodness of fit (X^2) was employed to assess the validity of the instruments that are used to evaluate the proposed framework; the results in table (1) confirmed that P values are less than 0.05 [7], which means that the results are significantly different from the actual observed values and the expected values of the entire statements used to evaluate the proposed framework. Based on the above indications, it can be established that the results of the research are valid and reliable.

Table1. Test Statistics for evaluating the framework in terms of the reliability and validity of the results obtained

	The FW Suitability/ Capability	The ability to boost competitiveness	The ability to deal with quality problems	The application in practice	The ability to achieve long term success	Any missing in contents of the model
Chi-square	31.387^a	33.323^a	41.387^a	31.710^a	34.129^a	37.161^b
df	4	4	4	4	4	1
Asymp. Sign.(P)	.000	.00	.000	.000	.000	.000
Cronbach's' (α)			0.865			

7. Conclusions

The paper focused on the development of an integrated quality management conceptual framework for manufacturing organisations, the study reviewed how to integrate the quality management system and how the proposed instruments have developed high internal consistency and reliability. The study demonstrated that the integration of Six-Sigma, Lean manufacturing and TQM is formulating a platform to manage the quality strategy and its vision on how to apply the operational mechanism to attain excellence performance. The paper concluded that the proposed framework developed is applicable for manufacturing organisations and can assist in achieving competitive advantages if adopted and applied correctly. In addition, it should also provide guidance towards a successful implementation. Due to the shortage of such frameworks, the proposed framework in this paper can be considered as a major contribution to both academia and industrialist knowledge.

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