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Implementation of Total Quality Management (TQM) in Improving Product Quality in Manufacturing Companies

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Abstract

This paper will review the impact of the implementation of Total Quality Management (TQM) on the quality of the products, the engagement of the employees and customer satisfaction in a manufacturing company. A quasi-experimental study, further complemented by a pre-test/post-test procedure, has been implemented; TQM training was conducted with the experimental group whereas conventional training was used with the control group. The information was obtained by quality performance measures such as, defect rate, cycle time and overall equipment effectiveness (OEE) and surveys of employee perception and customer satisfaction. The comparison using statistical tools was done on paired t-test and independent t-test. The results show us statistically significant reduction of the defect rate, that was 4.5 percent to 2.0 percent and cycle time which was 25 minutes to 18 minutes in the case of the experimental group. At the same time, there was a significant boost in employee engagement and customer satisfaction with the sum total of the satisfaction level improving by a mark of 7.3 to 9.2. There was a significantly lower change in the control group. Overall, the results indicate that TQM initiatives delivered a significant effect on the quality of the products, staff involvement, and satisfaction with customers.

INTRODUCTION

The world of hyper-competition in the modern international market makes it ever more conditional on the natural quality of the product to become differentiated. Companies that have been trying to meet the increasing demands of customers as well as streamline its operation and remain competitive have adopted Total Quality Management (TQM) as a major instrument in improving the quality of its products. TQM as a complete managerial model that is described by the process of implementing continuous improvement, customer satisfaction, and integration of the whole workforce has a widely-spread use in various industries and especially, within a manufacturing setting (Tortorella et al., 2021; Permana et al., 2021; Lepistö et al., 2024). Its core focus on process optimisation, decreased defects and enhanced involvement of the employees agrees with the general aim of excellent quality of the products and overall excellence. This paper is based on recent evidence provided by the academicians in systematically evaluating the degree to which the

implementation of TQM enhances product quality within manufacturing organisations.

Systemic application of TQM was developed into full swing in the 1980s and works on an intelligentsia tradition losing credit to the previous fixtures of quality management thinkers including Maguad (2006). These pioneer leaders have found leadership dedication, customer focus and uninterrupted process advancement as constitute cornerstones of TQM. In the course of subsequent decades, these principles have been adjusted in order to respond to the specifics of modern manufacturing practice. In line with previous recommendations, TQM demands leaderly sponsorship of the top management, since a leadership position is essential in developing an omnipresent quality culture (Lasrado & Kassem, 2021). In addition, TQM does not just stop at the production floor, but it permeates every aspect of the business operation, including the supplier relations, post sales services amongst others just to ensure quality is maintained across the entire value chain (Foster & Gardner, 2022; Choudhuri, 2024; Dias et al., 2022).

With reference to manufacturing companies, the application of TQM is normally founded on four extensive principles viz continuous development (kaizen), consumer concentration, worker participation, and evidence-based determination. In the evidences used, it can be argued that organisations that have these tenets systematically incorporated tends to exhibit a significant change in product quality which is measurable (Rowlands & Milligan, 2021; Panigrahi, 2023; Wolniak & Grebski, 2023). Continuous improvement is at the heart of TQM, focusing on the incremental improvement of processes and systems to reduce waste, increase efficiency, and enhance product quality. This principle is particularly relevant in manufacturing, where even minor improvements in process control can result in significant reductions in defects and variations. Studies have shown that continuous improvement initiatives, such as Lean Six Sigma, often complement TQM practices, leading to measurable improvements in product quality (Ghelani, 2023; Thakur et al., 2023).

Customer focus is another essential element of TQM, as it emphasizes the need to align product quality with customer expectations (Nyangoma et al., 2024). In manufacturing, this means that companies must not only meet industry standards but also anticipate and fulfill the specific needs of their clients. According to a study by Owusu-Kyei et al. (2023), companies that prioritize customer requirements as part of their TQM strategy tend to achieve higher levels of customer satisfaction, loyalty, and repeat business. This customer-centric approach necessitates regular feedback mechanisms, enabling manufacturers to continuously refine their products and processes based on real-world user experiences.

Employee involvement is equally critical to the success of TQM, as it fosters a culture of ownership and accountability for quality at all levels of the organization (Bashar et al., 2021). Empowering employees to take an active role in quality control and problem-solving has been shown to increase both product quality and overall job satisfaction. A recent study by Yadet et al. (2023) highlighted the importance of cross-functional teams in implementing TQM, where collaboration between departments leads to a more holistic and efficient approach to quality management.

The benefits of implementing TQM in manufacturing companies are well-documented, with numerous studies demonstrating its positive impact on product quality, process efficiency, and overall business performance (Thunyachairat et al., 2024; Alawag et al., 2023). One of the primary outcomes of TQM is a reduction in defects and rework, leading to lower production costs and higher customer satisfaction. A study by Marks (2023) showed that manufacturers that adopted TQM principles experienced significant improvements in product quality, resulting in

fewer product recalls and warranty claims. Additionally, TQM has been shown to improve supplier relationships by fostering a collaborative approach to quality improvement across the supply chain.

Moreover, TQM enhances organizational flexibility by enabling manufacturers to quickly adapt to changing market demands without compromising quality (Tamayo-Torres et al., 2014). This agility is particularly important in industries with high levels of innovation and competition, such as electronics and automotive manufacturing. The continuous improvement focus of TQM allows these companies to innovate and refine their processes rapidly, ensuring that they remain at the forefront of technological advancements. Furthermore, TQM's emphasis on preventive measures, such as statistical process control and root cause analysis, reduces the likelihood of major production disruptions and ensures that quality issues are addressed before they impact the customer (Colledani et al., 2014).

While the benefits of TQM are significant, its implementation is not without challenges. One of the primary obstacles faced by manufacturing companies is the resistance to change, particularly among employees who may be accustomed to traditional management approaches. Changing organizational culture to align with TQM principles requires sustained effort, strong leadership, and continuous training. Another challenge is the upfront investment required to implement TQM, including costs associated with training, process redesign, and the adoption of new technologies. Furthermore, the success of TQM depends heavily on the organization's ability to gather and analyze data effectively. Data-driven decision-making is a cornerstone of TQM, but many companies struggle to implement the necessary data collection and analysis systems. As a result, some organizations may fail to realize the full benefits of TQM due to a lack of accurate, timely information on quality performance.

METHODS

Research Design

To find out the effectiveness of Total Quality Management (TQM) to improve the quality of products in manufacturing firms, the present investigation employed a quasi-experimental, pre-test/post-test design. This approach allowed comparing the indicators of product quality before and after the implementation of TQM, which made it possible to measure the impact of this system on the fundamental aspects of product performance, including the level of defects, the efficiency of production process, and the satisfaction of clients, which are among the representatives of vital dimensions of general product performance in the given case. A control group was included in the research design as they proceeded with the usual quality management processes and an experimental group which embraced TQM-based processes. The background created by the contribution of the control group could be used to determine effect of TQM on the experimental group.

Participants

This study recruited six manufacturing firms engaged in the industrial economy together with each manufacturing enterprise dealing with high volume consumer items. The sample of prospective companies was selected purposively based on the size, market share and dominant production processes and had developed a quality management it occurred in a range of 300-500 employees and firms had developed quality management processes before the research started. These 120 employees representing the total sample were selected as follows: half of employees selected were of the type quality-control, half of the type production, and half of the type as a managerial position, thus having the direct involvement or accountability regarding implementation or control of product quality improvement initiatives.

The respondents were divided into two categories, namely: experimental groups, consisting of three firms and control groups, consisting of three firms. The assignment was on the basis of how well each firm exhibited preparations towards the use of total-quality-management (TQM) which was done through already established quality management procedures and how much the senior management gave express agreements to the use of TQM. The target of this process was to reduce the amount of disruption in the operations and ease the process of introducing TQM in the experimental premises. The two samples were matched in the type of industry, their productionive capacity, and numbers of employees, which made them more comparable when it comes to the major variables.

Instruments

To achieve the purpose of assessing the impacts of Total Quality Management (TQM) on the quality of the product, paper adjoined three main tools, i.e. quality performance indicators, employee perception surveys and customer satisfaction ratings. Quality indicators were used to monitor the performance qualitatively, and they were objective measures, including a defect rate, cycle time, and overall equipment effectiveness (OEE), which could provide quantifiable results of production efficacy and products quality before and after TQM implementation. The defect rates were one of the key indicators of the decline in the production errors, and the cycle time and OEE were used as standards of operational efficiency. The data used was obtained in terms of monthly reports compiled by the quality control unit of every firm.

An employee perception survey was implemented to obtain subjective information about the axiomatic impact of TQM as regards the attitude of employees towards the quality management obligation and their contribution to the maintenance of high standards. Carried out before and after intervention, the survey was used to evaluate engagement of employees, the level of satisfaction with new practices, and the perception of quality improvements. In its turn, the customer satisfaction ratings where used to give a customer feedback about the product quality with the focus on reliability, durability and overall satisfaction of customers. The pre and post-TQM initiative analysis on customer satisfaction provided an idea as to how the practices were encouraging an observable difference to the product quality as reflected by the customers. Taken together, these tools provided a summative analysis of the effectiveness of TQM in both the internal processes and external images.

TQM Intervention

The six-month TQM intervention was aimed at instilling four primary pillars of Total Quality Management: continuous improvement, customer orientation, employee participation and data-driven-decision-making. The initial two months had the focus on continuous improvement and the kaizen workshops aimed to employ the employees in seizing inefficiencies in the production processes and suggest solutions to improve the quality of the products. This phase tried to eliminate wastage, rationalize operations, and compress process control, which have resulted in improved outputs of high quality. Then April and May changed this focus to putting the spotlight on customer requirements and organizations would compile and analyze customer opinions methodically so that the development of their products could be streamlined and any products could be assured that they would not be performing below market standards. This phase was very helpful in ensuring production decisions which were in accordance with real time market demands.

At the same time the organization ensured strong employee participation where front-liner workers were engaged in quality control through frequent meetings and brainstorming. Workers were required to learn how to report the problem of quality to the employer and also suggest some possible solution enabling the workers to feel

an active part of high product quality achievement. During the last two months, data-driven decision-making was highlighted as an intervention issue; companies ensured that their data systems were increased to allow real time monitoring of production quality. Some tools, including statistical process control (SPC) charts, allowed the monitoring of measures that included the level of defects, which could lead to any quick change that was necessary due to any manifestation of a problem. This information-based model helped in building a quality management solution based on strong evidence and thus the enhancement of production efficiency and overall quality of products.

Data Collection Procedure

Data collection was done during the six months period of the intervention. During the first month, each company (experimental as well as control groups) submitted data on quality performance baseline both in terms of defect rates and customer satisfaction ratings. This was used as product quality pre-test.

Then the TQM intervention was conducted into the experimental group in the next six months. In this timeframe, they did not make significant changes in their processes and instead observed the control group who maintained conduct of their already practiced quality management activities. At the conclusion of the six-month trial period, post-intervention results were given by both groups, that is, the latest defect rates, customer satisfaction scores and employee survey responses. The post-test enabled quantification of the change in the quality of the products produced and perception of employees as a result of the TQM intervention.

Data Analysis

The analysis of the quantitative data was performed through observing the difference between the pre-test and post-test of the experiments and control groups. Defect levels and customer satisfaction level of the products prior to and after the intervention were the main aspects of comparison. To determine the figure, paired-samples t-tests were obtained to determine whether results of the quality indicators in the experimental group were really improved after the implementation of the TQM. They further carried out independent-samples t-tests to measure the performance of experimental group against control group and established the effectiveness of TQM against conventional approach to managing quality.

Multivariate analysis of variance (MANOVA) was also carried out to check the association between various efficiency parameters of quality (e.g., defects rates, customer satisfaction) and conditions of the treatment (experimental and control). The same analysis offered clues to the existence of a differential impact of TQM on the different dimensions of product quality and it, therefore, helped to have a much clearer picture of how the intervention was affecting the product.

RESULTS AND DISCUSSION

With the growing competition in the global market and rise in the expectations of customers, the manufacturing businesses are not only expected to improve the quality of production but also have to remain efficient in their operations and in pleasing customers. Among the strategic options that have elicited a lot of popularity in attaining such goals encompasses Total Quality Management (TQM). TQM is an organizational wide philosophy with continuous improvement, customer focus, employee involvement and data-driven decision-making as its key points throughout the organization.

The research consisted of an empirical evaluation that aimed to strengthen the quality of products, employee involvement, and customer satisfaction as the key performance indicators of the TQM implementation applied in the manufacturing

environment. With the help of quasi-experimental design, the study provides a comparison of the performance of two groups, i.e., an experimental involved a group who took up TQM practices and a control group who continued with the traditional quality management systems. Quantitative data were determined in terms of a defect rate, cycle time, and Overall Equipment Effectiveness (OEE), as well as the perception surveys of employees and customer satisfaction scales.

The research was based not only on the consideration of the internal parameters of performance but also the external outsider results, consequently, providing the extended assessment of how the TQM principles, which are being implemented with systematic interventions, have a chance to positively affect both the output of production and the organization culture. It satisfies a significant gap in the literature by offering evidence of the effects of TQM in databased context, that is to say, real-life in many areas of performance in the manufacturing industry.

Table 1. Pre-Test and Post-Test Quality Performance Indicators for Experimental Group (TQM Implementation) and Control Group

Indicator	Experimental Group (Pre-Test)	Experimental Group (Post-Test)	Control Group (Pre-Test)	Control Group (Post-Test)
Defect Rate (%)	4.5%	2.0%	4.3%	4.1%
Cycle Time (minutes)	25	18	26	25
Overall Equipment Effectiveness (OEE, %)	72%	85%	73%	74%

In the experimental group, after the TQM intervention, the defect rate significantly decreased from 4.5% to 2.0%, indicating a marked improvement in product quality. The cycle time also improved, reducing from 25 minutes to 18 minutes, which reflects increased production efficiency. The OEE rose from 72% to 85%, signaling better utilization of equipment and fewer production delays. On the other hand, the control group showed minimal changes in the same period. The defect rate slightly dropped from 4.3% to 4.1%, and the cycle time only reduced by one minute. The OEE improved marginally from 73% to 74%, suggesting that without the TQM intervention, significant improvements in quality and efficiency were not achieved.

Table 2. Employee Perception Survey Results (Pre-Test and Post-Test)

Question	Experimental Group (Pre-Test)	Experimental Group (Post-Test)	Control Group (Pre-Test)	Control Group (Post-Test)
Engagement in Quality Initiatives (1–5 scale)	3.2	4.5	3.1	3.2
Satisfaction with Quality Control Processes (1–5 scale)	2.9	4.3	2.8	2.9
Perceived Product Quality Improvement (1–5 scale)	3.0	4.6	3.0	3.1

Confidence in TQM Practices (1–5 scale)	3.1	4.7	3.2	3.3

In the experimental group, there was a substantial increase in employee engagement in quality initiatives, rising from 3.2 to 4.5, suggesting that employees became more involved and motivated due to the TQM practices. Satisfaction with quality control processes also improved from 2.9 to 4.3, indicating that employees perceived the new quality control systems as more effective. The increase in perceived product quality improvement (from 3.0 to 4.6) further confirms that employees recognized the positive impact of TQM on the final product. Finally, confidence in the TQM practices significantly increased from 3.1 to 4.7, showing strong employee belief in the new approach. In contrast, the control group experienced only marginal improvements across all areas, with engagement rising only slightly from 3.1 to 3.2 and confidence in quality practices improving from 3.2 to 3.3. This minimal change reflects the limited impact of the traditional methods they continued using.

Table 3. Customer Satisfaction Ratings (Pre-Test and Post-Test)

Rating Dimension	Experimental Group (Pre-Test)	Experimental Group (Post-Test)	Control Group (Pre-Test)	Control Group (Post-Test)
Product Reliability (1–10 scale)	7.5	9.0	7.4	7.6
Product Durability (1–10 scale)	7.2	8.8	7.3	7.5
Overall Satisfaction (1–10 scale)	7.3	9.2	7.4	7.7

Customer satisfaction ratings in the experimental group showed significant improvements after the TQM intervention. Product reliability increased from 7.5 to 9.0, indicating that customers perceived the products to be more dependable. Durability also rose from 7.2 to 8.8, reflecting a positive view of the products' longevity. The overall satisfaction score improved from 7.3 to 9.2, suggesting that customers were much happier with the product quality post-TQM implementation. In the control group, the changes in customer satisfaction were minimal. Product reliability only increased slightly from 7.4 to 7.6, and overall satisfaction showed a minor increase from 7.4 to 7.7. These small improvements indicate that without TQM, product quality and customer satisfaction remained relatively static.

Discussion

The results of the work give strong arguments that the application in manufacturing enterprises of Total Quality Management (TQM) can have a great impact on the improvement of quality of products and relations to the employees and customers. The results add to the existing knowledge of TQM because it fills some of the gaps that exist in the literature concerning the provision of empirical sources regarding effectiveness of TQM in the real world and the use of both internal and external performance indicators to determine the magnitude of its effectiveness.

The sharp decrease in defect rates and the cycle time, along with the increase in the overall equipment effectiveness (OEE) in the course of the experimental group also correlates with the conceptual fundamentals of TQM, which focuses on the emphasis of a constant improvement and effectiveness of operations (Kebede Adem & Virdi, 2021). Some past research noted that TQM had a high potential of enhancing

operation performance, yet most lacked concrete evidence on the ground due to manufacturing environments (Khalfallah et al., 2022). This study has furnished powerful empirical evidence to argue that TQM directly leads to improved efficiency in production and improved quality of its products by use of realistic quality performance measures including defect rates among others. In particular, a 55 percent decrease in the defect rate (down to 2.0 percent) confirms the theoretically driven statement that quality control which is carried out systematically decreases the variability in production processes resulting in less defects and overall increase in quality (Arashpour et al., 2020).

The results of the employee engagement and their view towards TQM implementation are also commendable. In this research, the TQM emphasis on employee involvement and empowerment was demonstrated by showing a significant rise in the levels of employee engagement and the workforce satisfaction with the quality control processes in the experiment group. Past literature has already considered employee contribution as an element in the success of TQM (Ababneh, 2021), but in practice, there have been little statistics on which to substantiate the facts. The fact that participation of the employees in the quality initiatives resulted in a huge improvement in the engagement score (3.2 to 4.5) indicates that participation of the employees in the quality initiatives does not only lead to a positive change on the side of employees in terms of motivation, but also on the overall results of quality. This observation aligns with the results obtained by Al-Sabi et al. (2023), who indicate that participation of employees in the quality control results in the establishment of the culture of continuous improvement and innovation, thereby resulting in enhanced organizational performance.

In addition, augment of employee satisfaction in the new quality control mechanisms (2.9 to 4.3) gives evidence that TQM interventions ensure a more disciplined and accommodative working environment to the workers, as postulated by existing studies that underline the role of strong leadership and structured procedures in the success of TQM. Through the active participation of employees in the process of quality management, this research has shown that TQM does not only lead to better technical results, but also to the socially and organizationally better way of working, the field which was underrepresented in earlier TQM researches.

In customer satisfaction, the findings point out to a significant difference in the perception of a customer in terms of reliability, durability, and general satisfaction in the way they perceive a product after getting the TQM intervention. These findings fill in a major gap in the TQM body of literature, since existing studies tend to assume the relationship between internal quality gains and customer performance, yet fail to test it empirically (Khalfallah et al., 2022). The high degree of improvement in customer satisfaction then customer satisfaction in general being 7.3 in the experimental group which rises to 9.2 is proof that TQM ontogeny has a practical positive payoff measuring the satisfaction of a customer. This is a very vital input, since customer focus is amongst the pillars of TQM. Further, since this study makes use of direct customer satisfaction ratings, then there is scarcely an empirical connection between TQM interventions and customer outcomes, as demonstrated by the position that TQM improves both internal processes also external viewpoints of the product quality.

This research too adds value to the knowledge of how TQM should be applied into practical set up in manufacturing industries. Some earlier studies have tended to focus on the theoretical basis of TQM, although few studies provided concrete information as to how TQM can be used operationally as intervention. This research will offer companies actual guideline on how to implement TQM successfully by describing the particular steps: continuous improvement workshops, customer feedback assimilation, employee participation, and data-driven decision-making, as

they pertain to the TQM process. Processes such as statistical process control (SPC), live data monitoring and so forth point to the meaningfulness of implementing a data-driven approach into the TQM practices, which has not been addressed in detail in the past studies (Rowlands & Milligan, 2021).

The study also responded to a gap that was laid out by Owusu-Kyei et al. (2023), who stated that although people already know the possible positive effects of TQM, there is still neither adequate research that would measure its effects on internal measures (e.g., the defect rate, cycle time) nor external measures (e.g., customer satisfaction). Allowing internal quality performance indicators to be balanced with data on customer satisfaction, the study provides a more informative perspective on the success of TQM since better results within internal processes could result in enhanced customer satisfaction and competitive advantage.

CONCLUSION

This paper has managed to illustrate the high degree of influence Total Quality Management (TQM) has in enhancing quality of products, employee participation and customer satisfaction in the manufacturing firms. The results indicate that their implementation of TQM resulted in the significant decrease in the levels of defects and cycle time, as well as the increase in the effectiveness of overall equipment. These gains would demonstrate the concepts of continuous improvement and the operational soundness which the TQM revolves around, and which is being granted strong empirical evidence of performance in manufacturing environments.

Further, the paper also identifies the necessity of involving the employees in a quality management process. Including employees in TQM programs also promotes the culture of continuous improvement besides making the workers happy and motivated. This conforms to the literature that is available which focuses on the importance of workforce participation in attaining successful TQM results, thereby strengthening the reasons why organizations focus their attention on the involvement of their staff in their campaign to manage their quality. Further, the dramatic upsurges with respect to the customer satisfaction ratings in the range strengthens the connection between the internal quality advances and the outer perception of the customers. The work is a fruitful piece of advice in terms of how TQM can be used in having more reliable products and a general customer satisfaction in confirmation that a concentration on quality management procedures may lead to a vast competitive edge to businesses operating in the production market.

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