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Implementing continuous quality improvement in a manufacturing environment (ACFA 7004)

Module – Research Methods and Professional Developments

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Abstract

This paper is a research proposal that examines the various aspects of quality improvement opportunities in manufacturing, including research methods, barriers, and costs. Companies have an obligation to continually improve quality as ISO 9001:2015 specifies. The literature review identifies several continuous improvement methods such as PDCA, Kaizen or Six Sigma. The research methods proposed to assist include both qualitative and quantitative approaches, such as surveys and interviews, these will provide insights into areas for improvement. However, barriers to continuous improvement, such as employee's resistance to change and lack of resource, can impede progress. The costs of quality, including prevention, appraisal, and failure costs, can also be significant and must be considered. To overcome these challenges, organisations can adopt ISO 9001 business requirements, including a quality policy, quality objectives, customer focus, and continual improvement, which can help establish, drive and sustain a culture of continuous quality improvements.

Abbreviations

CI	Continuous Improvement
CQI	Continuous Quality Improvement
ISO	International Organisation for Standardisation
QMS	Quality Management System
IMS	Integrated Management System
CoQ	Costs of Quality
PDCA	Plan Do Check Act
RCA	Root Cause Analysis
DMAIC	Define, Measure, Analyse, Improve, Control
TQM	Total Quality Management

Keywords

Continuous Improvement, Continuous Quality Improvement

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Introduction

Continuous improvement (CI) is a key concept in the manufacturing field, organisations should strive to continually improve in order to remain competitive. The International Organisation for Standardisation (ISO) standards, ISO 9001 requires companies to make efforts to constantly improve their quality management system (QMS). Continual improvement is driven by upper management, as a minimum it should address quality of the products and/or services provided whilst improving efficiency. Improvement is an ever-changing process of innovations and implementations which is an essential need in industrial manufacturing.

Hornbill Engineering is an electrical contracting company which offers full turnkey solutions. Some of the services offered by Hornbill include high voltage, low voltage, instrumentation, training, procurement, system design and panel manufacture. The bespoke manufacturing workshop section within Hornbill Engineering designs and manufactures made to order control panels ranging from MCCs, switchboards, PLC control panel, server cabinets, and much more. The need to continually improve is particularly important in this area, the components within control panels are continually improving. The process of manufacture can be complex and requires very high levels of precision and attention to detail. Hornbill Engineering currently has an integrated management system (IMS) that covers all work undertaken within the company, the manufacturing workshop is one section of the company. The IMS ensures that Hornbill are compliant with ISO 9001:2015, ISO 14001:2015 and ISO 45001:2018. External certification demonstrates this continued commitment.

This report presents the hypothesis that implementing continuous improvement initiatives within a bespoke manufacturing workshop will result in increased efficiencies, reduced waste and costs, improved product quality, and higher customer satisfaction.

The hypothesis can be tested by collecting and analysing data which will highlight quality failures. This could lead to the implementation of ongoing continuous improvement initiatives such as improvement quality controls in the workshop if the results support the hypothesis. The findings of this study will be useful for manufacturing organisations seeking to implement continuous improvement initiatives, as well as researchers and practitioners interested in the field of continuous improvement in manufacturing.

Literature Review

Continuous Improvement

Continuous improvement is a management philosophy and approach which is utilised to identify areas of opportunities to provide efficiencies to systems, processes, and products. CI requires a structured strategy for identifying improvement opportunities, the design and implementation of changes, and the impact measurements of the changes which can lead to efficiencies and increased productivity (Fruchtnicht, et al., 2013), with also reductions in waste (Anand, et al., 2012). It is more prominent than ever as organisations look to identify opportunities for savings due to dramatic increases in costs. One major benefit of introducing this practice is the increase in customer confidence and enhanced customer satisfaction (Doshi & Desai, 2016). Furthermore, a large portion of a company's sales revenue are quality related costs which further justifies the need to implement continuous quality improvement to reduce quality defects and therefore quality costs (Donauer, et al., 2015). It is proven that continuous improvement has led to organisations operating with increased financial performance through the removal of variability that is unnecessary (Hopp & Spearman, 2004).

The core principles of CI include the customer focus, understanding the customer expectations and needs as well as the stakeholders whilst incorporating these into the design, implementation and delivery of the products or services. Decision making must be made using data which identifies areas for improvement, the data should be used to measure the changes. The CI journey strives for perfection, it requires commitment from management, leaders, and teams to support in achieving common goals of improving processes, procedures, and products and/or services (Sanchez-Ruiz, et al., 2019). For the success of CI to be guaranteed it is important to point out that human factors are key.

CI is a cycle which contains several stages, the initial stage is generally an assessment where data is collected of the current state of processes, systems, or products. This is fed back to stakeholders. An analysis of the data identifies opportunities for improvement, root causes can then be determined. Development of a plan to introduce the changes is then undertaken before the implementation and monitoring. Finally, evaluation of the changes using data and feedback from customers and stakeholders is used to inform additional improvement.

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Continuous Improvement Tools and Techniques

Plan Do Check Act (PDCA)

The field of CI has been influenced by several gurus whose contributions have paved the way for many. One of which is Dr William Edwards Deming, who has been often referred to as the “father of continuous improvement” (Baum, 2019). The PDCA method shown in figure 1 was developed during the 1950’s by Deming. Since this time his method has become an integral tool used by many organisations today to formulate opportunities for change, and then test through a continuous feedback loop (Fruchtnicht, et al., 2019).

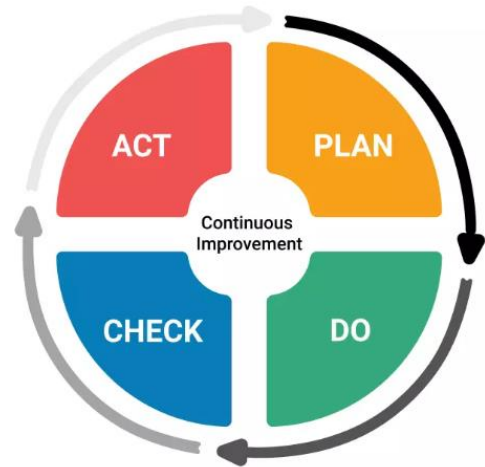


Figure 1 - PDCA Cycle (Kanbanize, n.d.)

The initial stage of this process is the plan, here organisations need to understand the opportunity or issue. This could be due to an increase in product defects on a production line. All information should be fully explored, ideas should be discussed then a robust implementation plan can be agreed with measurable success criteria specified (Jovanovic, et al., 2017).

After the possible solution is identified a small-scale trial can be experimented to confirm if the proposed changes do achieve the outcome that was intended. As the trial is progressing, data should be collected to demonstrate whether the changes are succeeding.

The third step involves analysing the results from the trial against the criteria which was defined during the first stage. If it was proved to a success, then the final stage can be started. If not, it would be advantageous to adjust slightly then repeat stage 2 and 3. However, if the idea was a total failure step 1 also may need to be repeated.

The final stage of the process is where the solution is implemented company wide. It should be noted that this process is a cycle of continuous improvement. The changes made now will become the new benchmark, but further improvements should be considered.

Additional to the PDCA cycle, Deming has been credited for other contributions such as statistical methods to control quality and reduce variability in manufacturing processes. He also introduced the concept of total quality management (TQM). This involves a systemic approach to quality improvement that involves all aspects of an organisation.

Kaizen

Masaaki Imai is another CI guru best known for his contributions to the concept of Kaizen, which is a Japanese philosophy of CI. Imai's contributions have impacted modern continuous improvement practices, with many organisations adopting this philosophy to drive improvement and innovation.

This six-step strategy shown in figure 2 aims to improve organisations through creating a continuous improvement culture where all employees are actively engaged (Oropesa-Vento, et al., 2015). Kaizen concentrates on applying minor changes daily or weekly that results in significant improvements in productivity, quality, safety, and workplace culture. The strategy pushes past simple improvements, when done correctly it will enable employees to identify and eradicate waste in processes whilst also allowing employees to work smarter without overworking themselves (Janjić, et al., 2020). Due to the nature of introducing small change, Kaizen is a low-risk and low expense strategy. Employees are encouraged to experiment with new ideas, if they are found to not be flawed, the changes can be reverted without large costs.

Kaizen brings many benefits such as process improvements, encourages teamwork, creativity, trust, engagement and ultimately morale in the workplace. Employees are given the opportunity to improve their working experience whilst benefitting the organisation. Employees that are engaged and motivated tend to become more efficient and take more pride in their work which in turn increases customer satisfaction (Oropesa Vento, et al., 2016).



Figure 2 - Kaizen 6-Step Cycle (Kanban Zone, n.d.)

Root Cause Analysis (RCA)

Continuous improvement can be driven through root cause analysis. Organisations that are able to get to the root of the issues that lead to customer complaints are more likely to fix the problems. This will prevent further issues arising again in the future (Balakrishnan, et al., 2019). Customers are more likely to continue working with an organisation if they feel their complaint or feedback has made a difference. A successful RCA investigates and provides solutions, it isn't about assigning blame (SAMS, et al., 2012). With the correct training and tools in place, improvements can be made company-wide which reduces complaints, improves the product or services provided and increases customer satisfaction.

Full organisational buy-in is required between relevant departments when addressing issues, investigation solutions and implementing improvement. RCA findings have more impacted on departments when presented in a format that is relevant for the internal audiences. For example, a finance department will be more interested in the financial impact of the RCA findings.

Six Sigma (DMAIC)

Six Sigma was developed by Motorola, in the 1980s, a team of engineers strived to improve quality control processes. Six Sigma has since been adopted by many organisations across various industries. It is a sequential methodology which measures defects in a current process then attempts to eradicate them as well as increasing efficiency (Box, 2006). It builds on existing processes whilst providing additional tools. This tool identifies variability in a process then provides the tools to reduce them and improve the process. Six Sigma significantly improves customer satisfaction, is used to reduce costs, and improve profits (Harry, et al., 2000).

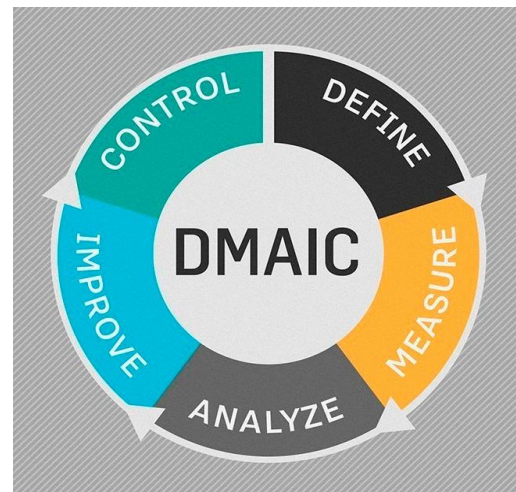


Figure 3 - Six Sigma DMAIC Process (McLaughlin, 2021)

Six Sigma can be applied to existing processes, or it can be used to create a new process. The 5-step improvement process type that will be focuses on is DMAIC (define, measure, analyse, improve, and control) which is applied to existing processes (Terra, 2019).

Define: In this step the product or process that needs improving as well as the needs of the customer are identified.

Measure: During this phase the target performance, the input and outputs are determined. The measurements that will be utilised are then validated.

Analyse: The root causes of the issue is identified.

Improve: This step is where ways are established to eliminate the defects.

Control: The control phase manages future performance by recording the solution, assigning responsibilities, and keeping track of the findings over time.

Continuous Improvement Barriers

CI barriers are defined as factors that hinder, obstruct, or limit the CI implementation process. Starting CI often begins with an organisation generating a list of initiatives they need to begin or plans that need to be executed. This may include attempting to educate and motivate the work force on what CI means to each individual. There will inevitably be problems along the way no matter how well-planned the initiative is. To ensure smoother implementation, understanding the barriers and identifying them is essential to assist design plans to pre-empt any issues (McDermott, et al., 2021). Table 1 lists some of the possible barriers companies will face when attempting to implement continuous improvement.

<i>Barriers to Continuous Improvement</i>
<i>Limited time</i>
<i>Lack of understanding regarding CI</i>
<i>Insufficient experience or training on CI topics</i>
<i>Suitable management system not present</i>
<i>Lacking management commitment</i>
<i>Lacking staff involvement and/or motivation</i>
<i>Proposed improvements are not monitored</i>
<i>Insufficient resources</i>
<i>Resistance to change</i>
<i>Unalignment between operational activities and the competitive strategy</i>
<i>Culture incapable of learning from mistakes</i>
<i>Not enough information or improper analysis of the information</i>
<i>Insufficient processes to solve issues</i>
<i>Interdepartmental barriers</i>

Table 1 - Barriers to CI

Costs of Quality

Measuring and noting costs of quality (CoQ) can assist in indicating if an organisations quality control measures are working correctly, if they need reviewing or if they need additional measures.

According to Feigenbaum, CoQ can be categorised into prevention, appraisal, and failure, both internal and external, costs. Costs can be collected using the Prevention Appraisal Failure model (Feigenbaum, 1956). Prevention costs are costs which are associated with reducing the possibility of failures such as design verification or training. Appraisal costs are costs that are accrued through ensuring the conformance of products and processes to pre-set specifications such as internal testing. Failure costs are the costs of non-conformance. Internal failure costs are costs which occur if a product fails to meet the specification before it has been delivered to the customer such as re-work. External failure costs occur if a product fails to meet the specification after it has been delivered to the customer such as warranty claims, recalls or loss of sales (Wheldon & Ross, 1998).

The CoQ has serious impacts of profitability and reputation. Company's that fail to invest in quality can be susceptible to increased failure costs, as well as loss of future sales due to damage in a company's reputation. However, large investments in quality will likely lead to customer satisfaction, reduced defects and increased future sales. Quality requires effective management, the quality and costs need to be balanced. Companies that can identify root causes of any quality issues can reduce costs and improve their products or services.

Methods

To prove or disprove the hypothesis, research studies will be undertaken within Hornbill. Both qualitative and quantitative research will be used to help identify any areas for improvement through comparing the results to gain deeper insights. For example, quantitative research may suggest that in a manufacturing environment 1 in every 10 bespoke control panels may leave with a defect. Adding a qualitative dimension could help find out the reasons for why these control panels end up with defects. The appropriate actions can then be introduced. Qualitative and quantitative research is now more easily accessible due to technology. Face-to-face focus groups would previously be key for qualitative research. Online communities and focus groups now exist to share information and collect quantitative data through surveys or polls with the same audience.

Qualitative

Interviews

Primary data collection in the form of interviews will play an important role. Direct and in-depth interviews and discussions will be held between the interviewer and important, influential, and experienced employees. The likelihood of success of any change introduced will be greater by engaging the most important, influential, and experienced employees as the Kaizen CI method suggests. Important and influential stakeholders are involved to ensure commitment as well as to motivate other employees to adopt the changes (Sonmez Cakir & Adiguzel, 2020). One-to-one interviews will allow for an open discussion without influence of others. This type of research will prove to be very effective at the beginning of the research. Each employee may also have a different view on what quality is and what it means. Therefore, they each will have different views on what improvements can be made. This will give a basis and help guide other methods of research such as surveys or focus groups that will be undertaken at a later stage.

Focus Groups

Focus groups are usually used in the preliminary stages of a study, however in this case it could be used before implementing any changes, a focus group could be set-up that involves those within the manufacturing environment such as panel builders, electricians, supervisors, etc. Discussions between this group of stakeholders will be important to gather the opinions about the changes. It will help gauge how the changes will be responded to as stakeholders will voice their feelings and beliefs as a group. Further modifications or research into the changes could be made if required.

Quantitative

Surveys

A list of mainly multiple-choice questions will be distributed to customers of the company which will aim to gather information. It will give an insight into the level of service and/or product quality the company currently provides, if there are any failings, and what can be done better. Considering the voice of the customer will be key in implementing continuous

improvement as ultimately the customers view is paramount to ensure the success of the company. It is thought that surveys can follow interviews have taken place to test the insights on a greater scale.

Internal Testing

A small group of individuals undertake in-house testing, this will help identify and rectify defects before releasing products to customers. Any data for defects will be tracked, if the same defects are found continuously this will provide an opportunity to improve. Internal testing enables faster feedback loops, as collaboration to address any defects or failings identified can be rectified quickly. This can provide valuable data on the performance of staff and processes.

Results

After conducting initial research on CI and the methods utilised to implement initiatives, it is proposed that Six Sigma (DMAIC) will be implemented to improve existing processes and quality controls within Hornbill. Six Sigma will help identify and eliminate defects and quality failings during the manufacturing and testing process. Decision making will rely upon analysis of data to help identify areas for improvement, this will be tracked over time.

Analysis Plan

1. Data preparation (Define): Design surveys, interview questions, identify key stakeholders ensure their commitment then allocate roles and responsibilities.
2. Data collection (Measure): Conduct surveys, interviews, focus groups, and complete any data entry.
3. Analysis (Analyse): Calculate descriptive statistics, such as means, standard deviations, and frequencies. Conduct analysis using software, such as Excel, to identify any patterns and relationships among the collected data and draw conclusions.
4. Implementation plan (Improve): Develop a plan based on the research findings, list specific actions to address identified improvements areas, considering CI barriers, include a timeline and allocate resources.
5. Implementation and evaluation (Control): Implement changes then evaluate the effectiveness, track progress, and collect data, ensure timeline is on target. Validate results through peer review. Develop recommendations for further improvements. Present findings to stakeholders.

The analysis plan should be detailed enough to guide the analysis process, whilst also allowing for flexibility to adapt to unexpected findings or changes in the research approach.

Proposed Timeline

The suggested timeline for the research and implementation begins in April 2023 and will end in September 2024.

Phase One: Planning and Preparation

- Week 1-3: Finalise research questions and goals, identify roles and responsibilities for those involved and design survey instruments.
- Week 4-6: Design interview questions and select participants.
- Week 7-8: Develop tools to track data.

Phase Two: Data Collection

- Week 9-14: Conduct interviews, surveys and track data following internal testing.
- Week 15-17: Complete data entry.
- Week 18-20: Verify data accuracy.

Phase Three: Data Analysis

- Week 21-24: Conduct descriptive statistics for each survey response.
- Week 25-28: Conduct analysis identifying any relationships between the data.
- Week 29-30: Validate results through per review or discussions with stakeholders.

Phase Four: Implementation Plan

- Week 31-34: Review results, prioritise and identify changes to be implemented.
- Week 35-38: Develop implementation plan.
- Week 39-40: Assign roles and responsibilities to stakeholders.
- Week 41-42: Develop communication channels/plan between stakeholders.

Phase Five: Implementation and Evaluation

- Week 43-45: Implement changes proposed.
- Week 46-56: Monitor and track progress, collecting data.
- Week 57-60: Analyse and evaluate collected data.
- Week 61-62: Validate results through per review or discussions with stakeholders.
- Week 63-64: Develop recommendations for further improvements.
- Week 65-66: Present findings to stakeholders.

Evaluation

Evaluation of the results can be achieved by a several methods. One of which is through statistical analysis, such as t-tests, this can be utilised to test the hypothesis to determine if there has been a significant change between data for pre-implementation and post-implementation of any changes. This will identify any significant changes in quality cost, efficiencies, or customer satisfaction.

Benchmarking can provide a comparison between the results obtained and industry benchmarks or best practices can be undertaken to provide relative results. This could identify further improvement opportunities. Visual aids such as scatter plots, histograms, and line graphs can be used to evaluate the data and identify any trends.

The final step will be evaluating the data and interpret the results, drawing conclusions and making recommendations. This interpretation can be validated through peer review and discussions with stakeholders. The evaluation findings will be used inform future initiatives for improvement and ensure that the workshop continues to operate at the highest levels of efficiency, productivity, and quality whilst constantly improving, striving for excellence.

It is important to identify the limitations, there could be errors in the data collected due to using inaccurate or imprecise measures. It is possible there could be data input errors or misinterpretation of the data that is fed back. Stakeholders may not always feedback all data for a number of reasons which can lead to an unreliable evaluation. Another limitation could be that the Hawthorne effect occurs, where workers alter their behaviour in response to data being tracked, this can lead to drastic changes in the results. Time and resources can be a constraint as the collection of data and the evaluation can be time consuming and resource intensive which can limit the depth of the analysis and data collection.

This research will contribute to future research depending on the findings. It could identify new areas for research due to the impact of different improvement initiatives. This study could provide new evidence or inspire new research questions relating to the impacts of implementing continuous improvement within a bespoke manufacturing workshop.

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