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An integrated framework for improving safety, quality, and stewardship standards in manufacturing: A case study

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ABSTRACT

Health and safety, quality assurance, and stewardship control, when integrated together, can streamline systems and work processes, reduce bureaucracy and increase efficiency. In this study, efficiency increase refers to improving and maintaining high standards of demarcation, housekeeping, no blocked safety equipment, tools storage conditions, good manufacturing practices and chemical storage conditions. Using industrial engineering tools, Plan-Do-Check-Act and Kaizen, the study illustrates a quick turnaround in standards improvement in a manufacturing plant, which resulted in culture change and increasing profitability. The manufacturing plant studied had below average standards that created health and safety hazards leading to incidents, created a risk of quality and stewardship systems failure. Incidents varied from minor to serious. With improved standards, the plant avoided and eliminated health amd safety, quality, and stewardship risks in critical areas such as production or operations floor, warehouse, laboratory, storeroom, utilities area, and workshop. This was achieved through the integration of health and safety, quality assurance and stewardship controls as one safety, quality, and stewardship (SQS) framework. The three are denoted as fundamentals and core foundation systems in a manufacturing environment in this study. An SQS tool was developed, tested, and implemented and results are shared. Implementation of the tool resulted in improvement of overall manufacturing plant standards, elimination of safety hazards, reduction of quality defects and scrap, eradication of internal controls issues, and business success. The study will be of great value for manufacturing plants who are looking to integrate more than two management systems.

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1. Introduction

The health and safety of the people is of utmost importance, with work related injuries presenting a serious and costly burden to business (Quinlan et al., 2010). The work environment should be a safe place. The occupational health and safety management system encourages a safe and healthy working environment by providing a framework that authorizes a business to find and control health and safety risks, reduce possibility for incidents, drive compliance and improve business results (Fuller et al., 2004). The product quality is the most imperative marketplace indicator and the very primary evidence for consumer evaluation of a product for customers (Parasuraman, 2007). According to Dalgleish (2005), an effective quality management system assures high product quality. High product quality contributes to market share and sales growth subsequently increasing sales margin. Such benefits enable the business to avoid unnecessary financial loss. Stewardship is taking accountability to protect company assets by doing the right thing all the time even when not watched. Having good controls eliminates risk of financial fraud. Financial fraud scandals were uncovered before the

Industrial revolution (Pearson and Singleton, 2008). Prabowo (2013) discusses stewardship from forensic accounting point of view that it detects fraud and cyber-crimes while Singleton (2002) shows how to build stronger internal controls that will enhance business objectives, and how to put measures to prevent fraud from happening than detecting it after occurrence.

It is necessary to discuss some of the prominent tools used to solve problems related to integration in safety, quality, and stewardship. PDCA cycle is a methodology when effectively completed, result in improved outcomes for business. In the study, PDCA is used to drive continuous improvement in health and safety, quality assurance, and stewardship controls. The continuous improvement cycle is captured in the steps as follows:

- Identify opportunities in the process workflow.
- Plan how can the current process be improved.
- Execute and implement changes.
- Review how changes are working for the team.

PDCA applies a logical sequence of stages to achieve persistent improvement. The cycle starts with a Plan step involving identifying the problem. The actions put in place are in the Do step, Check is a study step where the outcomes are monitored, the Act step closes the cycle integrating learnings from the entire cycle (Chandrakanth, 2016; Patel and Deshpande, 2017). Although PDCA is applicable to processes, businesses, and organization, it can be adopted at individual level to start small, test potential effects, then gradually leading to a bigger and more targeted change. Another important technique, i.e. Kaizen is a lean approach that focusses on continuous improvement through eliminating waste and total employee involvement (Slack et al, 2007). Under lean, various types of waste are: overproduction of information, over processing of information, miscommunication of information, stockpiling of information, generating defective information, correcting information, waiting of people and unnecessary movement of people (Wilson, 2015). Any non-value adding activity, task and process in safety, quality, and stewardship is defined as a waste. In this study, the key wastes to focus is, over production of information, over processing of information, and waiting on people.

2. Literature Review

The study focusses on losses that result from overprocessing of safety, quality, and stewardship information. The idea of integration brings about continuous improvement of systems in health and safety, quality assurance, and stewardship controls. For effective integration, total employee involvement and engagement driven by leadership is required across the entire organization. The basic approach to complement PDCA cycle provides a basic framework for developing, testing, and implementing changes to the way things are done that will lead to improvement (Moen and Norman, 2010). Spending quality time in each phase of the cycle is imperative to have a smooth and meaningful improvement [Chakraborty, 2016).

There is no evidence of integrated management system for health and safety, quality, and stewardship but existing integration of health and safety, and quality illustrate very important benefits. A study completed by Tepaskoulas and Chountalas (2017), explored the integration of health and safety and quality systems in a construction company, highlighting the benefits, issues, and success factors. The company successfully integrated the two systems resulting in keeping costs low, quick fixing of safety and quality outages, reduction in bureaucracy and efficiency.

Bernardo et al. (2015) and Rebelo et al. (2016) highlighted key benefits of integrating management systems that included reduction in costs and simplification of work processes. During integration, work processes were streamlined, audit systems were managed as one, common tools and models were used, and the sequence of auditing was enhanced. The level of auditing also improved the quality of the findings. Bernardo sited having a certified management system as a key factor to develop and sustain integrated results and performance. Furthermore, Bernardo et al. (2012) stated benefits of integration, which included consolidation and simplification of internal and external audits. Individual implementation and auditing lead to additional effort (Carvalho et al., 2020). Integration improves compliance as well.

Almeida et al. (2014) specified simplification in documentation control and record keeping as a key benefit to integration. With integration, it is easier to store documents and storage space required is reduced. Casadesus et al. (2011) said that integration of health and safety, and quality, gave businesses competitive advantage and increased market share. Integration is positively correlated with performance, as the business improves work processes to be efficient, customers get added value in return and satisfaction is enhanced resulting in increased revenue.

Simon et al. (2012) mentioned the efficient use of resources saving effort for the organization. Productivity is a key output measure. Both health and safety, and quality management systems are driven by ISO which attributes to risk management. Research done by Tepaskoulas et al. (2016) suggests that future research should

propose appropriate tools that can help businesses to effectively integrate the different risk management approaches that are used in their separate systems. With that said, this study is meant to explore various tools to integrate health and safety, quality management and stewardship systems and controls to improve manufacturing plant standards and business results. It is also important to highlight that the implementation of artificial intelligence and optimization techniques has also been found effective for evaluation, monitoring, and enhancement of quality for various business sectors (Fučić et al., 2022; Kovačić et al., 2022; Mišić et al., 2023; Youssef and Webster, 2022; Wang and Dong, 2023).

Our manufacturing plant, despite making strides to improve business results, faced challenges in terms of health and safety incidents, high consumer, and customer complaints with poor controls. This negatively affected profitability and put the plant at risk of being shut down. The huge effort required to do tasks, made it difficult to make a step change in the standards and resulted in poor culture, high costs and huge effort investigating and analyzing incidents and related data. Additional costs were spent paying for damages, and employees off workdays when injured. This prompted a study to look for efficiencies that will first fix the immediate internal gaps- demarcation standards, housekeeping standards, blocking of safety equipment, tools storage conditions, good manufacturing practices and chemical storage conditions, thereafter, continually improve health and safety, quality, and stewardship controls and systems.

3. Research Methods

This case study was completed in a manufacturing plant and the outcome responded to improvement of demarcation and housekeeping standards, blockage, tools storage conditions, good manufacturing practices and chemical storage conditions. Included in the study was the implementation of the integrated SQS tool. The tool helped develop a framework to manage health and safety, quality assurance and stewardship as one SQS management system through shared resources and effort. The tool is simple to use with six questions to be answered. The tool was tested for correctness before use. Thirty-eight responses were received from the testing of the tool.

The questions assessed compliance against health and safety, quality assurance, and stewardship procedures in various areas. The six questions are as follows:

1- Demarcation: were all raw materials, finished product pallets, trolleys, toolboxes, units, crane handle stored inside designated area,

2- Housekeeping: did you find clean floors, clean stairs, area under tanks, area under unwinders clean, no slippery floor and no lotion around tanks,

3- Blockage: did you see 1m clearance in front of fire protection, electrical panel equipment and direct access to the equipment walkways: no trip/slip hazards and blockages on the walkways,

4- Tools: was there no tools or parts on the toolbox, the floor, table, or other areas. tools free from defects and safe to use,

5- Were the manufacturing practices good: no raw and pack materials, or finished product bags or bundles on the floor,

6- Chemical storage: were all chemicals labelled and stored inside the chemical cabinet to the required capacity.

4. Analysis. Results and Discussion

The pictures before the implementation of the integrated tool illustrated poor standards creating hazards in the production floor, warehouses, laboratory, utilities area, storeroom, and workshop. Upon implementation of the tool, the plant standards improved, eliminating health and safety risks, reducing consumer and customer complaints, improving stewardship controls and culture. The tool integrated health and safety, quality assurance and stewardship controls, will be used to assess overall site culture in the three areas at a defined frequency on an ongoing basis. The tool is simple it can be accessed on a computer or mobile phone and employees have the option to scan the QR code anywhere to complete the assessment. Figure 1 gives a preview of the tool on a mobile phone and Figure 2 shows the scannable barcode to access the tool anywhere on a mobile phone or at a computer.

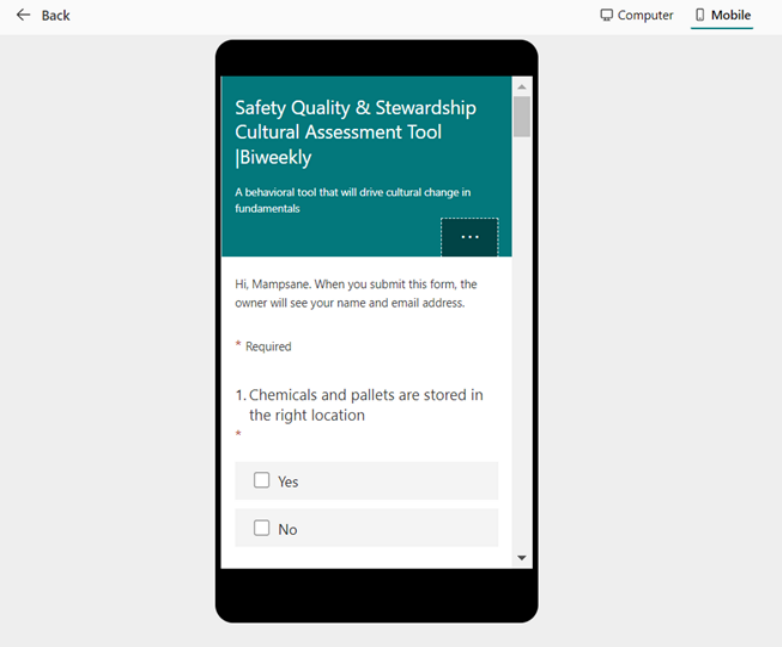


Figure 1. SQS tool on mobile

Figure 2. Scannable barcode for SQS tool

The data collected from the thirty-eight participants via this tool were summarized in participants' departments, the audited areas in the manufacturing plant, and insights were provided with before improvement and after improvement pictures of the standards. Some of the important results are discussed here.

The details of the departments, in which the participants of the tours and audits are employed, are given in Table 1. There is high participation of 45% from the operations department, reflecting the high percentage of employees currently waged under operations as reflected in Table 1. Twelve areas were assessed as shown in Table 2. The areas were defined based on the potential to have safety, quality, and stewardship risk due to frequency of use and the tasks completed in the area. Operations lines have been audited more often than any other area with a high combined percentage of 55%, followed by warehouses at 14%. The quality lab, offline and utilities areas are all at 8%. Workshop follows at 5%, and the lowest audited area is storeroom at 3%.

Table 1. Department wise distribution of the participants

Department name	Number of participants	Percentage participation
Operations	17	45%
Quality assurance	11	29%
Health & Safety	3	8%
Supply Network Operations	2	5%
Engineering	2	5%
Operations Support Organizations	3	8%
Other	0	0
	38	100%

Table 2. Areas audited

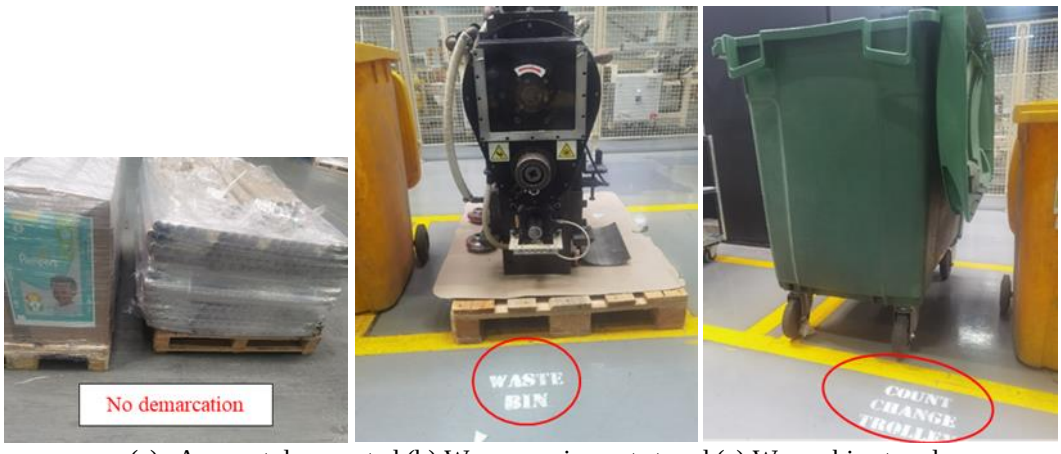
Department name	Number of participants	Percentage participation
Operations Hall Line 1	4	11%
Operations Hall Line 2	5	13%
Operations Hall Line 3	9	24%
Operations Hall Line 4	3	8%
Raw material warehouse	1	3%
Pack material warehouse	1	3%
Finished product warehouse	3	8%
Storeroom	1	3%
Quality lab	3	8%
Workshop	2	5%
Offline	3	8%
Utilities area	3	8%
	38	100%

4.1. Analysis of demarcation standards in audited areas

The responses to question 1 are provided in Table 3 - Demarcation: All raw materials, finished product pallets, trolleys, toolboxes, units, crane handle stored inside designated area. This question assesses whether areas are properly demarcated and used appropriately to avoid creating health and safety hazards. Some other parts of plant areas did not have proper demarcation while on other occasion wrong items were stored in a demarcated location. This is shown below in Figure 3. This created a safety risk for the many employees working 24/7 in this operation. The areas that were demarcated were not used appropriately – count change equipment was stored in a waste bin demarcated area whilst the waste bin was stored in the count change equipment trolley area. The pictures in Figure 4 reflect the corrected and improved demarcation standards after implementation of the integrated SQS tool.

Table 3. Participants' responses on demarcation

Demarcation	Responses	Percentage
Yes	25	65.7%
No	12	31.6%
NA	1	2.6%
	38	100%



(a) Area not demarcated (b) Wrong equipment stored (c) Wrong bin stored

Figure 3. Problems with demarcation

Figure 4. Improvement in demarcation.

4.2. Analysis of housekeeping standards in audited areas

The responses to question 2 are addressed in Table 4 - Housekeeping: Clean floors, clean stairs, area under tanks, area under unwinders clean, no slippery floor and no lotion around tanks. This question assesses whether areas are properly cleaned. The pictures in Figure 5 show very poor housekeeping in operations area with boxes of labels left on the floor. These labels are pack materials and should be prevented from contamination.

Table 4. Participants' responses on housekeeping

Housekeeping	Responses	Percentage
Yes	26	68%
No	12	32%
NA		0%
	38	100%

(a) Untidy workshop trolley (b) Untidy material labels

Figure 5. Examples of poor housekeeping.

In Figure 6, the housekeeping standards are significantly improved with shiny floors after implementation of the SQS tool and tours.

(a) Shiny floors in between production lines (b) shiny floors in the warehouse

Figure 6. Improvement in housekeeping.

4.3. Analysis of items locked in audited area

The responses to question 3 are given in Table 5 - Blockage: 1m clearance in front of fire protection, electrical panel equipment and direct access to the equipment walkways: no trip/slip hazards and blockages on the walkways. This question assesses whether safety procedures are met or not. Blocked walkways create a hazard for people and forklifts as shown in Figure 7. The cultural improvement helped employees to establish high standards whereby walkways, safety equipment i.e., fire extinguishers are clear and easily accessible, not blocked by any materials or any other items. This is shown in Figure 8.

Table 5. Participants' responses on blockage

Blockage	Responses	Percentage
Yes	36	95%
No	2	5%
NA		0%
	38	100%

Figure 7. Packing materials stored in non-demarcated location

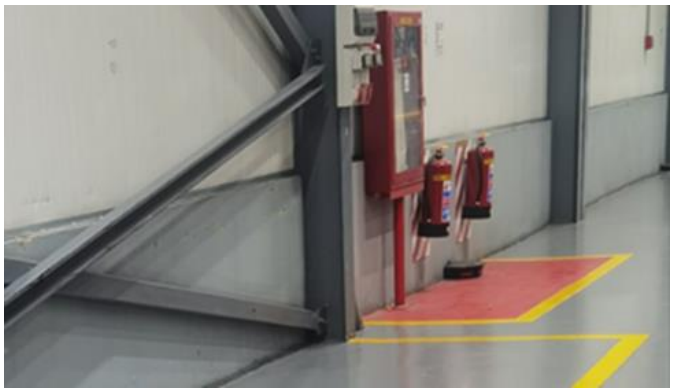


Figure 8. Unblocked pathway

4.4. Analysis of tool storage conditions

Table 6 offers the responses to question 4 - Tools: No tools or parts on the toolbox, the floor, table, or other areas. Tools need to be free from defects and safe to use. This question assesses whether that 5S is maintained with parts and tools placed where they are supposed to be. Tools that were not stored properly would get lost very often, unnecessary spending on replacement meant loss of money, and internal controls outages to account for some of the lost parts. Some of the smaller parts would disappear around the work area creating slipping and safety hazards. This was a result of the poor standards as presented in Figure 9.

After fixing the outages during SQS tool integration, tools are properly labelled and stored, hardly get lost and are easy to find. This increased inventory accuracy to 100% and the company avoids spending money on lost parts and equipment. The improvements are shown in Figure 10.

Table 6. Participants' responses on tool storage

Tool storage	Responses	Percentage
Yes	18	47%
No	14	37%
NA	6	16%
	38	100%

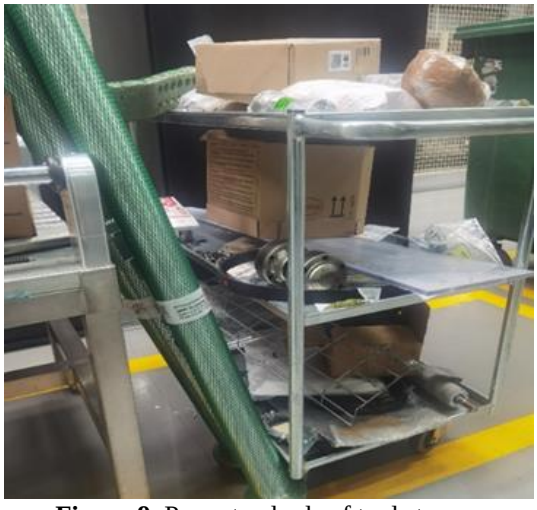


Figure 9. Poor standards of tool storage

(a) (b)

(c)

Figure 10. Improvement in tool storage standards

4.5. Analysis of compliance to good manufacturing practices

The responses to question 5 responses as addressed in Table 7 - Good manufacturing practices: No raw and pack materials or finished product bags or bundles on the floor. This question assesses whether good manufacturing practices are adhered to across the site. The picture of packaging materials left on the floor is another example of poor manufacturing practices as shown in Figure 11. It shows the packing materials, boxes of labels not placed on a pallet but on the floor creating a risk of contamination.

Figure 12 is a good example of proper manufacturing practices, clean floors without any potential cause of contamination, boxes placed where they are supposed to be in clearly demarcated areas after implementation of SQS integrated tool.

Table 7. Participants' responses on good manufacturing practices

Manufacturing practice	Responses	Percentage
Yes	28	74%
No	7	18%
NA	3	8%
	38	100%

Figure 11. Untidy material labels

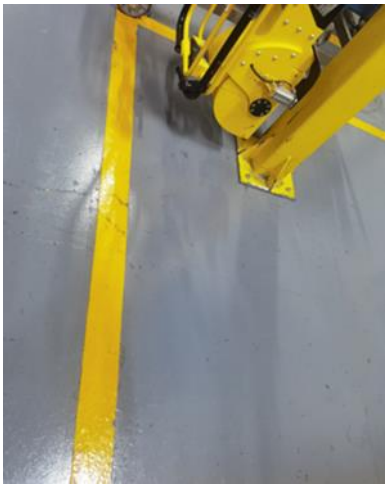


Figure 12. Clean floors

4.6. Analysis of storage conditions for chemicals used in different operations

The responses to question 6 responses as provided in Table 8 - All chemicals labelled and stored inside the chemical cabinet to the required capacity. This question assesses whether chemical are not stored in a way that poses safety risk to employees.

Before the SQS integration, some areas did not follow chemical storage conditions, chemicals were left inside production equipment after cleaning as teams would rush to start up the lines. The poor standards are shown in Figure 13. SQS implementation brought significant improvement in how chemicals are stored. Figure 14 shows chemicals in clean bottles, nicely stored in dedicated trolleys.

Table 8. Participants' responses on chemical storage conditions

Chemical storage	Responses	Percentage
Yes	11	52%
No	10	48%
NA		
	21	100%

(a) Chemical bottles left around (b) chemical bottles left inside machine

Figure 13. Poor chemical storage standards.

(a) Chemical storage 1 (b) chemical storage 2 (c) chemical storage 3

Figure 14. Improvement in chemical storage standard.

5. Conclusions

The integration of SQS through the tool helped to develop a framework to manage health and safety, quality assurance and stewardship as one SQS management system through shared resources and effort. Upon implementation of the tool, the plant standards significantly improved, eliminating health and safety risks, reducing consumer and customer complaints, improving stewardship controls and culture. Areas are properly demarcated, used appropriately, for the correct equipment and for the correct purpose with the risk of injury reducing by more than 95%, inventory accuracy increasing to 100%. The site reported zero slipping and tripping hazards after implementation of the tool. Clean floors promote 5S standards and prevents product contamination, decreasing complaints and adding value to customers. Safety equipment was no longer blocked. Workplace injuries that came from tools storage were eliminated to zero while employee health and safety, morale and work life balance improved significantly. Quality incidents because of material mix-up were eliminated to zero, share growth improved by +3 points and asset accuracy counts improved by more than 10 points to 100%. The overall systems management effort reduced from 1135 minutes (~19 hours) spent across different independent SQS tours, data gathering, data analysis and leadership reviews to 335 minutes (~6 hours) monthly.

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