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Postgraduate Dissertation

The combination of 5S and Kaizen principles as quality improvement methods and their implementation in pharmaceutical companies' laboratories.

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Abstract

Quality management systems and models are applied in almost every industry of all sectors so as to gain competitive advantage. Towards this direction, various quality improvement methods have been used the last decades in the pursuit of quality, such as Total Quality Management (TQM) and Six Sigma. Two easy on its application and non-expensive quality improvement approaches are the 5S and the Kaizen techniques. 5S focuses on improving workspace organization and standardization. Kaizen on the other hand, is a philosophy structured on the employee involvement and active participation in a company's objectives and procedures.

5S and Kaizen have been applied in multiple working environments separately, resulting in beneficial outcomes. This study examines the effects of the implementation of the two aforementioned techniques, as a combination, on a real working environment, an analytical Research and Development (R&D) laboratory of a Greek pharmaceutical company. Taking into consideration their advantages referred in literature, its applications was expected to increase the laboratory's efficiency and productivity.

The results showed that there was a perceived improvement in efficiency, by reducing experimental conduction times, less analytical mistakes, fewer instrument malfunctions and increased work morale.

Keywords

Quality, Pharmaceutical Industry, 5S, Kaizen

Περίληψη

Διάφορα μοντέλα και συστήματα διαχείρισης ποιότητας εφαρμόζονται από πολλές βιομηχανίες όλων των εργασιακών κλάδων, με σκοπό τη βελτίωση της απόδοσης. Προς την κατεύθυνση αυτή, πολλές τεχνικές βελτίωσης της ποιότητας έχουν χρησιμοποιηθεί τις τελευταίες δεκαετίες, όπως η Διαχείρηση Ολικής Ποιότητας και η Six Sigma. Δυό εύκολες στην εφαρμογή τους και χωρίς ιδιαίτερα κόστη μέθοδοι για τη βελτίωση της ποιότητας είναι οι τεχνικές 5S και Kaizen. Η πρώτη τεχνική, 5S, στοχεύει στην καλυτέρευση της οργάνωσης και στη συστηματοποίηση του εργασιακού περιβάλλοντος. Η μέθοδος Kaizen αντιθέτως, πρόκειται για μια ευρύτερη έννοια, που περιλαμβάνει την ενασχόληση και την ενεργή συμμετοχή των εργαζομένων στους στόχους και τις διαδικασίες της εταιρείας για την οποία εργάζονται.

Οι τεχνικές 5S και Kaizen έχουν εφαρμοστεί ξεχωριστά σε διάφορους τομείς εργασιακών περιβάλλοντων, με επωφελή αποτελέσματα. Η παρούσα εργασία εξετάζει τα αποτελέσματα που έχει η εφαρμογή του συνδιασμού των δύο προαναφερθέντων τεχνικών, σε ένα πραγματικό εργασικό περιβάλλον και πιο συγκεκριμένα, σε ένα αναλυτικό εργαστήριο Έρευνας και Ανάπτυξης φαρμάκων Ελληνικής Φαρμακευτικής Εταιρείας. Η εφαρμογή των δύο μεθόδων, έχοντας λάβει υπόψιν τα πλεονεκτήματα που παρουσάζουν και αναφέρονται στη βιβλιογραφία, αναμένεται να επηρεάσουν θετικά την αποτελεσματικότητα και την παραγωγικότητα του εργαστηρίου της μελέτης.

Τα αποτελέσματα έδειξαν αύξηση της αποτελεσματικότητας του τμήματος εφαρμογής, σημειώνοντας μείωση στο χρόνο εκτέλεσης των αναλυτικών πειραμάτων, λιγότερα αναλυτικά σφάλματα, μειωμένο αριθμό προβλημάτων στις ενόργανες αναλυτικές διατάξεις, αλλά και αυξημένο ηθικό και διάθεση των συμμετεχόντων.

Λέξεις – Κλειδιά

Ποιότητα, Φαρμακευτική Βιομηχανία, 5S, Kaizen

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List of Abbreviations & Acronyms

APIs	Active Pharmaceutical Ingredients
CGMP	Current Good Manufacturing Practice
DMAIC	Define-Measure-Analyze-Improve-Control
EMA	European Medicines Agency
EP	European Pharmacopeia
FDA	Food and Drug Administration
GLP	Good Laboratory Practice
GMP	Good Manufacturing Practice
HR	Human Resources
ICH	International Council for Harmonization
ISO	International Organization for Standardization
JIT	Just In Time
KPI	Key Process Indicator
PDCA	Plan-Do-Check-Act
QA	Quality Assurance
QC	Quality Circle
R&D	Research and Development
SMED	Single Minute Exchange of Die
SOPs	Standard Operating Procedures
TPM	Total Productive Maintenance
TQC	Total Quality Control
TQM	Total Quality Management
USP	United States Pharmacopeia

1. Introduction

1.1 Background

Owing to the increasing worldwide rivalry faced by business organizations in the 21st century, quality has become one of the most important engines to compete today. Augmented competition and growing customer's demand for better quality, make companies aware of the need for delivering high quality products and services. (Qudah, 2012). Total Quality Management (TQM) has been utilized by organizations, over the past decades, as a comprehensive quality improvement strategy in the pursue of operational excellence. TQM is considered one of the basic requirements for pharmaceutical companies to develop business goals, strategies, culture and knowledge at all levels of business structure. (Qin et al., 2022).

5S is considered to be a management method and a foundational component of TQM, that forms a well-ordered work environment resulting in improving quality and efficiency. Its implementation ensures that work areas are free from failures and breaks and are laid out in such ways that general housekeeping is sustained (Oakland, 2014). It stands for the five Japanese words seiri, seiton, sesio, seiketsu and shitsuke, which have been translated respectively to sort, set in order, shine, standardize and sustain (Kanamori et al., 2016). The major framework for understanding and applying its principles was mainly proposed by Takashi Osada (Jimenez et al 2015), although many people argue it was developed by Hiroyuki Hirano (Patel & Thakkar, 2014). The undeniable statement, it that Toyota automobile company firstly implemented 5S principles (Jaca et al., 2014).

Kaizen in Japanese means "continuous improvement". It entails the general idea of involving everyone in an organization, from manager to simple workers, towards applying efforts for constant progress. It was originated in Japan in 1950, when the government acknowledged a problem in the existing management system. (Singh & Singh, 2015). West companies in an attempt to decode Japan's industry competitive advantage, identified kaizen philosophy as the tangible tool for this success. This tool was evidenced years later in manufacturing plants in North America, Europe, United Kingdom and Australia. Kaizen philosophy was used since then to enhance production techniques, standardize operations and ask for greater employee's contribution (Macpherson, 2015).

Both methodologies have been successfully applied in various professional sectors. For example, Moica et al., 2018, demonstrated through their case study, that the principles of 5S resulted in increased productivity and overall performance of an automotive company in Romania. Another example of a 5S case study is recorded in the literature from Todorovic & Cupic, 2017, who applied 5S rules in a rubber products factory in Serbia. 5S was also implemented in the food sector, as proposed in the case study of Ashraf et al., 2017. Islam et al., 2018 studied how 5S affected the workplace conditions of a pharmaceutical factory. Kaizen is also reported in the literature as a tool that can aid an organization improve their efficiency and effectiveness to achieve its goals. Various case studies have studied its effects. For example, in 2017, Mekonnen applied Kaizen practices in a shoe factory in Ethiopia. Also, Suarez – Barraza et al., in 2012, studied how Kaizen implementation improved the already established processes of a multinational food company in Mexico. Bellgran et al., 2019, applied Kaizen methodology in a pharmaceutical production area, in order to create practical improvements aiming in cost reduction, scale up efficiency and environmental driven production handlings.

5S and Kaizen have also been reported as a combined tool for continuous improvement in organizations. Hammami et al., 2022, applied 5S and Kaizen practices in a public sector hospital in Tynisia. They highlighted the improved working conditions, the optimized on the hand processes and the strengthened teamwork spirit, as the outcomes of the study. Also, Dermitas et al., 2023, applied 5S and Kaizen on a surgical mask production area in a Turkish factory, reporting increased production levels, fewer stoppages and waste. Kaizen and 5S have been implemented separately and as a combination, resulting in both cases in beneficial outcomes. The majority of the case studies that their utilization is reported, are usually the production areas of the automotive, material, food and pharmaceutical sector.

1.2 Research justification

The quality of the pharmaceutical products is a critical topic. The pharmaceutical industry as a vital part of the health care system conducts research, manufacturing and marketing of pharmaceuticals used for the diagnosis and treatment of diseases (Mazumber 2011). Also, the pharmaceutical industry is one of the most regulated sectors, which includes specific quality systems, such as good laboratory practice (GLP), good manufacture practice (GMP)

and good clinical practice (GCP). (Geijo 2000). Hence, many pharmaceutical companies, apart from complying with these regulations, are seeking to implement new tools and techniques as a manner to improve their quality attributes. Such tools may be considered 5S and Kaizen, which have been applied successfully in healthcare facilities, mainly focusing on hospitals El-Sherbiny et al., 2017, and Sallam et al., 2024. Concerning the pharmaceutical sector, less studies are reported and are mainly targeting the production areas. Jonet, 2014, inserted Kaizen lean methodology in a Pharmaceutical Industry, specifically in logistics and production processes. Also, Srinivasan and Shah, 2018, at their review article, mention that Sanofi pharmaceutical company, implemented Kaizen practices at its production plant at Germany, focusing on improving administrative issues, such as item search times, transparency, ergonomics etc. Delgado-Ruiz et al., 2023, at their research case study, applied continuous improvement tools in order to increase inventory turnover ratio in a Peruvian pharmaceutical enterprise.

Research and Development (R&D) activities in pharmaceuticals are covered by GLP regulations. The main purpose of the R&D department of a pharmaceutical industry is the development of new drug formulas. During these processes a huge amount of chemical and biological work is required. (Geijo 2000). Hence, quality driven procedures are necessary, to ensure good scientific and technical performance. These elements may be maintained and enhanced using 5S and Kaizen methodologies. Mallick et al., 2013, exhibited at their case study article, that 5S can help a pharmaceutical laboratory sustain its workplace in an appropriate order totally complied with regulations.

Both methodologies, 5S and Kaizen, have been implemented in various scientific fields, as shown in section *1.1 Background*. In most cases, automotive companies and raw material manufacturing centers have been successfully part of the continuous improvement case studies. Less scholarly articles report pharmaceutical companies, which mainly focus on production areas. Taking into consideration that 5S and Kaizen are two very crucial tools of continuous improvement philosophy and the incremented need of pharmaceutical laboratories to maintain quality driven procedures, more research efforts should be done towards the implementation in this particular scientific field. Also, the fact that no significant literature is reported makes the need for further research bigger.

This study aims to fill this scientific gap by assessing how the implementation of 5S technique and Kaizen philosophy in an R&D pharmaceutical laboratory can influence the overall quality outcome, as an additional integrated method in the already applied

regulations. Both techniques have been labeled as fundamental tools for improving quality among other key factors of success in various professional sectors. (Kanamori et al 2016, Singh & Singh 2015).

1.3 Research methodology approach

The research methodology that was followed classifies this dissertation as a single case study analysis and is composed of the following steps:

- Step 1: Definition of the purpose of the study
- Step 2: Literature review regarding TQM, 5S and Kaizen, which will facilitate the better understanding of the role of quality in the continuous improvement philosophy.
- Step 3: Assessment of the work conditions before the implementation of the techniques
- Step 4: Implementation of the techniques in the actual work environment
- Step 5: Data collection after the implementation of the study
- Step 6: Data analysis and results overview

1.4 Research limitations

During this dissertation, 5S and Kaizen methodologies were implemented at an R&D analytical laboratory, which had already been operating under GLP regulations. The implementation required from all analytical laboratory members to comprehend and apply the new procedures and alterations regarding their everyday working norms. Each participant's adaptation to the new information played a crucial role in the study's outcome. Also, the level of cognition of the two techniques by the participants might have affected the responses.

Another limitation of the research, is the implementation period. The acquired data were collected after two months the techniques were put into practice. Also, the small number of participants who voluntarily answered the questionnaire provided the research small amount of data.

1.5 Dissertation structure

The dissertation is divided into seven chapters. A brief description is given below:

Chapter 1: The first chapter provides information about the main purpose of the research, the objectives and the basic definitions of 5S and Kaizen.

Chapter 2: This chapter sheds light on the major category of continuous improvement, which is comprised of various techniques and methodologies, such as the TQM, the Lean approach and the Six sigma.

Chapter 3: This chapter provides all the necessary information about the 5S technique. Historical elements, definitions for every "S" and implementation steps.

Chapter 4: At this chapter Kaizen philosophy is thoroughly described. The basic principles and the some of the possible implementation tools are also referred.

Chapter 5: General information about the pharmaceutical sector and the importance of quality are provided. The main characteristics of an analytical R&D laboratory of a pharmaceutical company are depicted.

Chapter 6: This chapter defines the type of the research methodology that was followed and provides details regarding the source of the acquired data.

Chapter 7: At this chapter the implementation plan and the obtained resulted are presented.

Chapter 8: This chapter comprises an overall discussion of the results, possible recommendations and the conclusions of the study.

2. The concept of Total Quality Management

2.1 How Quality is defined?

Quality is a subjective term, for which each person has his own definition, interpretation and use. The international definition, as per ISO 9001 2015, is "the degree to which a set of inherent characteristics fulfils requirements". However, in business world there is not a single accepted definition.

Dale, 2003, tried to share some definitions for quality. For example, BetzDearborn Inc. defined quality as "That which gives complete customer satisfaction" or Rank Xerox (UK) as "Providing our customers, internal and external, with products and services that fully satisfy their negotiated requirements". Also, Charantimath 2011, presented the definition of Philip Crosby: "Quality is the conformance to requirements/specifications" and that of Joseph Juran "Fitness for use or purpose is a definition of quality that evaluates how well the product performs for its intended use".

Despite the absence of a clear definition, the main key points coherent with quality are:

i. Operational excellence - lack of defects and deficiencies

ii. Satisfaction of customers' needs and expectations

iii. Services, processes, people and environments

Quality is used to signify "excellence". People often are discussing about "top quality products", indicating lack of defects and deficiencies. Before a customer makes a purchase does a calculation of whether that product satisfies their needs.

The last key point services, processes, people and environments are crucial, meaning that quality does not only apply to products but also to the people and processes that provide them.

2.2 The concept of Total Quality

Just as there are different definitions of quality, there are different definitions of total quality. Goetch et al. ,2014, defines total quality as "the continual improvement of people, processes, products and environments. With total quality anything and everything that affects quality is a target for continual improvement". He used the example of a three-legged chair to explain the concept of total quality, where the seat of the chair was the "Customer focus" and each of the legs were the notions "Measurement", "People" and "Continuous improvement", as shown in Figure 2.1.

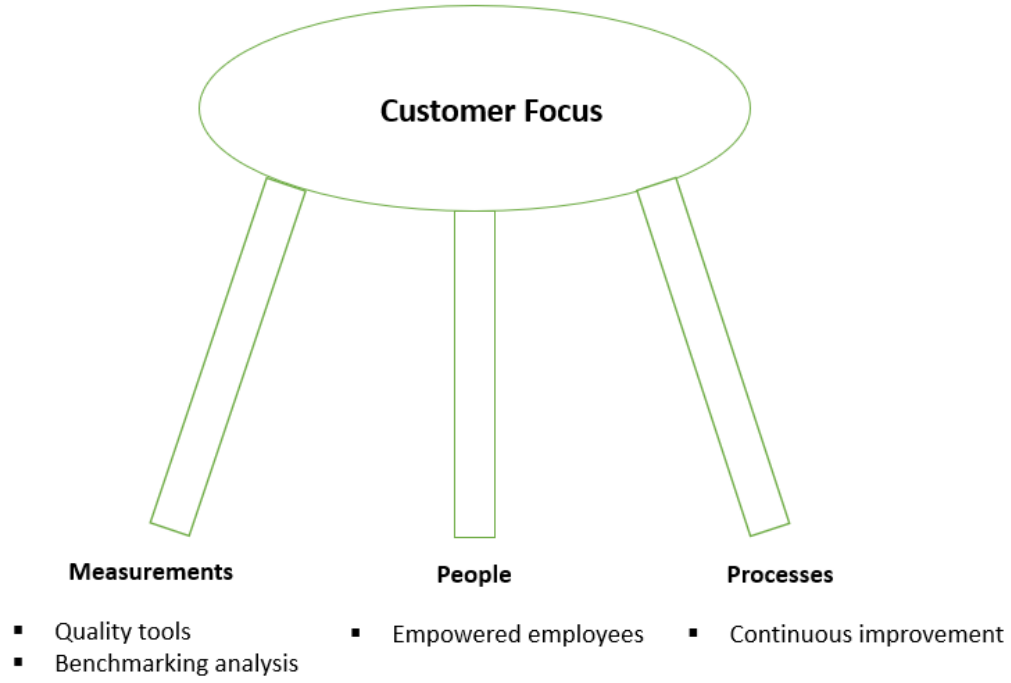

Figure 2. 1 Three-legged chair of Total Quality (Goetsch, 2014)

Each leg is important in total quality's philosophy. "Measurements" mean that quality should be registered and measured. "People" means that quality outcomes from employees' empowerment and the leg of "processes" stands for the need for continuous improvement of the procedures.

He also presents the main characteristics when total quality is implemented:

- Strategically oriented

- Customer focus
- Scientifically approached trouble shooting decisions
- Teamwork
- Continuous improvement of people, processes and services
- Training and education
- Employee involvement

Strategically oriented

Companies that apply total quality's principles, have a strategic plan to gain the competitive advantage in the marketplace.

Customer focus

Internal and external customers are of top priority.

Scientifically approached trouble shooting decisions

Decisions are made and problems are solved after insightful brainstorming based on data acquired from projects, experience and personal knowledge.

Teamwork

The better the collaboration between colleagues and departments within an organization the more quality driven results are obtained.

Continuous improvement of people, processes and services

The concept involves making incremental and ongoing enhancements to people, processes, and services to optimize efficiency, effectiveness, and overall performance.

Training and education

Training and education are fundamental elements of total quality, since they improve employee's knowledge and skills.

Employee involvement

Involving employees in companies' actions, decisions and improvements is crucial in total quality applications. It increases the likelihood of coming up with the best plan, by bringing

more minds together, especially people who are actually dealing with corporate issues regularly.

2.3 Towards Continuous Improvement

Various quality and operations improvement systems have been developed and implemented over the last decades such as, the Japanese Total Quality Control, Total Quality Management, Lean thinking, Six Sigma etc.

2.3.1 Japanese Total Quality Control

Total Quality Control (TQC) is a management philosophy to quality that originated in Japan and played a significant role in the country's economic success after World War II. It is associated with the work of quality management pioneer Dr. Kaoru Ishikawa. It is considered to be the first quality improvement system.

Chiarini 2011, defines TQC as "A network of the management/control and procedure that is required to produce and deliver a product with a specific quality standard".

Also, Dale 1991, cites that TQC requires a comprehensive control of cost, production, delivery, safety and other elements related to quality of performance. To achieve this, every person in a company should be quality minded.

2.3.2 Total Quality Management

Total Quality Management (TQM) is defined by Luthra et al. 2021, as a customer driven process for continuous improvement of business operations. It guarantees that all working actions are directed towards the common objective of improving the quality of the product or the service.

According to the literature, Deming was one of the founders of TQM, launching it in his book "Out of the Crisis".

The core fundamental of TQM is that every part of the organization, company, event, or process has customers and the needs of which must be fulfilled. Oakland 2014, presented the three management pylons for improved performance:

i. *planning*, including the right policies and strategies,

ii. *processes*, documented procedures and improvement tools

iii. *people*, with the appropriate qualification, skills, training, and empowerment.

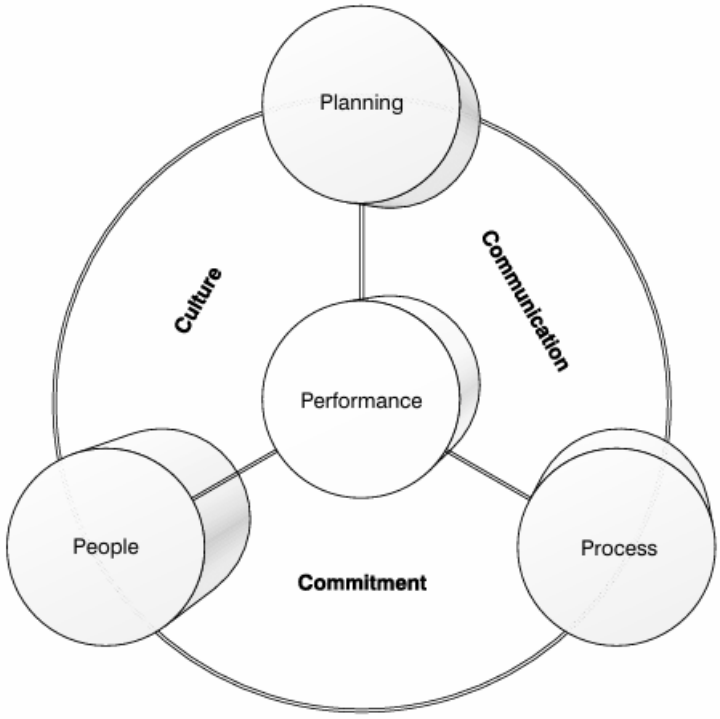

Figure 2. 2 The core principles of TQM (Oakland, 2014)

Many organizations have improved their day-to-day operations by implementing the concepts of Total Quality. Quality management systems, methods for statistical process control and quality driven brainstorming have allowed these organizations to provide quality products and services to customers. As a result, less development and design problems occurred as well as less defects, errors, service failures and market complaints (Westcott & Duffy, 2015).

2.3.3 Lean Thinking

"Lean" is a manufacturing and management philosophy that focuses on shorting the deliverable time between a customer order and the shipment of the parts or services ordered through the reduction of all kinds of waste. Through Lean philosophy, firms reduce cost, cycle times and non-value-added activities and thus may obtain a more competitive, agile and market-responsive profile. (Alukal &Manos, 2006)

"Lean Production" was firstly introduced by Womack at his book "The machine that changed the world: The story of "Lean Production" (Womack 1991), was describing an approach to quality that had been adopted by the Japanese car industry, primarily by Toyota. It focuses on eliminating waste, shortening duration and accelerating the flow of the production process.

"Lean Thinking" extends beyond the manufacturing sector and may apply in a company as a whole, including all departments.

Oakland 2014, has gathered all the myths and facts that exist around lean thinking, which are presented at the table 2.1:

Myth	***Fact***
Lean is a manufacturing concept	Lean applies to every organizational department
Lean is about cutting back people resources	Lean is about eliminating waste
Lean is a management trend	The practices of lean have been implemented since 1950
Lean is a resource hungry to implement	Lean is more successful when employees' skills and knowledge are leveled up
Lean is expensive to implement	Lean saves more that it costs when implemented

Table 2. 1 Lean Thinking Myths and Facts (Oakland, 2014)

2.3.4 Six Sigma

Sigma (σ) is letter in the Greek alphabet which has become a statistical symbol of process variation. The sigma scale of measure is related to defects-per-unit and parts-per-million defectives, whereas six is the number of sigma measured in a process, when the variation around the target is 3.4 outputs out of one million are defects (Park 2003).

Six sigma is a quality improvement process developed by Motorola company in the 80's. Motorola called the process "the six steps to six sigma", a methodology which helped the company to save billion dollars. Firstly, was implemented at production and continuously adapted to the rest departments of the company (Dahlgaard 2006).

The content of Motorola's "six steps to sigma" are summarized at Table 2.2 as presented by Dahlgaard 2006,

Manufacturing	***Non- Manufacturing***
1. Identify physical and functional requirements of the customers	1. Identify the product/service to external and internal customers
2. Determine the critical characteristics of the product	2. Identify the customer for your product/service and determine what he/she considers important
3. Determine for each characteristic of the product whether it is controlled by part or process	3. Identify company's needs to provide product/service desirable to customer
4. Determine the maximum range of each characteristic	4. Map the work process
5. Determine process variation of each characteristic	5. Eliminate effort and delays of the process
6. If process capability is less than two redesign process, materials and products	6. Ensure continuous improvement

Table 2. 2 Motorola's six steps to sigma

Six sigma approach has changed over the years after its implementation by various companies and currently follows the so-called DMAIC (Define-Measure-Analyze-Improve-Control) process. Park 2003, described these five steps,

Define: Identification of the process or product that needs improvement.

Measure: Identification of the product/process characteristics i.e., dependent variables, mapping the respective processes, making the necessary measurement, recording the results.

Analyze: Analyzing and benchmarking the key product/process performance metrics. Evaluation of the gap between the current and desired performance, prioritization of problems and indentation of root causes of problems.

Improve: Selecting the process/product characteristics that should be improved to achieve the goal.

Control: Ensuring that the new process conditions are documented and monitored through statistical process control methods.

2.4 The combination of Lean thinking and Six sigma

Six sigma, as described above, is a process improvement system that is problem focused and is geared more to reducing process variation. Lean thinking, targets on process flow and lead time and considers any action that does not add value as waste. The encounter of the two, combines the "speed" introducing by Lean and six sigma capability of reducing variation. (Arnheiter & Maleyeff, (2005).

This new combined view produces a more holistic approach and may provide a broader set of improvement tools and techniques. Oakland 2014, presented at Figure 2.2 the DMAIC steps combined with Lean techniques

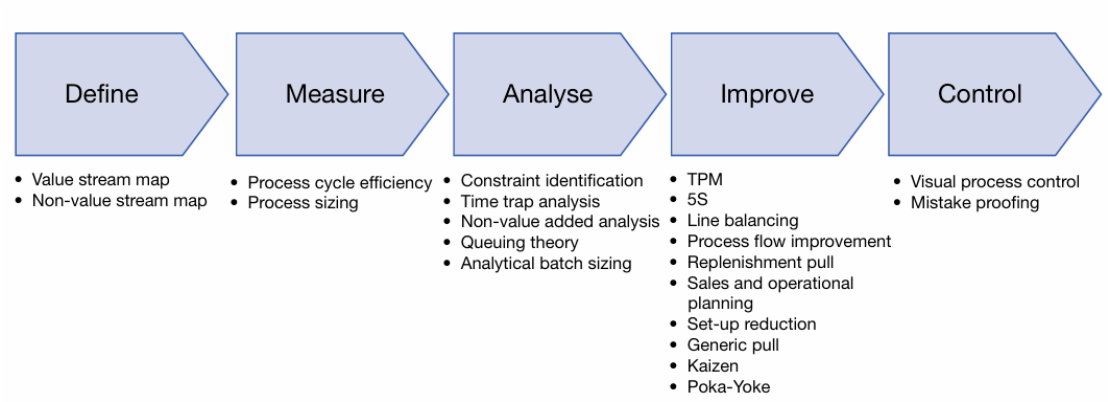

Figure 2. 3 DMAIC and the lean toolkit by Oakland

Among the tools that can be used, the Improve step of the DMAIC process contains the 5S and the Kaizen, two of the most famous and recognized methods for continuous improvement.

3. The concept of 5S

3.1 Introduction

5S have been described as a system that creates a well-organized, clean, high effective and high-quality workplace. Its implementation results in elimination of losses connected with failures and breaks and improvement of the quality and safety of work. (Michalska 2007).

5S was developed in Japan and was introduced at the end of the 1960s. The major framework for understanding and applying its principles was mainly proposed by Takashi Osada (Jimenez et al 2015), although many people claim it was developed by Hiroyuki Hirano (Patel & Thakkar, 2014).

3.2 Osada's view of 5S

Osada (1989) believed that 5S is part of Japan's culture and society. Not only for organizations, but also for any individual, 5S involves improvement activities in any environment, for example homes, schools, hospitals and communities in total.

In the workplace specifically, 5S is used "to organize the workplace, to keep it neat, to clean, to maintain standardized conditions and to maintain the discipline that is needed to do a good job" (Osada, 1991). The good first impression of visitors or potential customers is reassured when 5S is in place for an organization. Also, efficiency, productivity and cooperation between employees is increased. When Osada, linked 5S directly to working environment, he provided Figure 3.1, with the following definitions and descriptions,

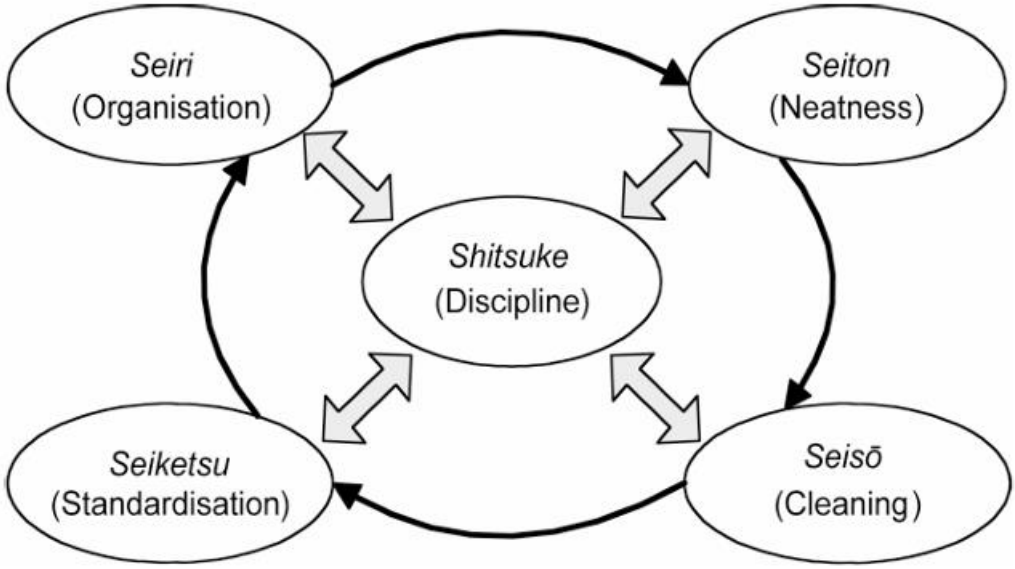

Figure 3. 1 Osada's point of view of 5S (Osada 1989,1991)

The order of the activities is not important, but they are linked and implemented simultaneously and cyclically.

Seiri: stands for 'organization', for Osada 1991 "put things in order, organize them, in accordance with specific rules and principles". At this phase, unnecessary items should be separated from what is needed and be discarded. The ultimate goal of the whole procedure should be the prevention of a possible reversion back at the initial situation (Osada, 1991).

Seiton: represents 'neatness' and means having things in the right place so individuals may use them easily and quickly. It focuses on effective storage and segregation of materials. It is crucial everyone in a workplace to be involved and continually follows storing rules. Ho and Cinmil 1996, characterized this phase as an exercise in the efficiency of the implementation area, where the parameter under examination is how quickly someone finds what is required and return it back.

Seiso: stands for 'cleaning' and prioritizes cleanliness, self-inspection and the creation of a faultless working environment. Three activities are mainly involved at this step, getting the workplace clean, maintain its appearance and use preventive measures to keep it clean.

Osada 1991, highlights that machinery parts is essential to be functional and therefore every operator who uses them should be familiar with how to clean and keep them in good condition. Also, cleanliness renders the environment of a workplace more comfortable and appealing to its personnel.

Seiketsu: means 'standardization', maintaining the level of the first three "S"s, so they become a routine part of day-to-day work. Osada 1991, referred to the third S as an approach to depict the current state of the circumstances. The are many methods to materialize this phase, but the most common procedures include diagrams, workplace mapping, scripts with rules and manuals.

Shitsuke: stands for 'discipline'. This step is about embedding the 5S methodology in the organization by involving people from all levels to achieve goals efficiently and effectively. Osada 1991, points out that this phase is not just about complying with the rules of 5S, but also pointing out previous mistakes which were repeatedly made and eliminating the possibility of repeating them.

3.3 Hirano's view of 5S

During the same decade as Osada, the 1990s, Hirano developed an alternative approach of 5S methodology, with a more practical focus. Hirano (1995) highlights that 5S should be used as a tool for corporate survival that leads to just-in-time production. He proposed that 5S should be promoted and established by the upper management of an organizations by using the following actions:

1. Found an organization 5S based
2. Establish a 5S plan
3. Develop 5S campaign materials
4. Establish in-house training
5. Implement 5S
6. Maintain and evaluate 5S

Hirano's view of 5S is depicted at Figure 3.2

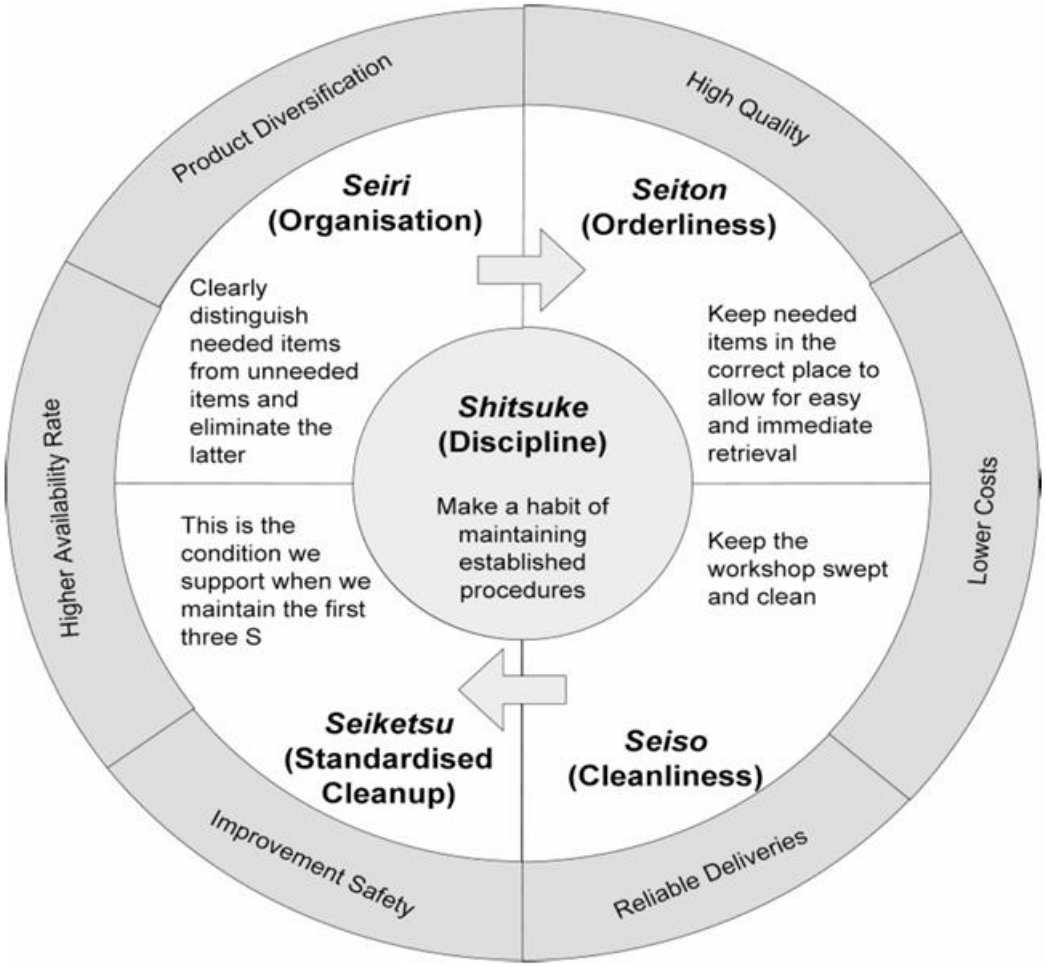

Figure 3. 2 Hirano's point of view of 5S (Hirano 1995)

3.4 Comparison of Osada's and Hirano's approaches

Kobayashi et al. (2008) compared the two frameworks, noticing that Seiri (organization) relates to Seiton (orderliness) and Seiso (cleaning) associates with Seiketsu (cleanliness/standardization) and that all four components are shaped by Shitsuke (training/discipline). However, he highlights some differences between them.

- Hirano emphasizes on the first two Ss, Seiri (organization) and Seiton (orderliness), whereas Osada (1991) underlines that Shitsuke (training/discipline) is the most important
- Hirano proposes that a "practical and comprehensive manual in 5S implementation" should exists, whereas Osada claims that some examples could be beneficial for an organization to learn the philosophy of the method.

- Osada believes that 5S may be implemented in any environment as a strategy toward improvement, but Hirano acknowledges limitations at the use of 5S.

Summarizing, Hirano views 5S as an industrial methodology that differentiates a company from its competitors, whereas Osada considers 5S as a strategy for organizational development, learning and upgrading.

3.5 The evolution of 5S

The complexity of the original words - Seiri, Seiton, Seiso, Seiketsu and Shitsuke – were removed in order to be easily understood and adopted by organizations and corporations throughout the world and have been replaced by the English words Sort, Set in order, Shine, Standardize and Sustain respectively.

5S is a philosophy for methodically achieving overall organization cleanliness and standardization at workplace that could be motivating and pleasing to all the employees in the organization. It is used for reshaping the workplace and laying the foundations for significant improvements. 5S changes the approach of the employees towards their work and improves communication among various business functions and departments. A well-organized workplace provides a safe and efficient production environment, which boosts the employee morale, promotes the feeling of ownership, pride in their work and ownership of their responsibilities (Randhawa & Ahuja, 2017).

Over the last few years, an additional S has been added to the 5S, standing for "Safety-Security". Organizations throughout the world have started implementing in their continuous improvement techniques the safety parameter. (Menezes et al. 2020). The additional 6S thoroughly examines all areas of the working environment by investigating the risks at each workstation. These risks must be evaluated and safety should be guaranteed (Jimenez et al. 2019).

3.6 Quality and 5S

Kanamori 2016 has characterized 5S as the starting point towards TQM. The quality aspect that is included in 5S's core is becoming of highly importance. Chapman, 2005 argues that other quality systems within an organization may be insufficient without a 5S implemented methodology. For the above reasons, previous research papers will be reviewed in order to point out 5S beneficial aspects.

Equipment functionality is reassured and confirmed by 5S procedures, in order to generate the expected outcome. 5S in this way impacts on the quality of the product. When workspaces and machinery are properly maintained, the employees are capable of identifying errors and abnormalities when they occur, preventing in this manner production losses and delays (Chapman 2005).

Standardization is one of the foundational elements of 5S, leading to improvements in inventory, cost and finally quality. Many organizations are obligated to comply with ISO standards. In this case, 5S may act as the forerunner for ISO implementation, which requires standardized procedures for eliminating bias and deviations. (Lokunarangodage, et al., 2015). 5S may assist in transmitting information about potential or occurred variabilities, eliminating them and establishing countermeasures.

Setting objectives is vital to move forward. Established plans need to be understood by the employees in order to evaluate the current conditions and the desired goal, so as to address the gaps and then to apply modifications. This cycle is crucial to be completed for the organization, in order to meets its targets and set up their future ones. This procedure is an approach to success and 5S integration is the first step towards this direction (Karvounis, 2021).

3.7 5S Implementation in Laboratories

Many research studies have dealt with the implementation of 5S techniques in different kinds of laboratories, such as chemical, biological, pharmaceutical, educational, mechanical etc. Some of them are presented below.

Jimenez et al. 2015, at their research article described 5S application to university engineering laboratories, as a method of improving safety. Four different autonomous laboratories were chosen for 5S practices and the results shown less workspace accidents, improved control of equipment, designated storage areas and fewer deviations. Laboratories costs were reduced in average values and space increased by 25%.

Ebueste 2018, at his thesis "Implementation of 5S at a Survey Laboratory in Western Kentucky University", aimed to enhance the safety and the efficacy of the survey laboratory by applying the continuous improvement technique. His team actions resulted in safer and cleaner work environment, smaller tools searching time and improved efficiency.

Khumalo, 2019, at his dissertation thesis, implemented 5S methodology in the mechanical laboratory of the industrial engineering department of University of Johannesburg. The variety and the number of tools and materials existed in the laboratory were creating problems in locating them prior to use. After 5S application, proper storage resulted in significant time saving, improved productivity and safety.

Gutierrez et al, 2020, applied 5S practices in the teaching chemical laboratories of the Faculty of Engineering Vitoria-Gasteiz, of the University of Basque Country. Their management project achieved workplace order and improved the efficiency of the facilities. Also, they observed positive effect on students, since working in a safer and friendlier enviroment encouraged them to take over their tasks in a more efficient manner.

3.8 5S Implementation in the Pharmaceutical sector

5S has been widely applied in all professional sectors, gaining more attention in the mechanical, engineering and technological sectors. Less case studies are registered in the literature concerning the pharmaceutical domain, some of which are presented below.

Dixit et al., 2019, presented in their study, how 5S principles aided India's enormous pharmaceuticals warehouse to be organized sufficiently. It is crucial for public healthcare, drug products handling and storage to be executed correctly. Dixit and his team under 5S approach succeeded in reducing waste, improving warehouse productivity, securing quality and promoting a safe work environment.

Islam et al., 2018, implemented 5S practices in a pharmaceutical factory. Their study focused on administration offices, specific production areas, warehouse and quality control department. The case study's result was diminished cycle times of all job tasks. Reorganization and proper labelling rendered easier for employees to find the desired items. In addition to this, sorting out redundant objectives made the workplace free from clutter.

A 5S implementation case study was performed by Mallick et al., 2013, when a pharmaceutical laboratory was sorted, set in order, shined, standardized and sustained under the continuous improvement principles. Proper chemical reagent arrangement, apparatus and instrument lists and documents relocation created better work flow.

Lestari and Subroto, 2022, used 5S practices, as an additional tool of a broader lean operation strategy, in order to enhance performance efficiency of a quality control laboratory of a pharmaceutical industry in Indonesia. Tasks completion was performed in 42.7% quicker than before the implementation of the continuous improvement tools.

4. Kaizen philosophy

4.1 Introduction

Kaizen is a Japanese word which stands for continuous improvement. It derives from the words "Kai" and "Zen" which means "Change" and "For good" respectively (Palmer 2001).

The foundation of Kaizen was laid in Japan after the Second World War, when the country was attempting to rebuild factories and rethink many systems, acknowledging the existing problems in the current management system and the pending labor shortage (Prosic 2011). The Japanese government introduced labor contracts, which were applied by the companies, settling down for the first time the notions of lifetime employment. These contracts considered to be the groundwork for all the forthcoming kaizen activities, providing the necessary emotional foundations to ensure confidence in the workforce (Brunet & New 2003).

Masaaki Imai is the person who brought together the theories, techniques and philosophies about management, which have aimed Japanese companies, over the last decades, to meliorate their efficiency in the business sector (Dale 2016). The basic distinguishing feature of the Japanese management is that it is process oriented and not exclusively goal oriented. As a matter of fact, it focuses on the improvement of all components of production and business processes, involving the participation of workers and managers in the decision-making process.

4.2 Kaizen basic principles

Berger (1997) at his article highlighted three basic principles of Kaizen philosophy as elaborated on Imai's book "KAIZEN – the Key to Japan's Competitive Success".

Principle 1: Process orientation

"Kaizen is process oriented, i.e. before results can be improved, processes must be improved, as opposed to result-orientation where outcomes are all that counts" (Imai, 1986, p. 16-17). Results are not considered of minor importance, instead creating clear processes is assumed to automatically result in good outputs.

Management should stimulate the efforts of employees to improve processes. To achieve this, a process should be understood in depth, as a result of trainings and participation in learning work-oriented activities.

Mekonnen 2017, mentions at his dissertation, that improvements should be grounded on the thorough evaluation of process performance data. Minor or small improvements will be followed by bigger improvements and may be spread throughout the entire company. Small changes may help employees work quicker and more efficiently. Step by step approaches should be followed, instead of radical changes. Employees' skills and knowledge should be gradually developed via training and involvement in the current process operations of their work routine.

Principle 2: Improving and maintaining standards

"Lasting improvements can only be achieved if innovations are combined with an ongoing effort to maintain and improve standard performance levels" (Imai, 1986, pp. 6-7).

The distinguishing feature of Kaizen is its focus on small improvements of work standards as the outcome of a continuous effort. Imai claims that "there can be no improvement where there are no standards", which indicates the connection between Kaizen and the existence of Standard Operating Procedures (SOPs).

The standardization of operating procedures follows three major characteristics in a work place,

- Individual authorization and responsibility
- Increased learning by transmitting the experience from one employee to another
- Self-discipline

Principle 3: People orientation

"Kaizen is people-oriented and should involve everyone in the organization from top management to workers at the shop floor". (Imai, 1986, p. 40)

According to Imai, there are three types of kaizen activities with its own form and function,

- Management-oriented kaizen, concerns the improvement of planning, control and decision-making processes
- Group-oriented kaizen, represents people who focus on improving work methods, routines and procedures
- Individual oriented kaizen, concerns suggestion systems

Mekonnen 2017, characterizes the human resources of a company as its most valuable asset. Kaizen's implementation at enterprises was successful only when employees were fully engaged. Making someone feel important, usually boosts his morale and his appetite for more. Keeping the personnel content, will lead to increased productivity and satisfaction.

4.3 Kaizen implementation tools

In simple terms, Kaizen is the process of incremental, systematic, gradual, orderly and continuous improvement that uses the best of all techniques, tools, systems and concepts. Some of them are the Plan-Do-Check-Act (PDCA) cycle, the Total Productive Maintenance (TPM), the quality circles (Dale 2016), Just In Time (JIT) and Single Minute Exchange of Die (SMED) (Dalem 2016).

4.3.1 PDCA cycle

The PDCA cycle is a continuous improvement model, firstly introduced by Edward Deming in 1950. The cycle consists of four major components, each of one contain problem-solving activities. Oakland 2014 elaborates on these components,

Plan

Performance objectives and standards should be established. This involves information gathering, goal setting and estimation of the required resources.

Do

The plan is set in order, the process is implemented and the actual data outcomes are measured.

Check

The actual performance is compared to the initially established goals and the difference between them is highlighted.

Act

Based on the results of the "Check" phase actions are taken to mitigate the difference. In case the results meet the desired expectations, the process should be standardized.

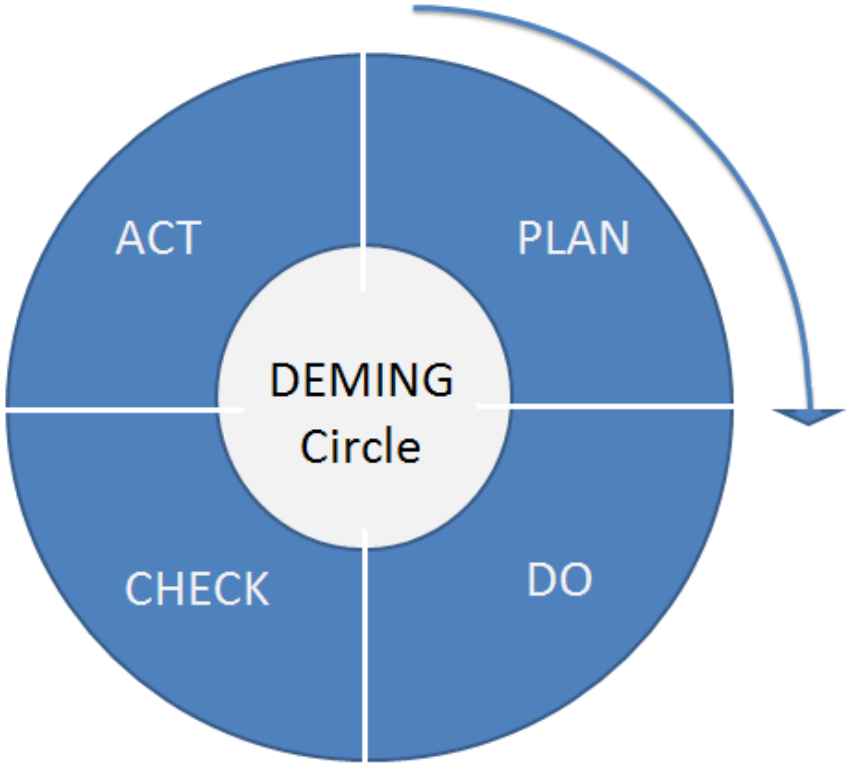

Figure 4. 1 The Deming cycle

4.3.2 Total Productive Maintenance

Dale (2016) reports that Total Productive Maintenance (TPM) was evolved by the Japanese based on the principles of Preventative maintenance (PM). TPM is considered as a total method of management complementary to TQM. The condition of the equipment machinery in a company is of significant importance since it influences the quality of the production output. The equipment needs the input of people to keep it lean and to improve its operation efficiency and performance, thereby creating a sense of "ownership" and a feeling of shop-floor goodwill.

The goal through TPM is to reduce the long-term life cost of the equipment by implementing more efficient maintenance management. It also emphasizes in improving the skills of employees concerning the machine technology.

The most important benefits of TPM, according to Luthra 2021 are:

- Increased efficiency and production

- Fewer incidents related to malfunctions
- Higher quality outputs
- Increased employees' confidence
- Elevated cooperation between employees
- Clean and attractive workplace

4.3.3 Quality circles

As Quality Circle (QC), or Kaizen Team, is defined a group of employees, inside a company, who voluntarily identify, analyze and solve work-related problems. A QC usually consists of 3 to 10 members, who meet regularly and discuss problems around their working environment. Luthra 2021, mentions that the Japanese professor Kaoru Ishikawa firstly used the term 'QC' in 1985. Since then, various Japanese and American companies implemented QC for improving corporate performance.

The main objectives of a QC are:

- To improve the department's overall performance
- To contribute in the department's development
- To improve the department's quality output
- To enhance the corporate culture
- To motivate colleagues into sharing their ideas and their questionings

The process steps of a QC are summarized at the Figure 4.2:

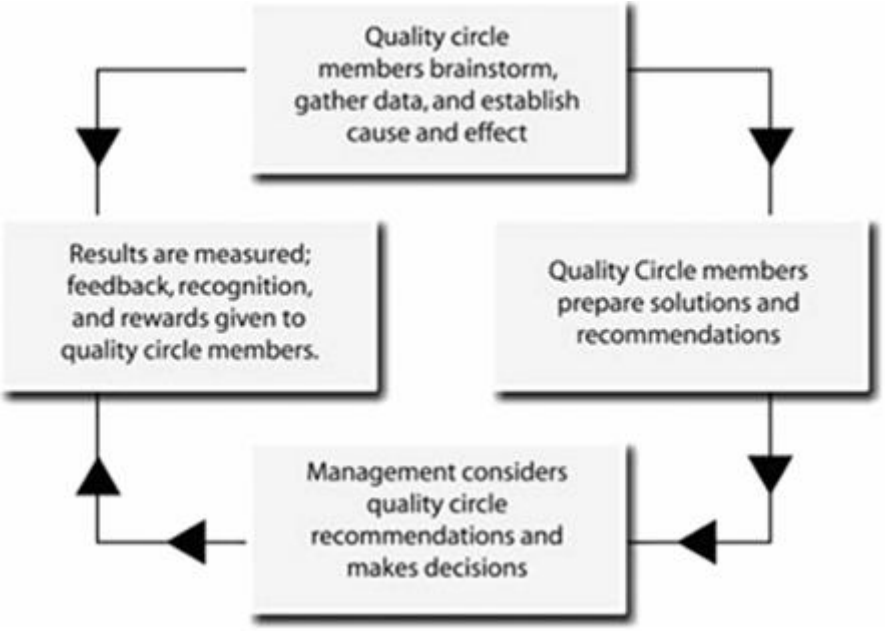

Figure 4. 2 The QC process (Source: Luthra 2021)

Oakland 2014, recommends that QC should often collaborate with experts from other fields in order to maximize their efficiency. That is experts from other departments such as quality professionals, safety officers, maintenance personnel. This collaboration should be encouraged by department's managers by inviting 'consultants' to attend meetings and offer advices. The overriding objective of QC is to motivate employees in being part of the decisions that are made concerning their own actions and future.

4.3.4 Just In Time

Folinas et al. 2017 define JIT as the process to produce the goods required, when they are needed and in the demanded quantity and quality. In simple terms, no excess of products should be materialized, being stored in inventories. In this manner, waste and unnecessary costs are diminished. This practice has two sides. On the positive side, storage and operational costs are minimized and on the other side expenditures like transportation costs, logistical and organizational costs may increase.

JIT is the action ducting all materials and consumables for the production of a good are in place when are needed just in time before the process. Why is JIT technique being part of Kaizen philosophy? PourAsiabi 2012, explains that various parameters must be fulfilled for the successful implementation of JIT method. Some of them are evaluation of production

potential problems, upper-level managers' engagement, employees' active participation in problem identification and decision making procedures, excellent production flow and inventory management. These factors cannot be accomplished in an unorganized company, without team spirit and continuous improvement culture. To summarize, JIT philosophy leads to waste reduction, minimized preparation times, better controlling of raw materials and consumables flow and efficient use of stocks (Callen et al. 2000).

4.3.5 Single Minute Exchange of Die

Single Minute Exchange of Die (SMED) means in simple terms "quick tool change". It is a methodology that is comprised of a set of techniques aiming to reduce the set up time of an instrument. When implemented properly, machines take less time to connect (Godina et al. 2018). Manufacturing companies with big variety in their product list, usually are called to produce different goods in small periods of times and strict deadlines to their customers. As a result, production time and product differentiation are considered as crucial economic factors. In order to accelerate production rate, time elapsed between product to product manufacturing should be diminished. SMED solutions may play a unique role in rapid tool change (Dillon & Shingo 1985).

The five most critical steps if this procedure are:

- Observe and record
- Separate internal and external duties
- Convert most of the internal tasks into external
- Design all potential tasks
- Document procedures

SMED systems provide quick tool change solutions that enhance manufacturing processes. These handlings require the employees' participation in every step. Continuous improvement driven mentality should be dominating, in order to achieve the successful implementation of SMED.

4.4 Kaizen and Management

The main functions of Kaizen according to Imai 1986, are maintenance and improvement of already subsisted operating and managerial procedures. The role of the Human Resources during Kaizen implementation at a company are categorized according to their role (Mekonnen 2017).

Top Management's role

Top management's role is vital for applying Kaizen philosophy in the company. They are responsible for engaging continuous improvement concept in the corporate culture, provide necessary resources to structure company around the philosophy and inform personnel for the new policy.

Middle Management's role

Middle managers should maintain Kaizen policies and improve working related procedures. Are also responsible for arrange training sessions for employees, in order to comprehend in depth, the new philosophy.

Supervisor's role

Supervisors are responsible for establishing Kaizen activities at their every day routine program. Theoretical approach given in training sessions should be applied in practice in the workshop. Some of the key aspects that supervisors should focus are discipline, self-development, communication and team work.

Employees' role

The cornerstone of Kaizen succession are the employees themselves. They are the ones that actually perform the company's procedures so their actions towards the continuous improvement road are crucial. Engagement in corporate objectives, work related suggestions, initiatives for job skills improvements and team spirit are some of the characteristics that would make Kaizen implementation successful.

4.5 Kaizen implementation in workplaces

Kaizen philosophy has been applied in various professional sectors aiming for a common goal, continuous improvement. Involving everyone in an organization, starting by performing small changes and finally targeting in long-term improvements.

Jagusiak-Kocik, 2017, applied PDCA cycle, as a Kaizen tool, in a plastic processing imdustry. The increased number of orders from the customers including the competitors' activities led the company to seek new methods in improving product quality. At this case study, all four steps were followed, Plan, Do, Check, Act and as a result the enterprise achieved to reduce discrepancies during the production by 60%.

Raodah et al., 2019, implemented successfully PDCA cycle in a beverage industry, which had shown delays in production deliverables. Employees' lack of training and production machine's breakdowns were improved after the application of Kaizen practices.

Darmawan et al., 2018, utilized Kaizen concept in the production line of an automotive battery factory. By involving every member of the enterprise in the procedure, defects during the production processes were identified and removed, using the PDCA cycle. TPM methodology was followed in order to maintain the renewed procedures in the manufacturing area.

Prayuda 2020, in her case study paper, showed how Kaizen philosophy improved an automotive company's productivity in Spain. She observed how the enterprise's culture changed towards continuous improvement. Employees were encouraged to meet their aspirations through their personal work, which led to better cooperation with each other, better inventory management, less defective products and reduced costs.

Nino et al., 2020, utilized Kaizen tools in the sterile processing department of a public hospital. Sterile tools are crucial for patient's health during surgeries and their availability during busy scheduled days is not always guaranteed. Nino et al., at their case study, implemented Kaizen philosophy to reorganize Sterilization department. Lean thinking, Kaizen teams and PDCA cycles are some of the tools they were successfully employed and led to elevated productivity and improved working conditions. Also, employees' awareness of how their personal effort may have positive effect on team work was risen.

4.6 Kaizen implementation in the Pharmaceutical sector

Kaizen philosophy has also been applied at the pharmaceutical sector.

Karam et al., 2018, implemented SMED Kaizen tool at the production line of a pharmaceutical industry. Big changeover time among products in a packaging machine caused delays in the drug production and difficulties in meeting the productivity targets. SMED application involved a methodology, utilizing tools and techniques so as a quicker and more efficient changeover process to be achieved, positively influencing the final product output.

Bellgran et al., 2019, used the PDCA cycle principles in order to re-establish the manufacturing processes of a pharmaceutical company, based on environmental aspects. Continuous improvement teams were formed to operationalize environmental strategies which successfully led the company to cost saving solutions, on-the-job environmental improvements and a more sustainable organization with growing competence.

Kotvitska et al., 2019, used Kaizen philosophy as a tool to improve the internal audit process of a quality management system of a pharmaceutical company. Internal audits assess the degree of readiness and compliance of the GMP requirements, of the departments of a pharmaceutical company. The importance of the term quality in the pharmaceutical sector is the ultimate goal for all enterprises and the implementation of Kaizen principles in the quality management system may rise quality awareness and optimize assurance policies.

Sugiyama et al., 2015, proposed a methodology during pharmaceutical manufacturing that resulted in less product losses, thus greater production yield. More specifically, their method consisted of 5 steps, (1) Analyze process, (2) Collect data, (3) Characterize loss causes, (4) Generate optimization plans, (5) Perform evaluation, all of which are part of the Plan phase of the PDCA cycle of the kaizen philosophy. They implemented successfully their proposal as a case study in a manufacturing plan, characterizing their effort as process improvement.

Kaizen tools have been used in the pharmaceutical sector as a manner to improve quality through the already established processes. Most of the case studies that have been reported in the literature concern continuous improvement practices in the production area of pharmaceutical industries.

4.7 The combination of 5S and Kaizen in workplaces

Case studies in the literature have reported 5S and Kaizen methodologies as a combined continuous improvement tool. Some of which are reported below.

Zadry and Darwin, 2020, utilized 5S and PDCA cycle techniques in a shoe manufacturing enterprise. Due to reported defects in products, the two methods were implemented in order to solve problems concerning methods, materials, equipment and employees' training. After the implementation period, registered defections were diminished.

Demirtas et al., 2022, applied 5S and Kaizen in a surgical mask manufacturing industry. The cleaner and safer workplace resulted in fewer stoppages and delays during production, more final product quantities, improved quality and less customer complaints.

At South Dakota state university, Koromyslova et al., 2018, implemented 5S and Kaizen practices at the Construction and Operations Management Department. The internal continuous improvements processes led the students and the faculty members to reduced searching times, reduced number of data entry errors and quicker onboarding of new members.

Baptista et al., 2021, studied the application of a combination of 5S and Kaizen at a textile company in Portugal. Due to increased orders and customers' more complex demands, the company sought a way to improve its quality. Baptista et al., organized the enterprise by applying the 5S methodology, reduced production setup time with the aid of SMED tool, improved communication between departments and achieved to reduced waste production.

In another case study, Bevilacqua et al., 2015, implemented a combination of 5S and Kaizen techniques in order to achieve smaller changeover times in the production area of a pharmaceutical industry. The basic Kaizen tool they used was SMED combined with TPM and 5S. The implementation of the techniques succeeded in fully trained personnel, organized production line, elimination of downtime and reduction of changeover time. All these alterations led to increased productivity.

Many case studies have been reported in the literature, combining 5S and Kaizen tools, aiming to improve workplace organization, productivity, company culture and safety. Less studies have been focused on the pharmaceutical sector, the majority of them concern production departments.

5. The pharmaceutical sector

5.1 Introduction

The pharmaceutical industry is a vertical field that discovers, develops, produces, and markets pharmaceutical forms for use by humans and animals to cure diseases. Pharmaceutical companies deal with generic or non-generic medications, biotechnological products, vaccines, and medical devices.

In the pharmaceutical industry, strict laws and regulations are applied so as to ensure that medicines are produced under the highest standards and safety for the patient. Drug manufacturers should comply with several standards and requirements to ensure the quality of the product. Current Good Manufacturing Practice (CGMP) regulations contain the minimum requisitions for the methods, facilities and controls used in manufacturing, processing and packing of a drug product. On the other hand, nonclinical laboratory studies, which are conducted at the quality control and research and development laboratories of a pharmaceutical industry, should comply with Good Laboratory Practice (GLP) regulations. These regulations define rules and criteria on the manner the conducted studies at the drug products are planned, performed, monitored, recorded and reported, achieving in this way, the quality and the integrity of the data (Geijo 2000).

5.2 Pharmaceutical quality

Many definitions of drug quality exist. The pharmaceutical industry has proposed the term "fitness for use", meaning that the drug meets its prespecified quality attributes or regulatory specifications (Woodstock 2004).

The International Council for Harmonization (ICH) states that the pharmaceutical quality system "assures that the desired product quality is met, suitable process performance is achieved, the set of controls are appropriate, improvement opportunities are identified and evaluated and the body of knowledge is continually expanded" (ICH Q10, Section 3.1.3 Commercial Manufacturing)

Dale 2016 defines the pharmaceutical quality system as a document-based management tool that displays the policies, procedures, objectives, principles, organizational authority to

ensure quality in every pharmaceutical development step, such as production, supply chain and quality processes.

The pharmaceutical quality is ensured by guidance documents, which contain clear recommendations and standards for pharmaceutical industries to comply, during the drug development, manufacturing and quality applications. Some of the most common guidelines are the Food and Drug Administration (FDA) guidance documents, the ICH guidelines, the European Medicines Agency (EMA). Also, standards for pharmaceutical ingredients and drug products are provided by the International Organization for Standardization (ISO) and the pharmacopeias, e.g. European Pharmacopeia (EP), United States Pharmacopeia (USP).

5.3 Analytical laboratories in the pharmaceutical industry

Analytical testing plays a vital part in the development lifecycle of pharmaceutical drugs, as it provides assurances of the safety and effectiveness of the products prior to patient use. As industry focuses on more complex molecules, growth within the analytical testing services sector is inevitable.

Analytical experiments in a pharmaceutical industry are performed in the Quality control department - which is usually divided in the chemical analysis, the microbiological and the packaging material laboratory – and the analytical Research and Development (R&D) department. Geijo 2000, mentions some of the various tasks that performed every day in an analytical R&D laboratory including,

- Chemical characterization of Active Pharmaceutical Ingredients (APIs) and raw materials
- Method development activities
- Method validation activities
- Stability studies
- Identification and characterization of unknown product related substances
- Instrumentation and equipment management

6. Research methodology

6.1 Introduction

This chapter depicts the research methodology that was utilized for the completion of the dissertation. Details about the source of data and the way that have been collected will be presented.

6.2 Research design and strategy

Etymologically "Research" means a quest for knowledge, a search for the truth. Research strategy cites the procedures and principles used in a logical context in a scientific thesis.

This study aims to examine how 5S and Kaizen continuous improvement techniques may affect enterprises in meliorating their workplace conditions, in terms of culture and everyday tasks. For the specific purpose, a single case study was selected since it provides an extensive opportunity for in-depth observations (Choundalas & Tepaskoualos, 2018).

For the single case study analysis, analytical R&D laboratory of a Greek Pharmaceutical company was chosen. The company was founded in the late 60s and specializes in the development and the production of pharmaceutical products. The analytical R&D laboratory is certified in ISO 9001. The department organizationally comprises of:

- One vice president, who sets corporate objectives and quality policies.
- Two managers, who are responsible of the coordination of the analytical workload and the implementation of the quality standards.
- Twenty research scientists, who are responsible for the execution of the analytical experiments and the interpretation of the results.

The choice of the R&D laboratory for the implementation of the 5S and Kaizen methodologies is justified by the following reasons. The routine work tasks contain various and complex analyses. Different samples are received every week from the laboratory personnel, such as APIs, non-active raw materials, lab-scale drug formulations, samples derived from the drug formulation process, stability samples. Also, demands for analytical development procedures, analytical method validation experiments, characterization of unknown organic degradation molecules render the work every day life more than

multitasking. These facts often stand against ordering and shorting things down. Another reason is the fact that the company is open to new ideas and suggestions regarding workplace improvements. Finally, we should highlight that the company provided us access to the R&D facilities, making this study feasible.

The research took place from November 2023 until April 2024. Although the laboratory adheres to GLP regulations and safety requirements, the study was performed in order to enhance its performance, improve data uprightness and the overall quality system.

The research design was based on the descriptive and the action approaches. The initial state of the laboratory was assessed, by observing the applied processes and the daily working routine of the employees, emphasizing on the obstacles they may face due to lack of organizational initiatives.

Ten analytical R&D employees took part in the research, all acquiring bachelor degrees in chemistry, biology and science engineering. The purpose of the research has been fully explained at the participants and their involvement was voluntary. Their personal data is fully confidential and is collected by the researcher. Four of them participated into the quantitative research, at which the time for the completion of an analytical experiment was measured before and after the implementation of the study. All ten employees participated at the qualitative research, answering in the same 7 questions before and after the study.

6.3 Quantitative research

This study aims to provide insight on how the implementation of 5S methodology and Kaizen philosophy impact on the processes of a pharmaceutical analytical laboratory. Comparative study between quantitative data before and after the research implementation will be displayed. The quantitative data before the 5S application were collected from existing organizational sources. Since the analytical R&D laboratory adheres to GLP and GMP regulations, data integrity is maintained, organizational data, concerning the analytical experiments, have been recorded and monitored since the business has been operational.

Deviations occurred in analysis are considered as a Key Process Indicator (KPI) in this research. There are divided into two categories. The ones that occurred due to analytical mistake (human factor) and are believed to materialize due to lack of arrangement. And the

ones that took place because of instrumental malfunction. In order to maintain anonymity and prevent anti-trust violations as an outcome of this research study, data will be referred as a number and categorized as described above. Deviations before the implementation of the research were registered during a four-month period, that is September 2023 until the end of December 2023. Whereas, post study data were recorded for the period January 2024 until April 2024.

Experiment conduction time is the second KPI. Four different analysts, with at least two-year experience each, were observed conducting three different types of experiments and their time required for the completion of their task was measured. This procedure was performed two times in total, before and after the implementation of the continuous improvement technique. On November 2023 the pre-study data were acquired, whereas on April 2024 the post-study data were obtained.

Both quantitative metrics were compared at the end of the research to demonstrate the effects of the organizational changes.

6.4 Qualitative research

Qualitative research data were obtained, so as to capture the perspective of the analytical R&D department employees before and after the implementation of the two methodologies.

A Likert scale questionnaire was used pre and post the case study to capture the beliefs, customs and emotions of the personnel.

The first two questions focus on the cleanliness and tightness of the laboratory workspace. It has been already evidenced in previous research papers, that the application of these two methodologies in workspace areas, leads to increased organizational conditions. Shyam (2011) implemented the 5S methodology in a university laboratory and after reviewing the results he concluded that the lab was much cleaner and better organized, which resulted in increased work efficiency.

The third question aims to depict the reduction in equipment tools and experimental materials searching time. Deshpande et al. (2015), after applying the technique in a manufacturing area of luggage bags, he recorded that searching time for tools and raw

materials required for the production were diminished. This outcome was a result of proper storage system with proper identification control.

The fourth question concerns about the efficiency of the analytical instrumentation. It is based on the Kaizen principle of TPM, which was described on chapter 4.3.2. The machinery and equipment that are usually mentioned on scholarship articles and refer to production sites are replaced, in this research, by the analytical instrumentation, which is consider to be the cornerstone of the analytical result. Setiawan 2021, at his review article presents various cases where proper instrumental maintenance resulted in fewer breakdowns and more qualitative outcomes.

The last three questions refer to employee engagement and corporate culture. Continuous improvement application in working environment may result in positive outcomes. These questions aim to highlight how the application of 5S and Kaizen principles affected the work culture and employees' morale. Gunawan et al. 2022, reviewed the literature on how Kaizen changed work culture and concluded that Kaizen events display enthusiasm and high work ethic in employees' attitude towards their company.

7. Case study implementation and results

7.1 Introduction

This chapter will present the implementation of 5S and Kaizen methodologies at the analytical R&D laboratory of the pharmaceutical company that was selected for the single case study analysis. Also, in order to evaluate the potential effects of this research, pre and post implementation collected data will be presented and schematic figures, graphs and tables will be depicted. Microsoft office excel and SPSS statistics programs, were employed. Results will be presented separately for the quantitative and the qualitative analyses data.

7.2 Applying Kaizen and 5S methodologies in an analytical pharmaceutical laboratory

The combination of 5S and Kaizen theories may result in the overall improvement of an organization. They may be applied from an office to a production line, even in domestic personal areas.

The aim of this research is to apply a continuous improvement plan on an analytical laboratory of a pharmaceutical company.

Prior to implementation of the techniques, the steps of the application and the goals were set. Below are presented the crucial steps that should be highlighted before any other action.

1. Acquire leadership permission and support
2. Form a Kaizen team
3. Provide training sessions
4. Conduct current state assessment
5. Implement 5S activities
6. Measure progress

These steps are described in details at the following sub-sections.

The case study implementation timelines are summarized at table 7.1:

Month	Action
November	Leadership permission acquired Kaizen team members were selected Questionnaires submitted to participants
December	Training of Laboratory personnel into 5S and Kaizen principles Conduction of current state assessment Measurement of experiment conduction times
January	Implementation of 5S phases
February	Implementation of 5S phases Monitoring of the new work conditions
March	Monitoring of the new work conditions
April	Evaluation of the new work conditions Measurement of experiment conduction times Questionnaires submitted to participants

Table 7. 1 Research implementation timelines

7.2.1 Acquire leadership permission and support

Before initiating any action, department's upper management and the manager of the analytical laboratory were informed about the 5S and Kaizen theories and their potential benefits of their implementation. Increased effectiveness and efficiency, more reliable analytical results, reduced delays in the conduction of the experiments, increased laboratory safety conditions and elevated working morale are some of the advantages that may arise by introducing 5S/Kaizen in the laboratory.

Also, the personnel involvement was discussed, since a number of participants is required for the implementation of the whole task. Employees who participated at the activity, apart from their daily assignments, had also undertaken the relevant task's responsibilities.

Finally, the analytical laboratory manager was informed about the financial aspect. 5S and Kaizen activities do not require expensive equipment and supplies.

Leadership support and engagements is crucial for initiating and sustaining the total efforts. Management commitment is one of the main factors (Bessant (2003), as managerial work through daily activities promotes the establishment of a culture of learning and continuous innovation.

7.2.2 Form a Kaizen team

A dedicated team, comprised with members from different working groups within the laboratory was established. A manager and three analysts were chosen as the initial members of this team. Their objective is to identify and solve working-related problems. Their colleagues usually discuss all the observations and obstacles they face in their everyday routine, suggesting solutions and their ideas towards a better working environment. Kaizen members are the ones who escalated the problem, if needed, to the upper management.

At this case study analysis, Kaizen team was in touch, from the begging of its establishment, with members from the Quality Assurance (QA) and the Human resources (HR) department. The ultimate objective of this team is to establish a continuous improvement culture in the laboratory environment. QA experts were called to analyze the importance of quality-driven procedures inside the working area, whereas HR specialists advised Kaizen team about behavioral issues.

The freshly formed Kaizen team, apart from being responsible of growing the continuous improvement culture inside the analytical laboratory, was also in charge for applying and sustaining the 5S techniques.

As Oakland 2014 suggests, Kaizen team members should be in touch in the most regular basis. Meetings can be held in the work area or away from it so that members are free from interruptions, and are mentally and physically at ease. If away from the work space, the room should be arranged in a manner conducive to open discussion, and any situation that physically emphasizes the leader's position should be avoided. To a large extent the nature of the problems selected will determine the nature of the meetings, the interval between them and the venue.

Usually, the main topics discussed at a Kaizen team meeting were the following:

- Training sessions, initial or refresher
- Problem identification
- Problem analysis
- Problem solution recommendation
- Management presentations
- 5S implementation status

7.2.3 Provide training sessions

Training sessions were provided to all analytical laboratory personnel and divided into two parts.

1st part – Continuous improvement session

At the first training session the notion of Kaizen was discussed as well as the importance of its application in the working environment.

The chronology of Kaizen was presented and the beneficial results of the companies that first adopted its theory were highlighted. Kaizen main points were categorized into two groups (Al Smadi 2009). The basic terms that were showed are the below:

- *Continuous improvement*
  - Form a long-term vision and meet challenges with patience
  - Continuously improve business operations always stirred by innovation
  - Build consensus and achieve goals
  - Realize that by company evolution personal evolution will eventually come

- *Respect for people*
  - Respect others, colleagues/external associates/customers, by making effort to understand each other
  - Built mutual trust and effective communication
  - Enhance teamwork by sharing professional knowledge and opportunities maximizing team performance
  - Commit to education and personal development

2nd part – 5S session

At the second session the acronym of 5S was analyzed, accompanied with a historical presentation about its conception by the Japanese. The benefits of its application were highlighted as long as the self-discipline requirements of all the personnel in order to sustain the upcoming changes in the working environment.

Also, the Kaizen team members were introduced to the analytical department and their role was explained in details so everybody would be aligned with the new changes.

Training and development sessions are considered as cornerstone tools of continuous improvement philosophy, so they will be held on a regular basis organized by the collaboration of Kaizen team members and HR specialists.

7.2.4 Conduct current state assessment

Current state assessment was conducted before the initiation of the 5S activities. Through direct and participative observations issues concerning the workings areas were reported and categorized. Some of the main problems were:

- Misplaced equipment or materials
- Misplaced final products, raw materials, reagents
- Lack of housekeeping
- Too much "travel distance" due to poor lay out on the laboratory
- Not performing actions right on the first time

7.2.5 Implement 5S activities

5S principles were implemented in the laboratory to standardize the working procedures and to increase its quality effectiveness.

The application of every phase of each of the 5S's is described in details.

1S - Seiri/Sort

After the current state assessment, the sort phase was started. Kaizen team members spotted the unwanted items in the laboratory areas and tagged them with a red indication label. All the red tagged items were collected at a designated red tag area. These items consisted of broken equipment parts, obsolete consumables and equipment belonging to other departments. Empty cartoon boxes and useless packaging materials were immediately disposed in order to free laboratory workspace.

Also, chemical reagents, such as solids, liquids, bases and acids, were checked according to their expiration dates. The expired ones were also red tagged and removed from the non-expired ones.

All employees were informed about the red tagged items, in case some of them are needed. Also, it was taken into consideration that some tools or materials at an analytical laboratory may be needed more seldom than every six months. Thus, items in the red tag area will be kept for 9 months, to avoid throwing away important tools.

2S - Seiton/Set in order

Set in order is considered the longer phase of the implementation of 5S in the analytical laboratory. During this phase, items were allocated at defined positions according their category and their frequency of use. Marking tapes and plasticized labels were used to designate these storage areas. The equipment, tools and materials that were relocated and sorted are,

- Solid and liquid reagents in certain chemical cabinets, sorted by initial name letter
- Bases and acids in chemical safety cabinets
- Analytical standards in designated areas inside fridges
- Glassware in drawers according to their volume capacity
- Columns for High performance liquid chromatographers in closets according to their type
- All type of consumables necessary for the analytical experiments at laboratory shelves

Furthermore, different colored-tapes were used as floor markings to indicate specific area utility,

- Yellow-colored tape was used for liquid waste disposal area
- Black and yellow colored tape was used to indicate forbitten areas of placing items
- Green-colored tape was placed around common waste bins

This phase aimed to improve efficiency, safety in the laboratory areas and reduced equipment/consumables search time.

3S - Seison/Shine

This step is related to cleanliness and keeping things is good working condition.

A weekly cleaning schedule was developed based on the laboratory workforce, which included working station areas, glassware and laboratory benches.

Analytical instruments play a major role in a laboratory, concerning the reliability and quality of the obtained results. At the pharmaceutical industry, they are as much crucial as the production machinery for the quality of the outcome. All the analytical experiments depend on the working condition of the analytical instrumentation. Most pharmaceutical laboratories usually have scheduled maintenance activities, performed by external technicians.

TPM system, as elaborated on chapter 4.3.2, usually refers to machineries at production areas, ensures that equipment run optimally, using proactive maintenance to anticipate problems before they occur, resulting in stabilizing performance and reliability of equipment. Many industrial sites after the implementation of TPM, have reported overall equipment effectiveness. Irwansyah et al., (2019) applied TPM in a beverage industry, resulting in increased equipment effectiveness, also Fam et al. (2018), reported that TPM elevated effectiveness of an electronic components manufacturing site.

During this study, a weekly maintenance schedule was established. Based on the TPM philosophy, every analyst at the laboratory is responsible for the weekly maintenance of the analytical equipment that is using. Predefined steps were standardized depended on the type of analytical equipment and followed by the employees themselves, in order to increase instrumental efficiency.

This phase emphasizes in improved visual laboratory conditions, enhanced safety and proper maintenance of equipment.

4S - Seiketsu/Standardize

The analytical laboratory had already established SOPs, but new – detailed laboratory rules and regulations were set. Details about all the 5S driven activities and changes that were performed are mentioned. But standardizing all the details and predicting all the future changes that might be needed is a very difficult task for this kind of working areas. The

nature of experimental work is very complex and dynamic, so very meticulous procedures may cause confusion in the future, when probably the testing methods or materials will have changed.

Goetsch 2014, mentions the use the "Kaizen Checklists". They are documents which represents opportunities for improvement in a workplace. They include all key elements that play role in the analytical laboratory operation. At these lists, all personnel are able to wright down observations concerning all aspects of their daily working routine, including ideas and solutions for the emerged problems. A customized checklist was placed at the laboratory noticeboard where employees are able to write down their problems and potential solutions. This is an extra method of expressing themselves and being engaged in the department's goals. This phase aims to automize the first three steps of the 5S activities.

5S - Shitsuke/Sustain

5S is considered a Kaizen tool towards continuous improvement. Analytical laboratory personnel should retain the changes that were made towards this direction being responsible for the whole workstation.

In order to sustain 5S and Kaizen principles, the Kaizen team members are authorized to audit the laboratory periodically, make the necessary amendments and keep activities on track.

Also, ongoing education and training sessions regarding 5S, Kaizen and the importance of quality were planned.

7.3 Quantitative analysis results

Deviations in analysis were registered and compared three months before and after the implementation of the study. They are separated into two categories, mistakes that occurred due to an instrumental malfunction and due to employee's mistake. The findings are presented at table 7.2,

	Pre implementation	Post implementation
Instrument malfulction	6	4
Analytical mistake	8	2

Table 7. 2 Deviations in the analytical laboratory

Registered deviations due to instrument malfunctions before the implementation of the research were 6 and due to analytical mistake (human error) were 8. On the contrary, after the study, there were measured at 4 and 2 respectively. These two finding are also depicted at figures 7.1 and 7.2 below,

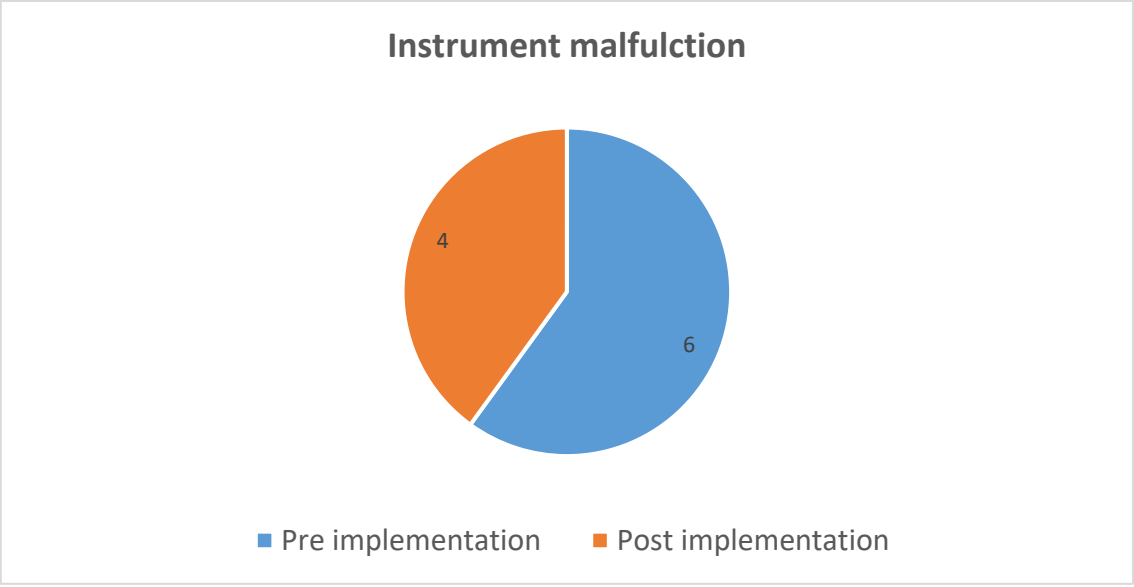

Figure 7. 1 Deviations in analysis due to instrument malfunction

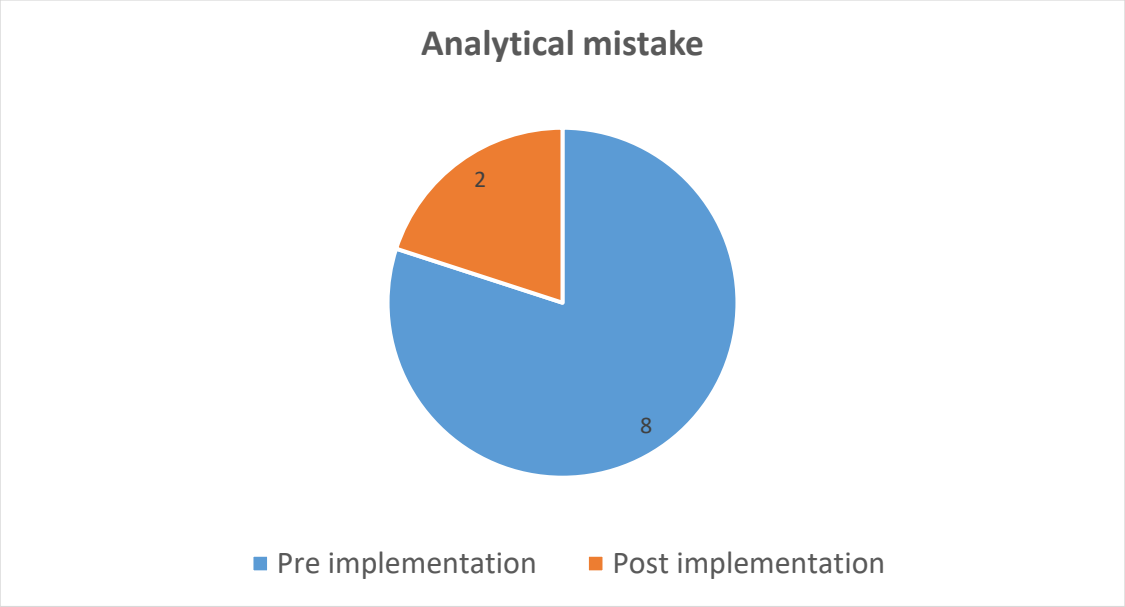

Figure 7. 2 Deviations in analysis due to analytical mistake

It is evidenced that there is a reduction in registered deviations in analyses after the implementation of the study. Deviations from 14 were reduced to 6 in total.

Quantitative result data were also obtained after measuring the experiment conduction time required by an analytical R&D scientist to perform an experiment. Three different analytical experimental procedures were utilized, conducted by four different employees before and after the implementation of the study. The obtained measured times are presented at the following tables, for each experiment, along with the calculated difference between the two periods,

Experiment 1			
	Pre implementation (min)	Post implementation (min)	Difference(min)
Analyst 1	65.2	56.4	8.8
Analyst 2	58.9	47.6	11.3
Analyst 3	55.1	46.7	8.4
Analyst 4	62.6	55.3	7.3
Average	*60.5*	*51.5*	*9.0*

Table 7. 3 Experiment 1 conduction times

Experiment 2			
	Pre implementation (min)	Post implementation (min)	Difference(min)
Analyst 1	140.1	123.6	16.5
Analyst 2	129.9	111.7	18.2
Analyst 3	134.2	115.5	18.7
Analyst 4	120.9	109.3	11.6
Average	*131.3*	*115.0*	*16.3*

Table 7. 4 Experiment 2 conduction times

Experiment 3			
	Pre implementation (min)	Post implementation (min)	Difference(min)
Analyst 1	188.4	162.1	26.3
Analyst 2	197.6	177.0	20.6
Analyst 3	179.0	163.3	15.7
Analyst 4	200.2	180.2	20.0
Average	*191.3*	*170.7*	*20.7*

Table 7. 5 Experiment 3 conduction times

Experimental times before and after the case study are also depicted at the following bar charts (Figures 7.3 and 7.4), where the average value for each case is shown in orange horizontal line,

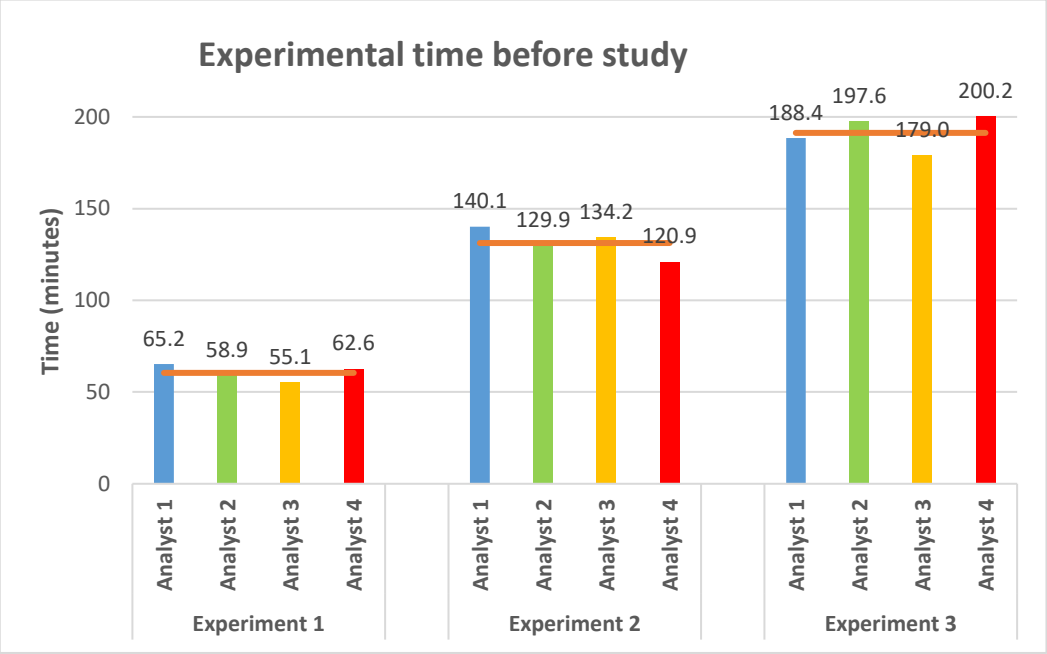

Figure 7. 3 Bar chart with experimental times before implementation

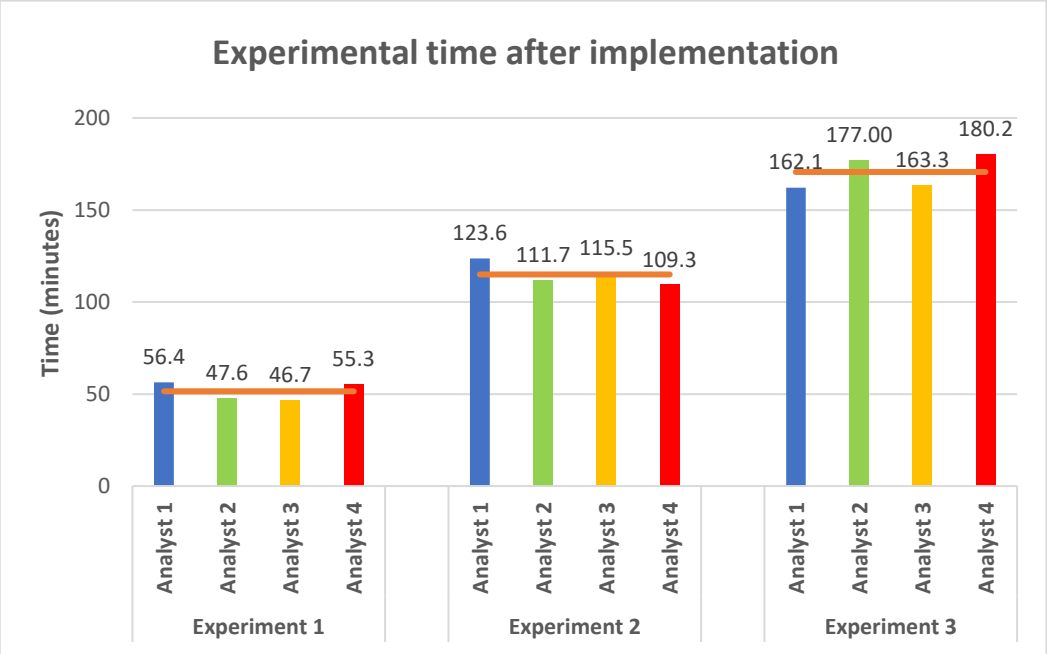

Figure 7. 4 Bar chart with experimental times after implementation

The first analytical experiment showed a calculated average time before the application of the 5S and Kaizen concepts at 60.5 minutes, whereas after the study this value was measured at 51.5 minutes. Comparing the findings for experiment 2 and 3 we had 131.3 and 191.3

minutes for pre study and 115.0 and 170.7 minutes for post study measurements respectively. These average experimental measured times are compared at Figure 7.5**,**

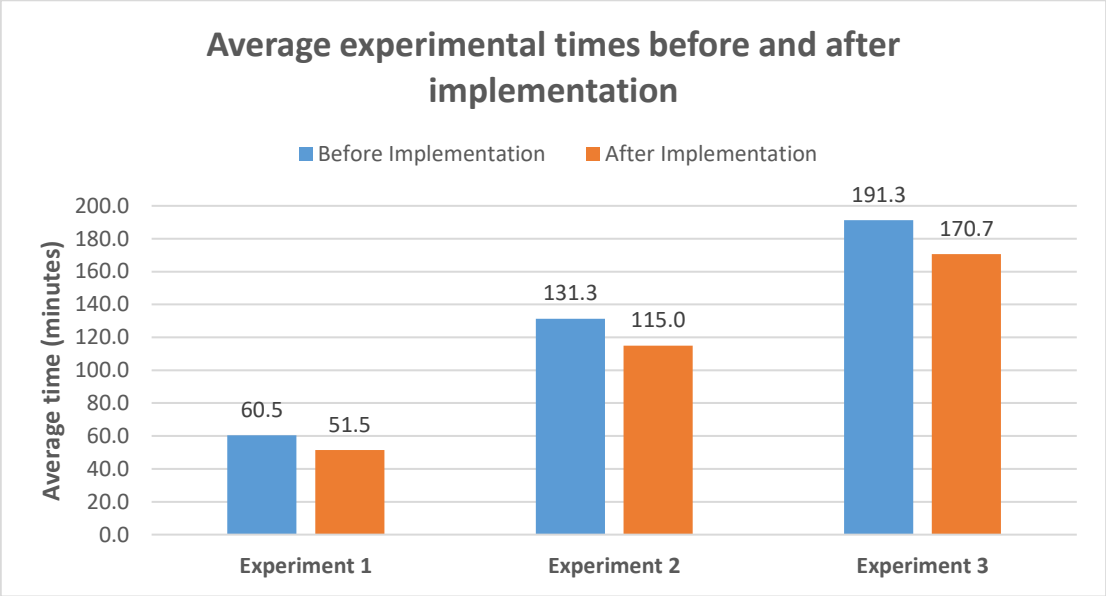

Figure 7. 5 Average experimental times

Each average comparison pair shows a reduction in time from pre to post study, suggesting an improvement in efficiency of the analytical procedures.

Additionally, a hypothesis testing was performed in order to examine whether there is difference between the sample statistics and the result we expected. Median difference between the pre and the post survey results is examined via Wilcoxon signed rank test. This is a nonparametric test, suitable for small sample sizes, where no assumption of normality is needed (Berenson et al. 2019).

The test was performed on SPSS statistics program, for a twelve total number of paired samples. The Null (H_0) and the alternative (H_1) hypothesis were defined as follows,

H_0= The median difference in experiment conduction time between pre and post study measurements is equal to zero

H_1= The median difference in experiment conduction time between pre and post study measurements is not equal to zero

The results from the SPSS statistics program are summarized at Table 7.6 and Table 7.7

Total N	12
Test Statistic	0.000
Standard Error	12.748
Standardized Test Statistic	-3.059
Asymptotic Sig.(2-sided test)	0.002

Table 7. 6 Related-Samples Wilcoxon Signed Rank Test Summary

	Null Hypothesis	Test	Sig.[a,b]	Decision
	The median difference between experiment conduction time pre and post study is equal to 0.	Related-Samples Wilcoxon Signed Rank Test	0.002	Reject the null hypothesis.

a. The significance level is .050.

b. Asymptotic significance is displayed.

Table 7. 7 Hypothesis test summary

P-value for this test is the Asymptotic significance (2-sided test) value in Table 7.6. So, the test result p-value=0.002 is smaller than the level of significance a=0.05, which leads us to the conclusion that the Null hypothesis is rejected. We may conclude that the differences in median values between pre and post study are statistically different. This suggests that the implementation of the two continuous improvements theories has effectively reduced the experiment conduction times in the laboratory as evidenced by the statistically significant decrease from pre to post study times across the measurements.

7.4 Qualitative analysis results

In the context of qualitative analysis, a five-point Likert scale questionnaire was utilized. It was submitted to laboratory scientists on November 2023 and resubmitted untouched, concerning its content, on April 2024. The goal of this approach is to gain insight from the personnel regarding their attitude and beliefs on how 5S and Kaizen changed their work routine.

Seven questions were displayed at the questionnaire and 10 laboratory scientists took part at the survey.

The questions are summarized at Table 7.8,

Q1	The laboratory workspace is well organized
Q2	The laboratory workspace is clean
Q3	Drug samples, experimental materials and equipment are easy to find
Q4	Analytical instrumentation is ready to use for analysis
Q5	Open communication is encouraged among members of the laboratory
Q6	Employees are involved in identifying working related problems
Q7	Work atmosphere and morale are high in the chemical laboratory

Table 7. 8 Questionnaire content

The answer options had two utmost poles, "1" for "strongly disagree" and "5" for "strongly agree" and a neutral option linked with intermediate answer options. At table 7.9 all available options are displayed,

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Table 7. 9 Questionnaire answer options

Answers obtained before the study are shown in Table 7.10 and graphically depicted in Figure 7.6,

Pre implementation answers					
	1	2	3	4	5
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Q1	0	8	1	1	0
Q2	0	7	2	1	0
Q3	0	5	5	0	0
Q4	0	6	3	1	0
Q5	0	2	6	2	0
Q6	2	6	2	0	0
Q7	1	4	4	1	0

Table 7. 10 Pre implementation answers

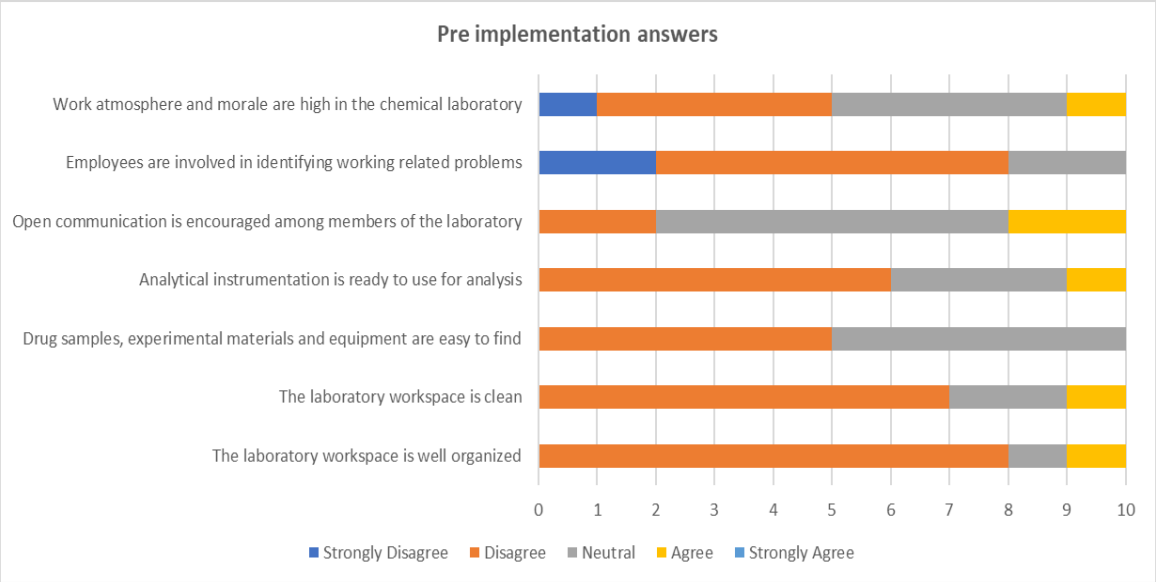

Figure 7. 6 Pre implementation answer chart

Answers obtained after the study are shown in Table 7.11 and graphically depicted in Figure 7.7,

Post implementations answers					
	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree
Q1	0	0	3	5	2
Q2	0	0	3	6	1
Q3	0	0	2	7	1
Q4	0	0	4	5	1
Q5	0	1	3	5	1
Q6	0	0	2	6	2
Q7	0	1	3	5	1

Table 7. 11 Post implementation answers

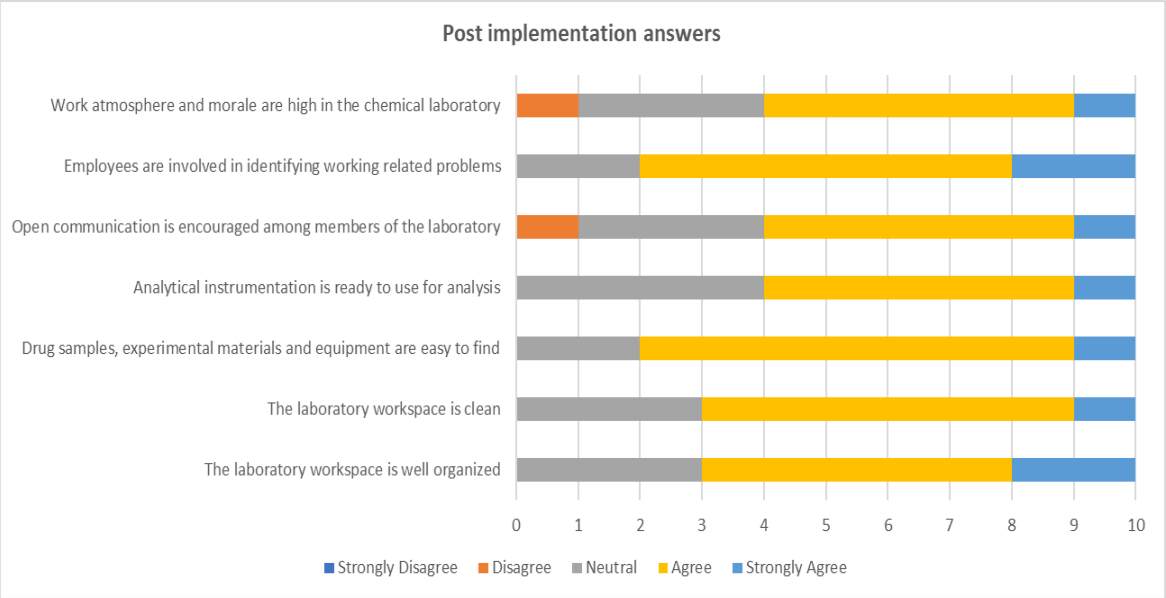

Figure 7. 7 Post implementation answer chart

The average values of the answers of both 5-point Likert scale questionnaires were calculated in order to depict the differences between the responses of the participants before and after the implementation of the continuous improvement concept.

The average value is categorized according to the interval it matches. For 5 Likert scale cases, the intervals are defined according to Table 7.12 below,

1	Strongly Disagree	1.00 - 1.80
2	Disagree	1.81 - 2.60
3	Neutral	2.61 - 3.40
4	Agree	3.41 - 4.20
5	Strongly Agree	4.21 - 5.00
	Range	4
	Interval	0.8

Table 7. 12 Five-point Likert scale intervals

Every participant's answer, as long as the average value of each answer are shown in table 7.13 for pre-study implementation questionnaire and at table 7.14 for post-study implementation respectively.

Participants	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**
1	2	2	2	2	3	2	2
2	3	4	3	2	3	2	3
3	2	2	2	2	2	1	2
4	2	2	2	3	3	3	3
5	2	2	2	3	4	2	2
6	2	2	2	3	4	2	2
7	3	2	3	2	2	3	3
8	4	3	4	3	3	2	4
9	2	2	2	2	3	2	3
10	2	3	3	3	3	1	1
Average	**2.40**	**2.40**	**2.50**	**2.50**	**3.00**	**2.00**	**2.50**
	Disagree	*Disagree*	*Disagree*	*Disagree*	*Neutral*	*Disagree*	*Disagree*

Table 7. 13 Pre implementation individual Likert scale answers

Participants	Q1	Q2	Q3	Q4	Q5	Q6	Q7
1	4	4	4	4	4	5	5
2	4	4	4	4	4	4	4
3	3	3	3	3	2	3	3
4	5	4	4	4	4	4	4
5	4	4	5	5	5	5	4
6	3	3	3	4	3	4	3
7	5	5	4	4	4	4	4
8	4	4	4	4	4	4	4
9	4	3	3	4	3	4	3
10	3	4	3	3	3	3	2
Average	**3.90** *Agree*	**3.80** *Agree*	**3.70** *Agree*	**3.90** *Agree*	**3.60** *Agree*	**4.00** *Agree*	**3.60** *Agree*

Table 7. 14 Post implementation individual Likert scale answers

The average values for each answer from Tables 7.12 and 7.13 are compared at Figure 7.8,

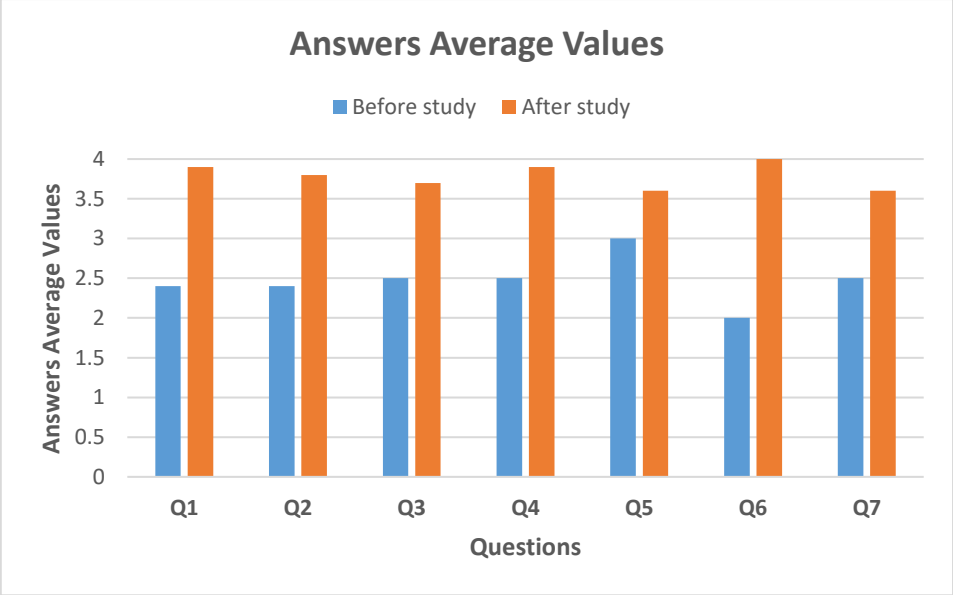

Figure 7. 8 Survey average value answers before and after the implementation of the study

During Q1 "The laboratory workspace is well organized", participants' average answers were measured at 2.40 before the study and at 3.90 after. This difference indicated that the laboratory in perceived more organized and tighter than before.

Answers at Q2 "The laboratory workspace is clean" depicted increased average values, from 2.40 to 3.80, indicated that the workspace in cleaner compared to the previous conditions.

Answers at Q3 "Drug samples, experimental materials and equipment are easy to find" showed elevated average values, from 2.50 to 3.70, which may lead us to conclude that tools and materials important for every experiment are now easier to spot and use.

Participants' average answer at Q4 "Analytical instrumentation is ready to use for analysis", increased from 2.50 to 3.90, denoting in this way that analytical instruments are ready to use without obvious malfunctions.

Answers at Q5 "Open communication is encouraged among members of the laboratory" depicted incremented values from 3.00 to 3.60, presented a slight improvement in communication conditions among colleagues.

During Q6 "Employees are involved in identifying working related problems", participants' average answers were measured at 2.00 before and at 4.00 after the study. This is the biggest registered difference, suggesting that laboratory personnel are involved more in identifying working related issues.

Finally, answers at Q7 "Work atmosphere and morale are high in the chemical laboratory", showed increased average values from 2.50 to 3.60. This denoting that work culture in the analytical department meliorated.

8. Discussion, recommendations and conclusions

8.1 Introduction

This chapter will shed light at the research findings, will illustrate the key findings from the data analysis and point out recommendations for potential future studies.

8.2 Discussion on research findings

The aim of this research was to implement two continuous improvement methods, 5S and Kazen, on an analytical pharmaceutical laboratory and to study the potential benefits in terms of experimental processes, quality of analytical results, employee engagement and workspace cultural environment.

Registered deviations in analytical R&D laboratory, after the implementation of the study, were reduced from 14 to 6 in total, presented a 51.7% decrease. Analytical mistakes were reduced from 8 to 2, 75% less errors due to human factors occurred. Towards this direction 5S technique contributed the most. During "Seiri-Sort" phase, items that were not used for a long period and considered obstacles were removed. At "Seiton-Set in order" phase, chemical reagents, samples and analytical micro equipment were placed in designated places. "Seison-Shine" phase, housekeeping and cleanliness were prioritized, contributed in cleaner laboratory glassware and materials. These alterations eliminated mistakes during analytical experimental procedures, thus less deviations. On the other hand, instrument malfunctions were reduced from 6 to 4, thus 33.3% less. The basic reason for this small but important reduction is the third phase of 5S, which was combined with a Kaizen tool, the TPM. During this step, every laboratory analyst was responsible for the weekly maintenance of an analytical instrument. Standardized steps for cleaning, as preventive maintenance action, were followed. Defects in analytical instrumentation affects the reliability of the analytical result, thus may have serious implications on the quality of the product. Also, lead to increased delays at the analytical outcomes, since in many cases after an instrument breakdown the experiment has to be repeated. Nishal et al. 2018, showed in their case study article, that by involving personnel in TPM philosophy, creates awareness and responsibility in maintaining the equipment, resulting in a positive effect on productivity. We may

conclude at this point, that the combination of these two continuous improvement methods contributed positively in the diminishing of errors in work routine.

Moreover, the experiment conduction time after the implementation of the research was reduced. As analyzed on Chapter 7.3 and depicted on Figure 7.5, average experimental times were smaller after the study. The first experiment showed a reduction of 14.9%, from 60.5 to 51.5 minutes, the second experiment 12.4%, from 131.3 to 115.0 minutes and the third experiment 10.8%, from 191.3 to 170.7 minutes. 5S technique played an important role because all necessary items for the execution of an experiment were placed on designated areas. Drug samples and analytical standards, chemical reagents, clean glassware ready for use and all kind of equipment consumables and tools were arranged. Diminished experimental time may contribute in the quality of the result. Personnel may spend the time saved from equipment searching, into more meticulous sample preparations and analysis execution or into literature searching reading related to pharmaceutical sector.

The improvement of laboratory overall conditions and analytical instrumentation efficacy were also proved from the survey questionnaire that was available to personnel before and after the research. Answers generated from Q1, Q2, Q3 and Q4 displayed that 5S and Kaizen increased laboratory arrangement and cleanliness, decreased equipment searching times and maintained machinery stabilized performance.

Questions Q5, Q6 and Q7 targeted in capturing the belief of participants about communication between colleagues, employee engagement into troubleshooting and work atmosphere and culture of the analytical development department. As explained in chapter 6.3 and depicted on figure 6.8, average answers from these three questions, increased towards the "Agree" interval.

Communication from 3.00, neutral opinion, increased to 3.60. During continuous improvement training session, it was highlighted to all employees the importance of team member communication and the potential benefits this may trigger. Communication not only between analysts, but also direct contact among them and managers. Increased communication brings more efficient teamwork which results in greater results. Wickens 1990, also described how the concept of Kaizen enhance communication and positively affected corporate performance.

Employees involvement into working related problems increased from 2.00 "Disagree" interval to 4.00 "Agree" interval, based on average answers from Q6, displaying the biggest increase at this survey. Continuous improvement training elaborated on the benefits of building consensus and achieving goals, which focused not only on the company prosperity but on the personal evolution and growth. Managers encouraged personnel in actively participating in troubleshooting and actually being part of the solution, broadening their knowledge and work experience. Hyland 2004 in his presentation, highlighted that continuous improvement is responsible for increased "people performance", in terms of development, empowerment and participation.

Work atmosphere and employees' morale were captured from answers of Q7, which also were incremented, from 2.50 to 3.60. These results are aligned with Karvounis 2021, who proved in his research thesis, that the implementation of 5S in a manufacturing company had a positive effect in employees' attitude. Also, Teshome 2018, assessed the effect of Kaizen philosophy in employees' attitude of a textile company, where he concluded in increased morale, job satisfaction, commitment and reduced stress. Both techniques may contribute at a better work atmosphere, resulting in employee's higher morale, thus greater team spirit and productivity.

The implementation of the continuous improvement techniques offered significant alterations at the workplace. The above benefits were also presented to the upper management team. When important decisions should be taken, managers consider various parameters that may affect corporate strategy. The most difficult decision was the initial resource allocation. Before and during the implementation of the techniques, valuable working hours were required for the training of the involved personnel, without disrupting routine workflow. Another consideration was the potential resistance to the new changes, firstly by the managers themselves and secondly by the laboratory staff. New practices, habits and tasks was supposed to be adopted in their daily mindset. The greater challenge of this effort is the employee engagement for the sustainability of the continuous improvement alterations. Corporate culture fitted perfectly to the idea of the implementation of the two techniques at the laboratory workplace, because the company was already continuous improvement oriented. Management committed to the active engagement in 5S and Kaizen activities, fostering a healthier workplace culture.

8.3 Recommendations on future research studies

The research study should be repeated after 5S and Kaizen techniques are being applied for a longer period in the R&D laboratory. In this way, laboratory personnel would have comprehended in depth the application of the techniques, as long as its long-term benefits. Also, amendments may have been made concerning the in-place application of the five phases, customized at the unique needs of the workplace, which were not possible to be determined in the first place. Furthermore, Kaizen is a philosophy and do not get implemented so fast. Thus, further training sessions about its basic characteristics would be beneficial for being completely understood. It has been recorded in the research study of Schwerha et al. 2020, that team members who were initially unwilling to participate in relevant studies, have been transformed into key participants, when a clear and comprehended feedback was provided. Finally, a larger number of samples (participants) would reinforce the validity of the results. More of the analytical scientists may participate at the research methodologies in order to eliminate bias from the acquired data. It is important to sustain 5S and Kaizen culture over a long period of time and validate a relationship with continuous improvement.

8.4 Conclusions of the research

The 5S practice is a set of guided principles, on the other hand Kaizen is a philosophy, the combination of them forms a unique tool for a continuously improving organization. Their implementation is not easy. It demands a series of requirements that must be fulfilled; investment in training for both management and personnel, top management commitment and focus on sustaining 5S implementation and preserving Kaizen principles in the organizational culture.

The current thesis studied the effects of the implementation of the prementioned techniques, as a combination, in an analytical R&D laboratory of a pharmaceutical company. Quality is the ultimate objective of all the enterprises of all sectors. The pharmaceutical sector is obligated to comply with several regulations and strict laws to ensure the safety of the patients. This research focused on the enhancement of the already quality driven procedures, a GLP approved laboratory follows. Previous studies have repeatedly shown positive

relationships between successful implementation of 5S (Randhawa & Ahuja, 2018), Kaizen (Chandrasekaran et al., 2008) and quality.

The outcome of this study was the improvement of the working environment of the analytical laboratory, in terms of orderliness. Deviations and errors in analyses were diminished and conduction times for the execution of analytical experiments were reduced. The sessions in Kaizen policies enhanced the official communication channels between the employees and the superiors and the engagement of all personnel in problem identifications and solutions, led at elevated work morale and team-spirit based atmosphere. Quality cannot be bought and by applied at an organization. The idea of quality should be beheld as a lifestyle rather than an operational tool. 5S and Kaizen principles may result in employees' empowerment and continuous improvement, which might be the aftermath to support and adopt newcoming quality improvement methods in the future.

Bibliography

Al Smadi, S., (2009), *Kaizen strategy and the drive for competitiveness: challenges and opportunities*, Competitiveness Review: An International Business Journal, Vol. 19 No.3, pp. 2023-211.

Alukal, G., Manos, A., (2006). *Lean Kaizen, A Simplified Approach to Process Improvements*, Milwaukee: ASQ Quality Press.

Arnheiter, E.D. and Maleyeff, J. (2005). *The integration of lean management and Six Sigma*, The TQM Magazine, Vol. 17 No. 1, pp. 5-18.

Ashraf, S., Rashid, M., Rashid, H., (2017). *Implementation of 5S Methodology in a Food & Beverage Industry: A Case Study*, International Research Journal of Engineering and Technology, Vol. 04, Is. 03.

Baptista, A., Abreu, A., Brito, E., (2021). *Application of Lean Tools Case Study in a Textile Company*, Proceedings on Engineering Sciences, Vol. 3 No. 1, pp. 93-102.

Bevilacqua, M., Ciarapica, F.E., De Sanctis, I., Mazzuto, G., Paciarotti, C., (2015). *A Changeover Time Reduction through an integration of lean practices: a case study from pharmaceutical sector*, Assembly Automation, Vol. 35 Issue 1, pp. 22 - 34

Bellgran, M., Kurdve, M., Hanna, R., (2019). *Cost driven Green Kaizen in pharmaceutical production – Creating positive engagement for environmental improvements*, 52nd CIRP Conference on Manufacturing Systems, Procedia CIRP 1219-1224.

Berenson, M. L., Levine, D. M., Szabat, K. A., Stephan, D. F., (2019). *Basic Business Statistics: Concepts and Applications*, 14th ed., United Kingdom: Pearson.

Berger, A., (1997). *Continuous improvement and kaizen: standardization and organizational designs*, Integrated Manufacturing Systems, Vol. 8 No.2, pp. 110-117.

Bessant, J., (2003). *High-Involvement Innovation: Building and Sustaining Competitive Advantage through Continuous Change*, Wiley, Chichester.

Brunet, A. P., New, S., (2003). *Kaizen in Japan: an empirical study*, *International Journal of Operations & Production Management*, Vol. 23 No.12, pp. 1426-1446.

Callen, J. L., Fader, C. Krinsky, I.. *Just in time: a cross-sectional plant analysis*, International Journal of Production Economics, No. 63, pp. 277–301, 2000

Chandrasekaran M, Kannan S and Pandiaraj P (2008). *Quality Improvement in Automobile Assembly Production Line by Using Kaizen*, Manufacturing Technology Today, Vol. 7, No. 3, pp. 33-38.

Chapman, C. D. (2005). *Clean house with lean 5S*. Quality Progress, 38(6), 27-32.

Charantimath, M. P., (2011). *Total Quality Management*, 2nd ed., Pearson Education in South Asia.

Chiarini, A. (2011). *Integrating lean thinking into ISO 9001: A first guideline.* International Journal of Lean Six Sigma, 2(2), 96-117.

Choundalas, P. T., Tepaskoualos, F. A., (2018). *Selective integration of management systems: a case study in the construction industry.* The Total Quality Management Journal, Vol. 31 No. 4, pp. 1754-2731.

Dale, B. G., (2003). *Managing Quality*. 4th ed., Blackwell Publishing.

Dalhgaard, J. J., Dahlgaard-Park, Su Mi, (2006). *Lean production, six sigma quality, TQM and company culture*, The TQM Magazine, Vol. 18 No. 3, pp. 263-281.

Darmawan, H., Hasibuan, S., Purba, H. H., (2018). *Application of Kaizen Concept with 8 Steps PDCA to Reduce in Line Defect at Pasting Process: A Case Study in Automotive Battery.* International Journal of Advances in Scientific Research and Engineering, Vol. 5 Issue 8.

Delgado-Ruiz, S., Lopez-Herrera, Y., Castro-Rangel, P., (2023). *PDCA Model for Increasing the Inventory Turnover Rate through Integrate ABC, 5S, Kanban and Cycle Counting in a Peruvian Pharmaceutical SME.* 9th International Conference on Industrial and Business Engineering, ICIBE 2023, pp. 198-205.

Demirtas, E., A., Gultekin, O., S., Uskup, C., (2022), *A case study for surgical mask production during the COVID-19 pandemic: continuous improvement with Kaizen and 5S applications*, International Journal of Lean Six Sigma, Vol. 14 No. 3, pp. 679-703.

Deshpande, S. P., Damle, V. V., Patel, M. L., Kholamkar, A. B. (2015). *Implementation of '5S' Technique in a manufacturing organization: A Case Study*, IJRET: International Journal of Research in Engineering and Technology, Vol. 4 No. 1, 136-148.

Dillon, A. P. & Shingo, S., (1985). *A Revolution in Manufacturing: The SMED System*, CRC Press.

Dixit, A., Routroy, S., Dubey, S. K., (2019). *An efficient drug warehouse operations: An application of 5S.* AIP Conference Proceedings 2200, 020005 (2019).

Ebueste, E., (2018). Implementation of 5S at a Survey Laboratory in Western Kentucky University, Dissertation, University of Western Kentucky, United States of America.

El-Sherbiny, N. A. K., Elsary, A. Y., Ibrahim, E., H., (2017), *Application of the 5S-KAIZEN Approach in Improving the Productivity and Quality of the Healthcare System: An Operational Research*, Patient Safety & Quality Improvement Journal, Vol 5 No 4, pp. 594-600.

Fam, S. F., Prastyo, D. D., Loh, S. L., Utami, S., & Yong, D. H. Y. (2018). *Total productive maintenance practices in manufacture of electronic components & boards industry in Malaysia*. Journal of Telecommunication, Electronic and Computer Engineering, Vol. 10 No. 2–8, 97–101.

Folinas, D.K., Fotiadis, T.A. and Coudounaris, D.N. (2017). Just-in-time theory: the panacea to the business success?, Int. J. Value Chain Management, Vol. 8, No. 2, pp.171–190.

Geijo, F., (2000) *Quality management in analytical R&D in the pharmaceutical industry: Building quality from GLP*. Accred Qual Assur (2000) 5:16–20 Q Springer-Verlag, Practitioner's report.

Godina, R., Pimentel, C., Silva, F. J. G., Matias, J. C. O., (2018). *A structural Literature Review of the Single Minute Exchange of Die: The Latest Trends*, Procedia Manufacturing, Vol. 17, pp. 783-790.

Goetsch, D. L., & Davis, S. (2016). *Quality management for organizational excellence*: *introduction to total Quality*, 8th ed., Pearson.

Gunawan, F., Fauzi, A., Worabay, E., Hafat, S., Nasution, Y., (2022). *Role of Kaizen work culture as moderating work quality and productivity improvement*, Dinasti International Journal of Management Science, Vol. 3 No 6, pp. 2686-5211.

Gutierrez, J., Santaolalla, A., Tercjak, A., Rojo, N., Encinas, D., Gommez-de-Balugera, Z., Gallastegui, G., (2020). *Creating a Green Chemistry Lab: Towards Sustainable Resource Management and Responsible Purchasing,* Sustainability, Vol 12, 8934.

Hammami, S., Hmida, F., Gharbi, H., Salah, A. B., Hamouda, C., (2022). *Implementation of the 5S-KAIZEN-TQM approach in a public hospital in Tunisia.* La Tunisie Medicale, Vol. 100 No. 07, pp. 503-513.

Hirano, H. (1995). *5 pillars of the visual workplace: The sourcebook for 5S implementation*. New York: Productivity Press.

Ho, S. K., & Cicmil, S. (1996). *Japanese 5-S practice*. The TQM Magazine, 1, 45-53.

Hyland, P. W., Milia, L. D., Terry, R. S., (2004). *CI Tools and Technique: Are There any Difference Between Firms?*, Proceedings 5th CINet Conference, Sydney, Australia.

International Council for Harmonization, Q10, Section 3.1.3 Commercial Manufacturing.

introduction to total Quality, 18th ed., Pearson.

Irwansyah, D., Harahap, M. R. F., Erliana, C. I., Abdullah, D., Sari, A., Siregar, N., Achmaddaengs, G. S., Indahingwati, A., Sumartono, E., Wilujeng, S., Nurmawati, Subekti, P., Kurniasih, N., Rosalina, F., & Hartono, H. (2019). *Improvement Suggestion Performance of Blowing Machine Line 4 with Total Productive Maintenance (TPM) Method at PT. Coca-Cola Amatil Indonesia MedanUnit*. Journal of Physics: Conference Series, 1361(1).

Islam, S., Samad, M., Islam, T., (2018). *Implement Kaizen Tool 5S to Improve Workplace Condition and Pave Way for Lean Management at a Selected Pharmaceutical Factory,* International Conference on Engineering Research and Education School of Applied sciences & Technology, SUST, Sylhet.

Jaca, C., Viles, E., Paipa-Galeano, L., Santos, J., & Mateo, R. (2014). *Learning 5S principles from Japanese best practitioners: case studies of five manufacturing companies*. International Journal of Production Research, 52(15), 4574-4586.

Jagusiak-Kocik, M. (2017). *PDCA cycle as a part of continuous improvement in the production – a case study.* Production Engineering Archives, Vol. 14, pp. 19-22.

Jimenez, M., Romero, L., Dominguez, M., & Del Mar Espinosa, M., (2015). *5S methodology implementation in the laboratories of an industrial engineering university school*. Safety Science, 78, 163-172.

Jimenez, M., Romero, L., Del Mar Espinosa, M. & Dominguez, M., (2019). *Extension of the Lean 5S Methodology to 6S with An Additional Layer to Ensure Occupational Safety and Health Levels*, Sustainability, 11, 3827.

Jonet, P. M. D., (2014). *Process improvement in Pharmaceutical Industry through Kaizen Lean Methodology*, Kaizen Institute.

Kanamori, S., Shibanuma, A., & Jimba, M. (2016). *Applicability of the 5S management method for quality improvement in healthcare facilities: A review*. Tropical Medicine and Health, Vol. 44 No.21, 1-8.

Karam, A., Liviu, M., Christina V., Radu, H., (2018). *The contribution of lean manufacturing tools to changeover time decrease in the pharmaceutical industry. A SMED project.* Procedia Manufacturing, Vol. 22, pp. 886-892.

Karvounis, D., (2021). *Lean Application: An assessment of 5S on employee attitudes and productivity*, Dissertation, Faculty of Old Dominion University.

Khumalo, V. L. V., (2019). *Implementation and Effectiveness of 5S in a Mechanical Workshop – A Case Study.* Dissertation, University of Johannesburg.

Kobayashi, K., Fisher, R., & K. Gapp, R., (2008). *Implementing 5S within a Japanese context: an integrated management system*. Management Decision, Vol. 46 No. 4, pp. 565-579.

Koromyslova, E., Steinlicht, C., Hall, T. J., Yordanova, A. Y., Garry, B. G., (2018). *Implementing Lean Practices in an Academic Department: A Case Study*, Paper presented at 2018 ASEE Annual Conference & Exposition , Salt Lake City, Utah

Kotvitska, A., Lebedynets, V., Karamavrova, T., (2019). *The PDCA cycle implementation at the internal audit process of quality management systems of pharmaceutical companies.* The Pharma Innovation Journal, Vol 2. No. 2, pp. 709-713.

Lestari, D. A., Subroto, A., (2022). *Performance Efficiency of Quality Control Laboratory Through Implementation of Lean Operation.* Journal of Management an Entrepreneurship, Vol. 24 No. 1, pp. 64-72.

Lokunarangodage, C. V., Wickramasinghe, I., & Ranaweera, K. K. (2015). *Effectiveness of 5S application in tea industry and synchronization of 5S into ISO22000:2005*. Journal of Tea Science Research, Vol. 5 No.6, pp. 1-14.

Luthra, S., Garg, D., Agarwal, A., Mangla, K. S., (2021). T*otal Quality Management (TQM) Principles, Methods and Applications*, CRC Press.

Macpherson, G. W., Lockhart, C. J., Kavan, H., Laquinto, A., (2015). *Kaizen: a Japanese philosophy and system for business excellence*, Journal of Business Strategy, Vol. 36 No. 5, pp 3-9.

Mallick, A., Kaur, A., Patra, M., (2013). *Implementation of 5S in Pharmaceutical Laboratory.* International Journal of Pharmaceutical Research and Bio-Science, Vol 13 No 1, pp. 96-103.

Mazumder, B., Bhattacharya, S., & Yadav, A. (2011). *Total Quality Management in Pharmaceuticals: A Review*, International Journal of PharmTech Research, Vol. 3 No.1, pp. 365-375.

Mekonnen, E., (2017). *Assessment of Kaizen implementation practices and challenges in the case of Tikur Abbay shoe share company*, Dissertation, St. Mary's University, School of Gratuate Studies.

Menezes, S.T., Kamath, G.B. and Prasad, H.C.S. (2020). *Implementation of '6S' practices adapted for an electrical assembly line*, Int. J. Productivity and Quality Management, Vol. 29, No. 2, pp.250–267.

Michalska, J., Szewieczek, D., (2007). *The 5S methodology as a tool for improving the organization*, Journal of Achievements in Materials and Manufacturing Engineering, Vol. 24 No 2.

Moica, S., Veres, C., Marian, L., Al-Akel, K., (2018). *Case Study Concerning 5S Method Impact in an Automotive Company*, Procedia Manufacturing, Vol. 22, (2018), pp. 900–905.

Nino, V., Claudio, D., Valladares, L., Harris, S., (2020). *An Enhanced Kaizen Event in a Sterile Processing Department of a Rural Hospital: A Case Study.* International Journal of Enviromental Research and Public Health, Vol. 17, 8748.

Nishal, M., Ramprasad, K., Theja, A. J. A., Saravanan, S. A., & Abishek, S. (2018). *Need for Total Productive Maintenance in SME and barriers in implementing TPM in SME*, International Journal of Mechanical and Production Engineering, Vol. 6, pp.15–20.

Oakland, J. S. (2014). *Total Quality Management and Operational Excellence*, 4th ed., Routledge.

Osada, T. (1989). *5S- Handmade management technique*. Tokyo: Japan Plant Maintenance.

Osada, T. (1991). *The 5S's: Five keys to a total quality environment*, (6th ed.). Hong Kong: Asian Productivity Organization

Palmer, V. S., (2001). *Inventory Management Kaizen*, Proceedings of 2nd International Workshop on Engineering Management for Applied Technology, pp. 55-56, Austin, USA.

Park, H. S., (2003). *Six Sigma for Quality and Productivity Promotion*, Asian Productivity Organization.

Patel, V. C., & Thakkar, H. (2014). *Review of 5S in various organization*. International Journal of Engineering Research and Applications, 4(3), 774-779.

Patel, V. C., & Thakkar, H. (2014). *Review of 5S in various organization*. International Journal of Engineering Research and Applications, Vol. 4 No.3, 774-779.

PourAsiabi H., PourAsiabi H., (2012). *Just In Time production and supply chain management*, International Iron and Steel Symbosium, Karabuk, Turkey.

Prayuda, R. Z., (2020). *Continuous Improvement Through Kaizen In An Automotive Industry.* Journal of Industrial Engineering & Management Research, Vol. 1 No. 1.

Prosic, S., (2011). *Kaizen Management Philosophy*, 1st International Symposium Engineering Management and Competitiveness, Zrenjanin, Serbia.

Qin, S., Duan, X., Fatehallah Al-hourani, A., Alsaadi, N. (2022). *Evaluation of Total Quality Management in Turkish Pharmaceutical Companies: A Case Study*. Sustainability 2022, 14, 10181.

Qudah, A., (2012). *The impact of total quality management on competitive advantage of pharmaceutical manufacturing companies in Jordan*, Perspectives of Innovations, Economics & Business, Vol.12 No. 3.

Randhawa, J. S., & Ahuja, I. S. (2017). *5S implementation methodologies: literature review and directions*, International Journal of Productivity and Quality Management, 20(1), 48-74.

Raodah, W., Astutik, A., Aris, A., Bahri, S., (2019). *Quality Improvement Using PDCA Methodology in the Beverage Industry,* IOP Conference Materials Science and Engineering, 885 (2020) 012068.

Sallam, M., Allam, D., Kassem, R., (2024). *Improving Efficiency in Hospital Pharmacy Services: An Integrated Strategy Using the OCTAGON-P Framework and Lean 5S Management Practices,* Cureus, Vol. 16 No. 3.

Schwerha, D., Casey, A., & Loree, N. (2020). *Development of a system to integrate safety productivity and quality metrics for improved communication and solutions*. Safety Science, 129.

Setiawan, H., Purba, H., (2021). *A systematic Literature Review of Total Productive Maintenance on Industries*, Performa: Media Ilmiah Teknik Industri, Vol. 20 No. 2.

Shyam, M., (2011). *Implementing the SS Methodology for a Graphic Communications Management Laboratory of University of Wisconsin Stout*, Research Paper, Master of Science Degree in Technology Management, Vol. 4 No 4.

Singh, J. and Singh, H. (2015). *Continuous improvement philosophy–literature review and directions*, Benchmarking: An International Journal, Vol. 22 No. 1, pp. 75-119.

Srinivasan, G., Shah, N., (2018). *KAIZEN and Lean Implementation in Pharmaceutical Industries: A Review.* Asia Journal of Pharmaceutical and Clinical Research, Vol. 11 Issue 7.

Suarez-Barraza, M., Ramis-Pujol, J., Rstrada-Robles, M. (2012). *Applying Gemba-Kaizen in a multinational food company: a process innovation framework.* International Journal of Quality and Service Sciences, Vol. 4 No1, pp.27-50.

Sugiyama, H., Ito, M., Masahiko, H., (2015). *Process-based Method for Reducing Product Losses in Pharmaceutical Manufacturing.* 12th International Symposium on Process Systems Engineering and 25th European Symposium on Computer Aided Process Engineering, Copenhagen, Denmark.

Teshome, M., (2018). *The effect of Kaizen implementation on employees' affective attitude in textile company in Ethiopia*, World Academy of Science, Engineering and Technology International Journal of Industrial and Manufacturing Engineering, Vol. 12 No 9.

Todorovic, M. and Cupic, M., (2017). *How Does 5s Implementation Affect Company Performance? A Case Study Applied to a Subsidiary of a Rubber Goods Manufacturer from Serbia*, Engineering Economics, Vol. 28 No. 3, pp. 311–322.

Westcott, R., & Duffy, G. L. (2015). *The certified quality improvement associate handbook: Basic quality principles and practices*, 3rd ed., ASQ Quality Press.

Wickens, P. D., (1990). *Production Management: Japanese and British Approaches*, IEE Proceedings Science, Measurement and Technology, Vol. 137, No. 1, pp. 52-54.

Womack, J. P., Jones, D.T. and Ross, D. (1991). *The Machine that Changed the World: The Story of Lean Production*, Harper Collins, New York.

Woodcock, J., (2004). *The concept of pharmaceutical Quality*. American Pharmaceutical Review 7 (60), 10–15.

Zadry, H. R., Darwin, R., (2020). *The Success of 5S and PDCA Implementation in Increasing the Productivity of an SME in West Sumatra.* IOP Conf. Series: Materials Science and Engineering 1003 (2020) 012075.

Appendix A: "Questionnaire"

The combination of 5S and Kaizen principles as quality improvement methods and their implementation in pharmaceutical companies' laboratories.

Dear colleagues, my name is Charalampos Binellas and as a part of my M.Sc. thesis in Master in Business Administration program at Hellenic Open University, you are kindly invited to participate in this study by providing answers to the following questionnaire. It requires approximately 2 minutes to be completed, is anonymous, no personal information will be submitted and the data will be statistically processed.

Questions

1. The laboratory workspace is well organized

    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree

2. The laboratory workspace is clean

    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree

3. Drug samples, experimental materials and equipment are easy to spot

    - Strongly disagree
    - Disagree
    - Neutral
    - Agree
    - Strongly agree

4. Analytical instrumentation is ready to use for analysis

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

5. Open communication is encouraged among all members of the laboratory

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

6. Employees are involved in identifying working related problems

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

7. Work atmosphere and morale are high in the chemical laboratory

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

Author's Statement:

I hereby declare that, in accordance with article 8 of Law 1599/1986 and article 2.4.6 par. 3 of Law 1256/1982, this thesis/dissertation is solely a product of personal work and does not infringe any intellectual property rights of third parties and is not the product of a partial or total plagiarism, and the sources used are strictly limited to the bibliographic references.