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A case study on organizing a workspace using 5S Technique and LIFO Principle

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ABSTRACT

5S Technique is an important tool of Lean manufacturing being utilized worldwide in industrial and service sectors for workspace organization and management. This study successfully applied the 5S methodology alongside the Last-In-First-Out (LIFO) principle to organize a workspace in one of the storerooms of the engineering department of a university. The 5S approach (Sort, Set in Order, Shine, Standardize, and Sustain) was utilized to improve space utilization, reduce clutter, and enhance operational efficiency. The LIFO principle was implemented to manage inventory by ensuring the most recently added items were accessed first, preventing obsolescence. Root cause analysis and time study are the other tools utilized in this work. Notable improvements included a 37.4% reduction in retrieval time for frequently used materials and increased consistency in material handling, evidenced by a significant decrease in the coefficient of variation (CV) for retrieval times. The study contributes to practical demonstration of integrating 5S and LIFO in an academic setting, an area often looked in Lean Manufacturing studies. The findings highlight the importance of systematic workplace organisation in reducing waste, enhancing accessibility and fostering a culture of continuous improvement, offering actionable awareness for organisations seeking to optimize operation through lean tools.

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INTRODUCTION

In today's era of global competitiveness, organizations across various industries are making use of industrial engineering tools and techniques for enhancing efficiency and productivity, reducing abnormalities, risks, and wastes, and achieving safety and sustainability. One of the most widely recognized and effective methodologies for achieving these objectives is Lean Manufacturing. Originating from the Toyota Production System (TPS), Lean is a corporate strategy to eliminate non-value-adding activities (in other words wastes) and to propel for continuous improvement to enhance the quality of products and services (Silva & Ferreira, 2019; Vinodh, 2022). Lean principles have transcended their manufacturing origins and are now being applied across a wide array of sectors, including healthcare, finance, logistics, education, and office environments, illustrating their versatility and impact (Randhawa & Ahuja, 2017). One of the foundational techniques within Lean is the 5S methodology, a workplace organization technique that enhances efficiency, productivity, and safety by creating a clean and orderly work environment (Castaneda et al., 2022; Makwana & Patange, 2019). The five Japanese words: Seiri (Sort), Seiton (Set in Order), Seiso (Shine), Seiketsu (Standardize), and Shitsuke (Sustain), constitute 5S technique. Over time, 5S has emerged as a globally adopted standard for improving workspaces and processes, with proven benefits in various industries including service sectors. The 5S methodology offers numerous benefits that extend beyond mere tidiness by systematically organizing the workspace for greater efficiency and safety. First, the principle of Sort enables organizations to remove unnecessary items, focusing only on essential tools and materials, which leads to immediate time savings as employees no longer need to shift through clutter to find what they need (Singh et al., 2022). In the second step, Set in Order, ensures that everything has a designated place, reducing the time spent searching for items and preventing disruptions in workflow. In a well-ordered environment, everything from tools to paperwork is arranged logically for easy access. The third principle, Shine, emphasizes cleanliness, which is crucial for both safety and operational efficiency. Regular cleaning helps identify issues such as equipment wear or leaks, preventing accidents or breakdowns that could hinder productivity. Standardize involves establishing routines and setting standards to maintain this organized and clean state consistently, promoting discipline and ensuring long-term sustainability of improvements (Makwana & Patange, 2019). Finally, Sustain fosters a culture of continuous improvement for employees to adhere to established guidelines while seeking ways to enhance their work environment, thus creating a lasting system of efficiency (Randhawa & Ahuja, 2017). Together, these five principles reduce waste, optimize resources, and create safer, more efficient workspaces. The 5S methodology aligns directly with Lean's overarching goal of eliminating non-value-added activities, helping companies operate more efficiently at reduced costs (Deshmukh et al., 2022).

The relevance of the 5S methodology continues to grow, particularly as industries face increasing demands for higher productivity, cost-efficiency, and environmental sustainability (Marodin et al., 2017). In sectors such as manufacturing, the implementation of 5S has shown to improve workflow and reduce lead times, making it easier for companies to adapt to just-in-time (JIT) production systems (Kumar et al., 2022). In logistics, 5S helps streamline supply chain processes, ensuring that goods are stored, tracked, and dispatched more efficiently (Shinde & Ramdasi, 2021). Additionally, the growing focus on sustainability and environmental responsibility has led to the development of the 3S approach (Safety, Security, and Sustainability), which complements the 5S methodology by focusing on workplace safety and environmental impact.

Beyond manufacturing, Lean and the 5S methodology are widely applied in service industries, logistics, and healthcare (Davim, 2018; Silva & Ferreira, 2019). In hospitals, for instance, 5S is utilized to streamline operations, ensuring that medical tools and supplies are easy to locate, which improves response times and patient care (Randhawa & Ahuja, 2017). Studies in the healthcare industry, such as those conducted by Randhawa and Ahuja (2017), have demonstrated that applying Lean techniques, including 5S, significantly reduces errors, enhances patient outcomes, and increases staff satisfaction. In logistics and warehousing, 5S has been instrumental in optimizing inventory management, where tools, equipment, and goods can be systematically stored to prevent delays, misplacements, or damages (Makwana & Patange, 2019).

Last in first out 'LIFO' and first in and first out 'FIFO' are the two most important methodologies for inventory management (Sulaj, 2023; Tanaka and Respati, 2021). As per FIFO, the first product or stock received at a facility should go out or used first; whereas LIFO works exactly opposite in which the lastly received stock is used or processed first. Both methodologies have their inherent benefits and limitations. LIFO is useful to effectively organize the workspace when the focus is on new and/or the most frequently used items. The old or outdated stock with low frequency of usage and second priority can be placed after the new items. LIFO is preferable for quality sensitive products. LIFO requires careful management of inventory layers and foolproof record keeping. The risk of deterioration or damage of the old stock is involved in LIFO based inventory management. However, inventory of files, tools, and consumables etc. for offices and workshops can be better managed using LIFO. A goods distribution company implemented LIFO based inventory information system and achieved substantial improvement in inventory management efficiency (Saputra et al., 2023).

Educational institutions and research labs have also found value in adopting 5S principles to maintain order, particularly in spaces where various materials and equipment are used frequently. The methodology fosters a culture of discipline and organization, which can lead to improved efficiency in academic and research settings. This is especially important in environments that demand a high level of precision, such as scientific labs, where disorganization can lead to errors, contamination, or even safety hazards. A study by Vijayanand and Vaddi (2024) reported 5S implementation in a machine shop of an engineering college with achieving more than 80% decrease in chances of machine failure and tool search time. A case study conducted by Mukoma et al. (2023), highlighted the impact of 5S implementation to significantly reduce the search time and increase the orderliness, cleanliness, and safety of a university workspace. The detailed assessment of the implementation effectiveness of 5S program in a school indicated a significant improvement in the form of clutter-free, incredibly clean, and well-organized classrooms; and more knowledgeable and responsible teachers for 5S sustenance (Nerona, 2022). In a pharmaceutical laboratory of a university, after implementing 5S under a lean occupational health and safety strategy, impropriety in the storage of chemicals was significantly eliminated and waste was optimally regulated, that led to a safer chemical storage and laboratory environment (Ulu and Birgun, 2024). In a university machining shop, integrated 5S and systematic layout planning, eliminated unnecessary motion related waste by effectively arranging machine tools (Dubey and Gupta, 2023). The process efficiency was also improved more than 20%.

Lack of training and leadership involvement, and lack of interest and motivation to adopt and maintain 5S culture, are some of the challenges required to be overcome for successful implementation of 5S. Especially in educational settings such as universities, libraries, schools, laboratories, and workshops, the main reasons behind lack of involvement and failure to maintain the 5S implementation are two folds: primary focus and task of the main users i.e. technicians, staff, and faculties, is different than implementing and maintaining 5S; and educational facilities are tend to be frequently visited and utilized by different new users such as students, visitors, maintenance personnels, and other stakeholders.

After reviewing the literature on 5S implementation in educational setups and facilities, it was concluded that sincere future attempts are still required, especially using LIFO principle under 5S implementation, for improved inventory management, waste reduction, and efficiency enhancement.

With an intention to fill that gap, the present study combines four methods: 5S methodology, time study, LIFO principles, and Root Cause Analysis (RCA) to resolve the problems related to abnormalities of an unorganized workspace which is an important facility i.e. storeroom of one of the departments in an international university. The primary goal of the 5S method in this work is to reduce waste and improve efficiency in the storeroom by organizing the workspace and ensuring that everything is in its proper place. The ongoing maintenance in the storeroom prompted to change arrangements from its typical messy and unsafe settings, for ease of accessibility, better inventory management, and improved efficiency and safety. The time study is conducted to compare the time required to find and store materials in the workspace before and after applying the 5S approach and LIFO principles, which focus on ensuring that newer inventory is used before older stock to minimize waste and optimize storage space. RCA is integrated into this approach to identify and address any underlying issues that may be causing inefficiencies or recurring problems in the storeroom operations. By combining these methods, the study aims to develop a more organized, efficient, and problem-free environment that not only optimizes the use of space and time but also ensures that any root causes of inefficiencies are effectively addressed to prevent their recurrence.

There were prominent reasons behind using LIFO instead of FIFO. The storeroom primarily stored module files, which needed to be accessed frequently for the most recent academic year and semester. By using LIFO, the newest files were placed in the front, ensuring they were retrieved first, while older files were moved to the back. This prevented the unnecessary build-up of outdated materials. The other reason was to reduce misplacement of items proper labeling and systematic placement of module files based on LIFO ensured that older materials were less likely to be misplaced while keeping recent files readily accessible.

The key objectives of the present research work are as follows:

- To identify the root causes of inefficiencies in the storeroom using root cause analysis tools (i.e. Fishbone diagram).
- To implement the 5S technique and LIFO principle to organize the storeroom efficiently, ensuring optimal use of space and improving inventory management practices.
- To investigate the effects of the 5S methodology and LIFO principle on improving the accessibility and retrieval of frequently used materials in the storeroom.
- To assess the overall impact of the 5S and LIFO implementations on the organization and operational efficiency of the storeroom.

METHODOLOGY

This study uses a combined 5S and LIFO methodology to address the organization challenges for the storeroom considered in the present work. The primary objective of this methodology was to systematically optimize space, improve retrieval times, and ensure the efficient handling of frequently used items. The 5S approach (Sort, Set in Order, Shine, Standardize, and Sustain) was implemented at each step to create a structured, clutter-free environment, while the LIFO principle facilitated inventory management by prioritizing the use of newer items first. Through the integration of these methods, the study aimed to achieve improved organization, reduced time wastage, and better storage practices in the storeroom setting. Figure 1 illustrates the full methodology applied, with each step discussed in detail below.

Study Setting

The study was conducted in a workspace which is an important facility of one of the departments in an international university. The work area was facing challenges due to disorganization and underutilized space. The study was undertaken in the reception store area, where observations were carried out to assess the flow and accessibility of stored items, and discussions were held with employees to gather insights into the current storeroom operations and how it could be improved, along with any identified obstacles in retrieving frequently used items. The storeroom was operating below ideal efficiency, with clutter and misplacement of items hindering smooth operations. It was expected after implementing 5S and LIFO, that the storeroom can improve its efficiency, reduce wastes, and improve overall productivity of the operations.

Sampling Methods and Data Collection

Purposeful sampling was used to collect data targeting the specific participants directly involved in the engineering department storeroom operations. This sampling method was chosen because it allows for the selection of individuals who are most knowledgeable about the storeroom's operations and who frequently interact with the stored items. The sample included employees responsible for material handling, inventory management, and daily operations in the storeroom. By focusing on these key participants, the study ensured that the data collected were relevant and representative of the storeroom's operational challenges. A combination of observation studies and structured interviews were used to gain deeper insights into their experience and to identify specific challenges in the current system. Initial observations were conducted to assess the existing storeroom organization and workflow, documenting challenges such as item retrieval times, congestion and disorganisation. Time study was conducted after the observation using a stopwatch, retrieval times for commonly accessed items were recorded before and after Implementing 5S and LIFO principles to measure changes efficiency. A total of 5 employees participated in the time study, this included employees who frequently interact with the stored items. Each employee was tasked to retrieve the same set of 4 frequently used items during the time study. The retrieval tasks were repeated five times for each item within the 5 consecutive days with each employee performing the task under the same conditions.

A total of 20 trials for frequently used items were selected for the time study including module files, printer papers, paper clips and sticky notes etc. enlisted in Tables further. These items were chosen based on their daily usage and importance to the storeroom's operations. For each item, five trials were conducted over five consecutive days to ensure consistency and reliability in the measurements. The setting of the workplace was kept identical across all trials, including the second day of retrieval. This repetition helped control for variability in retrieval times due to external factors such as employee fatigue and temporary disorganisation. A stopwatch was used to record the time taken by employees to retrieve each item. The same employee was tasked with retrieving the same item across all trials to minimize variability caused by differences in individual efficiency. The retrieval process was observed and timed from the moment the employee began searching for the item until it was successfully retrieved.

The retrieval times for each item were recorded in minutes. The mean retrieval time, standard deviation, and coefficient of variation were calculated for each item to assess variability and consistency in retrieval times.

Data analysis was conducted by recording the times it takes to retrieve frequently used materials in the existing unorganized setup. This served as a control measure to compare against post implementation times. Thereafter coefficient of variation was calculated for each retrieval times to measure variability, giving insights into the inconsistency and inefficiency in the initial setup.

After conducting preliminary time study, Fishbone diagram was employed as a central tool in root cause analysis. As illustrated in Fig. 2, the diagram helped to outline the challenges they face while managing inventory and maintaining order. The data collected was used to evaluate the impact of implementing the 5S methodology and the LIFO principle on the storeroom's organization and operational efficiency. We employed this diagram to fully understand the extent of the problem from the data gathered through direct observation of the area operation. The collection of the data helped to identify the main symptoms of the issues experienced in the reception store area. The problem was found that the storeroom lacked an organized system for storing and retrieving items, which led to inefficiency, waste, and difficulty in locating items when required. Figure 3 presents the pictures of the workspace under consideration, before implementation of 5S and LIFO.

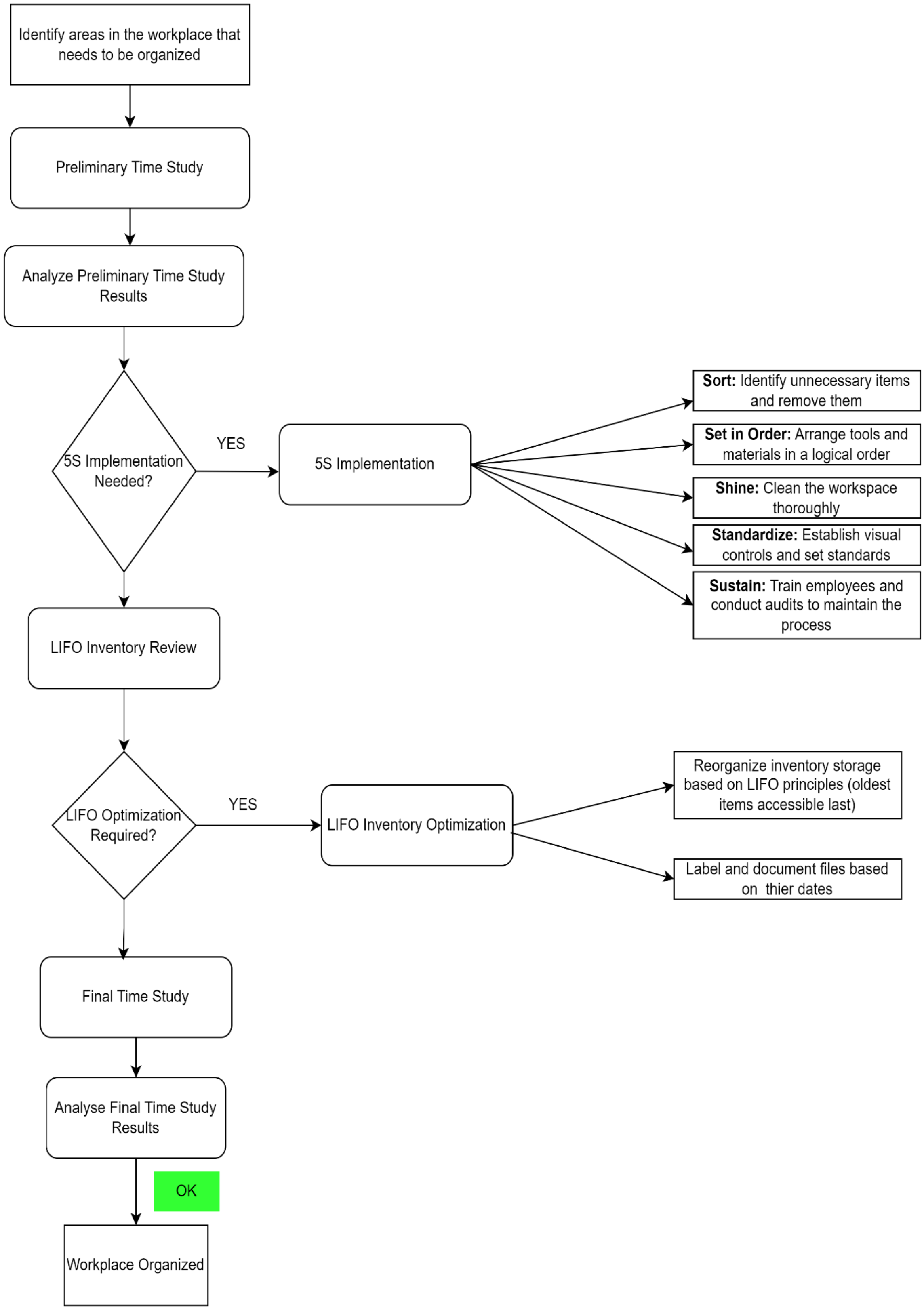

Fig. 1. Overall methodology of 5S and LIFO Implementation adopted in the present work.

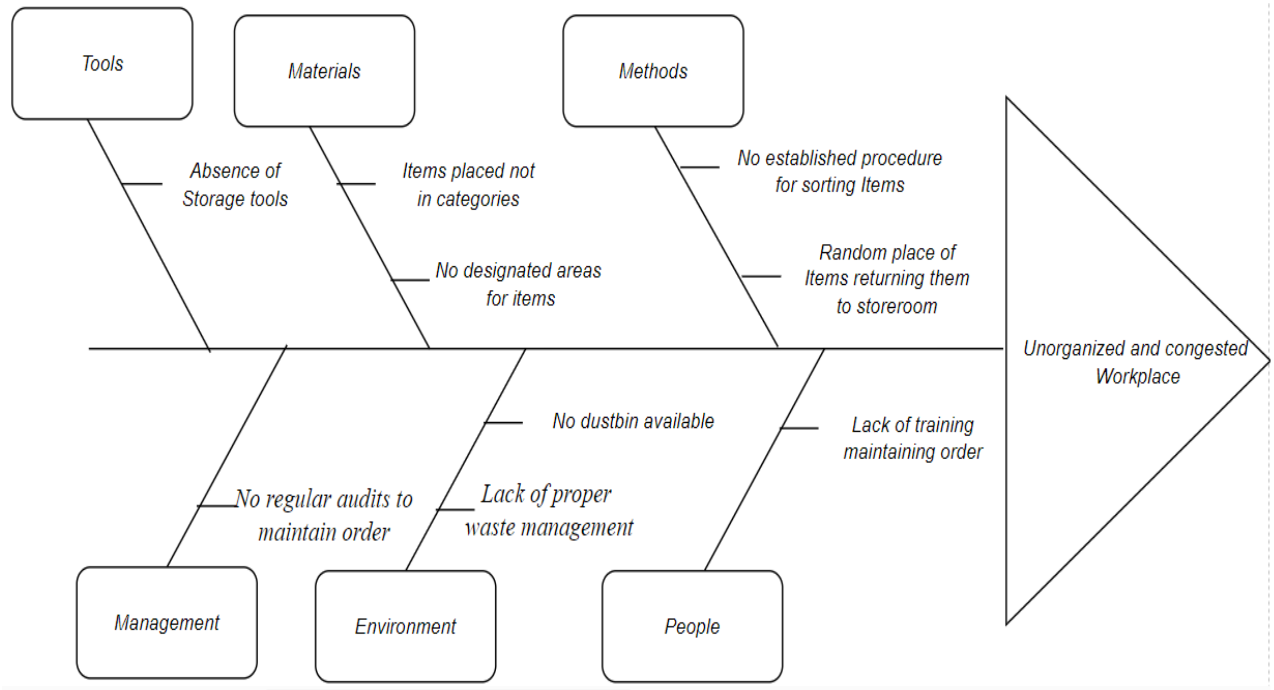

Fig. 2. Fishbone Diagram for root cause analysis in the present work.

Fig. 3. Before Implementation of 5S and LIFO principles.

RESULTS AND DISCUSSION

Table 1 shows a detailed assessment of various office items, categorizing them based on their necessity, the degree of that necessity, and the frequency with which they are required. The items were evaluated to determine whether they are essential for daily operations and how critical their presence is in the workplace. Table 1 uses a scoring system ranging from 0 to 10 to quantify the importance of each item, with 10 indicating a critical necessity. The frequency of use daily, weekly, monthly, or not at all was noted to provide a clear understanding of how often each item is needed. Through evaluation it clearly indicated that stationery, printer paper, files, sticky notes, and staplers emerge as the most essential items, all with high necessity scores and daily usage requirements.

Table 1. Various office items

Items	Necessary	How necessary?	Required
Boxes	No	0	None
Stationery	Yes	7	Daily
Notepads	Yes	5	Weekly
Paper Clips	Yes	5	Weekly
Staplers and Staples	Yes	9	Daily
Sticky Notes	Yes	7	Daily
Folders	Yes	6	Monthly
Printer Paper	Yes	8	Daily
Files	Yes	10	Daily
Polymers	No	0	None
Extra keyboards	No	0	None
Papers	No	0	None

Table 2. Observation of time before Implementation of 5S and LIFO principle

Items	Day 1 (mins)	Day 2 (mins)	Day 3 (mins)	Day 4 (mins)	Day 5 (mins)	Mean (μ)	Std dev (σ)	CV
Modules Files	2.9	3.7	4.5	3.2	4.0	3.66	0.635	0.173
Printer Papers	3.0	4.1	4.8	3.3	4.3	3.90	0.738	0.189
Paper Clips	2.9	3.8	4.6	3.1	4.2	3.72	0.719	0.193
Sticky Notes	3.1	3.9	4.7	3.4	4.4	3.90	0.667	0.171

In the second step i.e. preliminary time study, a stopwatch was used to record the time each employee was taking to retrieve frequently used materials for 5 days with the unorganized setup. The time recorded for the preliminary phase are given in Table 2. The parameter coefficient of variation (CV) was calculated to measure the relative variability in the time taken for each observation across different office materials. The standard deviation σ and coefficient of variation CV were computed using equation 1 and equation 2 respectively. The below calculations show these parameters for module files.

$$\sigma = \sqrt{\frac{\sum(x_i - \mu)}{n-1}} = \sqrt{\frac{sum\ (Time\ each\ day - Mean)}{number\ of\ days - 1}} \tag{1}$$

$$\sigma = \sqrt{\frac{(2.9-3.66)^2 + (3.7-3.66)^2 + (4.5-3.66)^2 + (3.2-3.66)^2 + (4-3.66)^2}{5-1}}$$

$$\sigma = 0.635$$

$$CV = \frac{\sigma}{\mu} = \frac{Standard\ Deviation}{Mean(average\ times)} \tag{2}$$

$$CV = \frac{0.635}{3.66} = 0.173$$

Items like module files and sticky notes exhibited the lowest CV (0.173 and 0.171), which indicated that the time taken to retrieve or manage them was relatively consistent and predictable across different days. This suggested that the materials are partially well organized and easy to access, with minimal fluctuations in retrieval time. However, paper clips and print papers had the highest CV (0.193 and 0.189), indicating a greater variability in the observation times. The variability pointed to potential inefficiencies in the storage and accessibility of module files, which led to delays and inconsistencies when they are needed. The coefficient variation of sticky notes was moderately low (0.171).

Seiri – "sort" Implementation

In this step, the storeroom items stored in the reception store area were systematically arranged by identifying necessary and unnecessary items. Figure 4 shows the arrangement of the items according to the nature of the use. Once all the items were categorized, unnecessary items that were no longer in use were removed from the storeroom, freeing up valuable space for more essential items.

Seiton – "set in order" Implementation

All the items in the storeroom were given a designated place for easy access and retrieval. The goal was to enhance the operation efficiency by minimizing the time employees spent searching for materials. The items were placed in a specific location based on their frequency of use and importance. The reorganization of the workplace allowed for more efficient use of the space as one of the employees was relocated to the storeroom, transforming it into dual-purpose area. Figure 5 shows how the storeroom was turned into an office.

Seiso – "Shine" Implementation

The storeroom was cleaned to create a well maintained and healthy environment. Cleaning materials such as brooms and vacuum cleaners were used to clean the workplace. The cabinets were cleaned as well and are shown in Figure 6.

The cleaning improved the visual appeal of the storeroom also improved the hygiene and safety standards. This stage was completed by Implementing a structured cleaning routine, ensuring that the storeroom would remain in a clean and orderly state going forward.

Seiketsu – "standardize" Implementation

We ensured that all the necessary items have specific storage location and colourful labels were placed on each module files for name tagging, making it easier for employees to identify items quickly. The workplace was furnished with only essential items like dustbin, fridge, worktable and chair and arranged in an office like manner shown in Figure 5. We formalized the cleaning schedules and employees were trained on the importance of maintaining a cleanliness and order in the workplace.

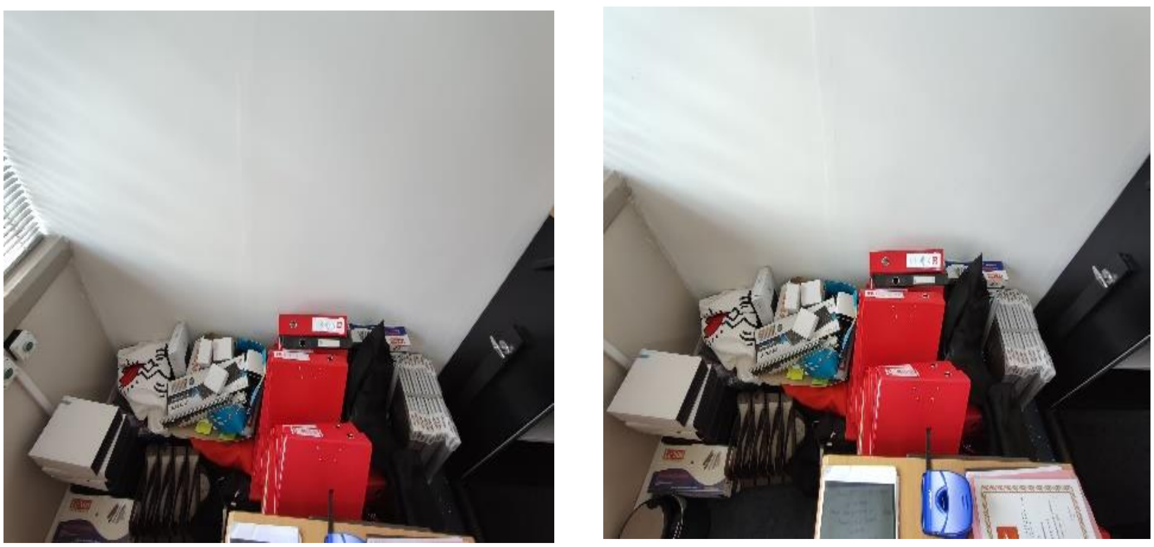

Fig. 4. Pictorial representation of items sorted.

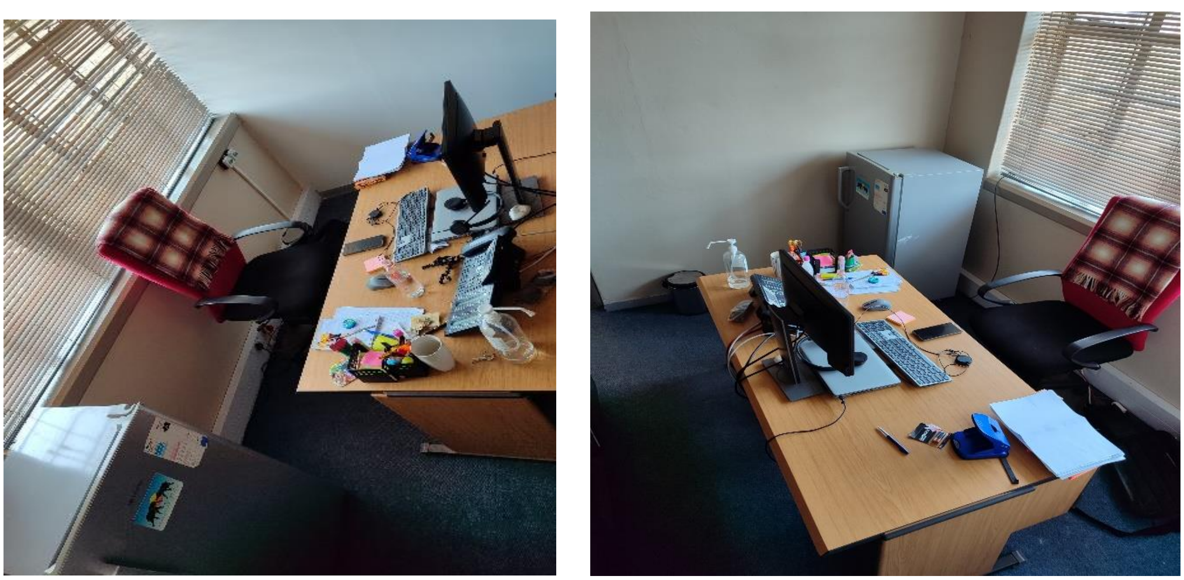

Fig. 5. Pictorial representation after Implementation of set in order.

Shitsuke – "sustain" Implementation

The employees were trained for 3 days on how to maintain an order in the workplace. It was ensured that employees after using the items stored in the cabinets, they place them back where they are supposed to be, avoiding the random placement of materials and improving operational efficiency. This phase ensured that the improvements achieved through the 5S Implementation became a lasting part of the workplace culture.

LIFO Implementation

The Last-In-First-Out (LIFO) was applied on the module files, were the recently added files typically from the most recent academic year and semester, were placed in front of the storage shelves. These files were now the first materials to be used when required. Older files were moved towards the back of the storage shelves to ensure they would only be accessed once the newer files had been used. This arrangement not only allowed for quick retrieval of the most recent files but also prevented the possibility of misplacing the files. Labelling played a crucial role in this system each file was marked with its respective year and semester, providing a clear indication of its "age" in the storeroom. Figure 7 shows how the files were arranged in the cabinets.

Fig. 6. Pictorial representation of cleaned shelves.

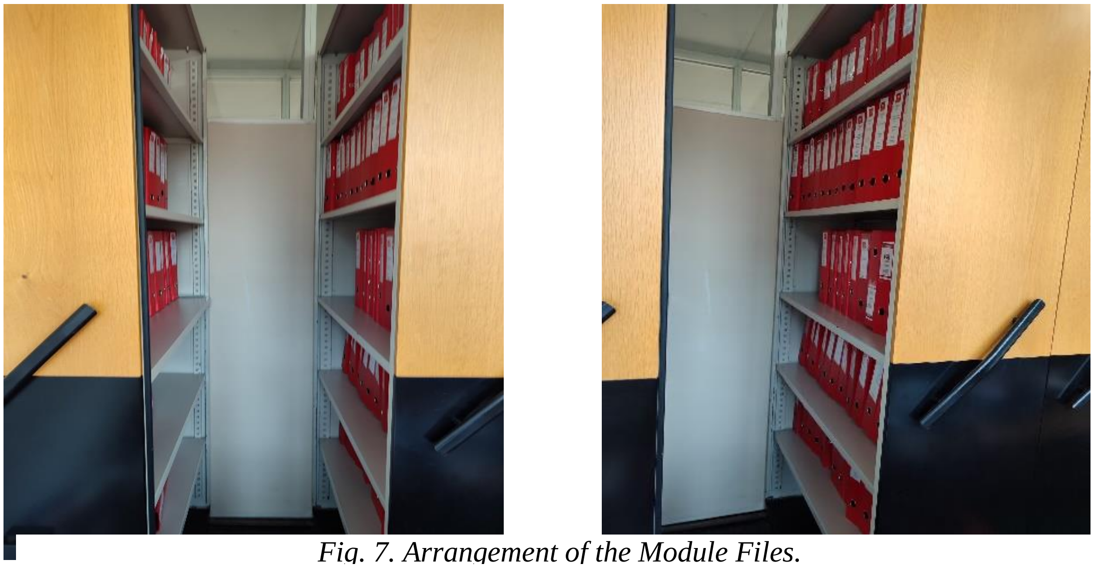

Fig. 7. Arrangement of the Module Files.

After implementing 5S and LIFO, the variability in retrieval times decreased significantly across all items. As indicated in Table 3 and Fig. 8:

- The CV for module files dropped from 0.173 to 0.047, indicating an 72.8% improvement in consistency.
- Sticky notes showed the most consistent performance, with their CV decreasing from 0.171 to 0.019, an 88.9% improvement.
- Printer papers and paper clips also saw notable improvements, with CVs decreasing from 0.189 to 0.024 (87.3% improvement) and 0.193 to 0.029, respectively.

The initial observations indicated that some employees required time to familiarize themselves with the reorganized storeroom. To support employee adaptation, training sessions were conducted over three days to ensure that all staff understood the new organization system and the importance of maintaining it. This proactive approach helped minimize resistance and ensured a smoother transition. After a brief training period, employees reported increased satisfaction with the new system, citing easier access to materials and reduced frustration during retrieval tasks.

Table 3. Observation of time after Implementation of 5S and LIFO principle

Item	Day 1(min)	Day 2(min)	Day 3(min)	Day 4(min)	Day 5(min)	Mean(μ)	Improved Std Dev(s)	CV
Modules Files	2.50	2.65	2.70	2.40	2.55	2.56	0.119	0.047
Printer Papers	2.70	2.80	2.70	2.75	2.85	2.76	0.065	0.024
Paper Clips	1.90	2.00	2.05	1.95	2.00	1.98	0.057	0.029
Sticky Notes	2.20	2.25	2.15	2.20	2.25	2.21	0.042	0.019

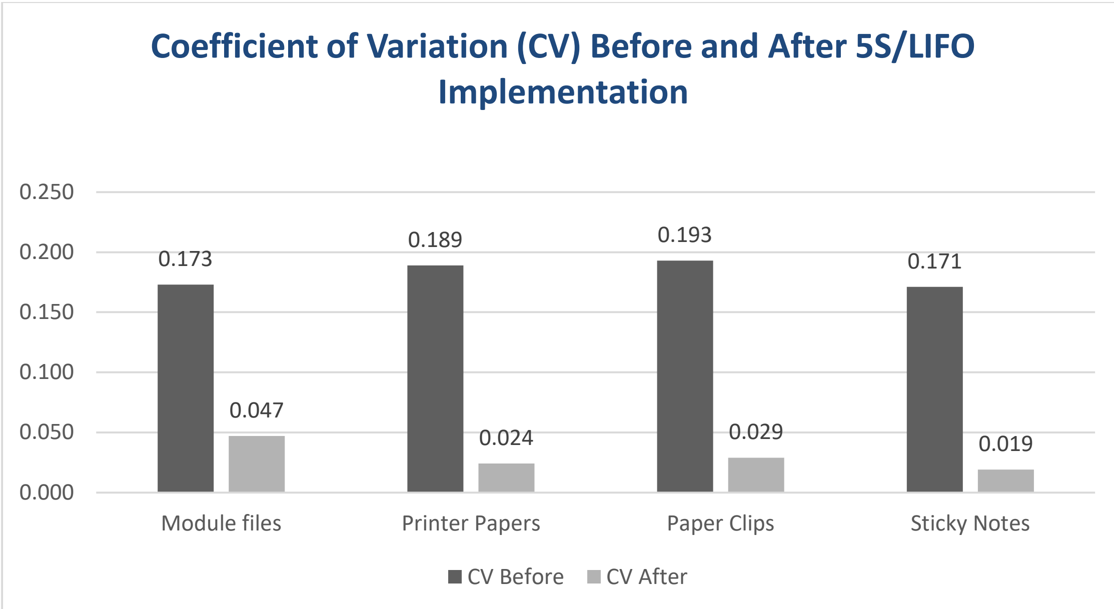

Fig. 8. Coefficient of Variation (CV) Before and After 5S/LIFO Implementation.

CONCLUSION

This article has presented a case study of resolving workspace abnormalities using a combination of 5S and LIFO principles. The following conclusions are drawn:

- Successfully implemented the 5S methodology and LIFO principles to enhance the organization and efficiency of the storeroom.
- The waste was successfully removed from the store area and the practical benefits of 5S and LIFO for inventory management were highlighted, with potential for wider application in similar settings.
- The coefficient of variation of frequently used materials in the store area has been significantly reduced by 72.8 %, i.e. for module files it was 0.173 before and 0.047 after the 5S and LIFO implementation.
- The implementation ensured that space was utilized by moving one of the employees to the storeroom, transforming it into dual-purpose area.
- Material retrieval times were significantly minimized by 37.4%, making item access faster and more predictable.

The effectiveness 5S and LIFO principles can further be extended to other storage and inventory areas to improve efficiency and production. Since the focus of the present study was limited to the engineering department reception storage area, future initiatives could include the following:

- Maintaining the 5S and LIFO principles in the storeroom to ensure high levels of organisation and efficiency, with the possibility of transferring these practices to additional storage locations and departments.
- Adopting a more comprehensive Lean approach to improve inventory management in other university departments or comparable environments.
- Identifying and tackling further inefficiencies and waste sources in linked areas using a 5S, Lean, and continuous improvement approach.

RECOMMENDATIONS

To ensure the long-term sustainability of these improvements and to build on the findings of this study, the following recommendations are made:

- Conducting monthly audits to ensure that the 5S principles are being maintained and that items are returned to their designated locations.
- Conducting periodic training programs for employees to maintain the 5S and LIFO principles implemented.
- Using visual cues, such as color-coded labels and floor markings, to make it easier for employees to maintain order and quickly locate items.
- Using structured product labelling system to ensure employees return items to their designated locations, as the random placement of materials could undermine the system's efficiency over time.

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