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Improving Inventory Management Efficiency Through the Reduction of Stock Discrepancies Using a Lean-6S Framework Based on the DMAIC Method

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digital 6s, stock discrepancy, dmaic, inventory management, safety.

Abstract
Effective inventory management is a critical factor in ensuring operational continuity and efficiency in manufacturing companies. However, many organizations still experience inventory inaccuracies caused by stock discrepancies, improper material placement, inadequate storage standards, and ineffective control systems. This study aims to improve inventory management efficiency by implementing a digitized 6S framework integrated with the DMAIC (Define, Measure, Analyze, Improve, Control) method to reduce stock discrepancies in a printer manufacturing company in Indonesia. The research employed a quantitative approach supported by qualitative descriptive analysis using a case study design. Data were collected through direct observation, interviews, documentation analysis, 6S audits, stock discrepancy measurements, material search time assessments, and safety condition evaluations. The results showed that the implementation of digitized 6S successfully reduced average stock discrepancies from 35.53% to 29.70% and increased inventory accuracy from 64.5% to 70.3%. Furthermore, material search time decreased from 150 minutes to 60 minutes, misplacement cases declined from 56 to 23 cases, and unsafe condition findings decreased from 19 to 6 findings. These findings indicate that the integration of digital control systems, workplace standardization, and lean improvement practices can enhance inventory accuracy, operational efficiency, and warehouse safety. In conclusion, digitized 6S based on DMAIC provides an effective and sustainable approach for reducing stock discrepancies and improving inventory management performance in manufacturing environments.

INTRODUCTION

In the era of globalization and increasingly competitive market dynamics, manufacturing companies are required to improve efficiency, productivity, and accuracy to consistently meet customer demands (Omogbai & Salonitis, 2017). One of the key factors determining operational success is effective and efficient inventory management, as inventory serves as a buffer to ensure production continuity and represents a significant cost component. Inventory management in manufacturing companies involves planning, procurement, receiving, storage, utilization, control, and inventory record management to ensure that materials are available in the right quantities, at the right time, and in the right locations (Brownlow, 2022; Seredyuk, 2024). Inaccuracies in inventory management not only increase operational costs but can also reduce process reliability and hinder the achievement of production targets (Alsoussi & Tahboub, 2025; Sudarmi & Sunaryo, 2024).

Although many companies have implemented inventory management systems, such as Enterprise Resource Planning (ERP), Warehouse Management Systems (WMS), receiving procedures, and periodic stocktaking, their effectiveness at the operational level is not always optimal. Common challenges include weak inventory control, inadequate warehouse work processes, and limited visibility regarding the status, location, and condition of goods (Buzu, 2021; Ghapar et al., 2024). When warehouse activities are not properly organized and standardized, the risks of misplacement, incorrect identification, transaction delays, and discrepancies between physical records and system data increase (Pawlak et al., 2023; Richards, 2017). These issues may result in overstock or stockouts, unnecessary storage costs, increased rework, and disruptions to production processes (Shahriar et al., 2022).

This problem was experienced by one of the printer manufacturing companies in Indonesia (Sariani et al., 2023; Suhariyono et al., 2021). The printer industry is characterized by high component complexity, a wide variety of parts, and strict delivery requirements to maintain production continuity; therefore, inventory data accuracy is critical (Mulyana et al., 2022; Rahardjo et al., 2025). Although an inventory management system has been implemented, discrepancies between physical stock and system records are still identified during inventory activities. One of the main causes of stock discrepancies is material misplacement, which refers to the storage of parts in locations that do not comply with the designated storage system. This issue occurs due to unclear location labeling, layouts that do not support workflow efficiency, inconsistent storage standards, and insufficient operator discipline in following storage procedures.

The operational impact of warehouse misplacement and irregularities creates waste from a lean manufacturing perspective, particularly in terms of unnecessary motion and waiting time. Operators spend additional time searching for misplaced parts, moving between storage areas, and performing repeated verification processes, which in the worst cases can take up to 2.5 hours per incident. In addition to operational impacts, inventory inaccuracies also generate financial consequences through false shortages and false overstock conditions. These situations can lead to production stoppages when required components are unavailable, trigger emergency procurement activities with higher costs, extend lead times, and potentially affect supplier quality performance.

Beyond causing production line interruptions, stock discrepancy incidents also lead to repeated emergency material procurement during certain periods and reduce the performance of on-time delivery to customers, although the delivery performance level remains relatively maintained above 99%. This condition confirms that warehouse issues are not merely related to housekeeping practices but are directly associated with cost efficiency, customer service performance, and production continuity.

To address these problems, a corrective approach is required to improve warehouse performance and ensure that operational standards are implemented consistently. The 6S methodology in lean manufacturing—Seiri (Sort), Seiton (Set in Order), Seiso (Shine), Seiketsu (Standardize), Shitsuke (Sustain), and Safety—serves as an important foundation for establishing an organized, safe, and controllable workplace. However, in practice, 6S implementation often encounters sustainability challenges because manual audits tend to be subjective, lack real-time monitoring capabilities, have limited documentation, and make it difficult to track compliance trends over time. Based on these needs, this study proposes the development of a digital 6S audit system to ensure consistency in 6S implementation while improving real-time visibility of warehouse conditions. This system is integrated with the lean manufacturing framework through the DMAIC (Define–Measure–Analyze–Improve–Control) approach, which is suitable for addressing complex and repetitive operational problems, particularly when the root causes are influenced not only by technical factors but also by human behavior, process variation, and weak standard controls.

Previous studies have demonstrated that the implementation of 5S methodology can improve workplace organization, reduce search time, shorten process duration, and enhance operational efficiency. However, most existing studies still focus on conventional 5S implementation, with limited emphasis on integrating safety aspects explicitly through the Lean-6S framework. Furthermore, many studies have not incorporated systematic improvement methodologies such as DMAIC to address operational problems comprehensively. Although previous research has generally confirmed that 5S implementation positively affects work efficiency and workplace conditions, several limitations remain and provide opportunities for further investigation, including: (1) most studies continue to focus on conventional 5S without positioning the Safety element as an explicit and integrated component; (2) not all studies apply structured problem-solving frameworks such as DMAIC from the Define phase through the Control phase; and (3) many previous studies have been conducted in limited operational contexts, making their findings highly dependent on specific organizational conditions. Based on these research gaps, this study focuses on extending the conventional 5S approach into a 6S framework by incorporating Safety as a central improvement element and integrating it with the DMAIC method as a systematic framework for continuous improvement.

Formulation of Research Problems and Objectives

Based on the identified background and research gaps, the research problem addressed in this study is how to improve inventory management efficiency through digitized 6S implementation to reduce stock discrepancies. In line with this research problem, the main objective of this study is to design and develop a digitized 6S system capable of improving inventory management efficiency and reducing stock discrepancies in printer manufacturing companies (Agrahari et al., 2015). More specifically, this study aims to identify the current conditions of inventory management and the root causes of stock discrepancies, analyze weaknesses in the existing inventory management system, develop a 6S-based improvement design integrated with a digital system, and evaluate how the proposed system supports storage area organization, improves inventory data accuracy, accelerates recording and material search processes, and strengthens safety and work discipline aspects.

Inventory management is one of the critical operational aspects of manufacturing companies that plays an important role in maintaining production continuity. According to Heizer et al. (2017), inventory management refers to a set of policies and controls used to monitor inventory levels and determine the appropriate inventory quantity to be maintained, the timing of replenishment, and the optimal order size. Manufacturing companies generally manage several types of inventory, including raw materials, work-in-process inventory, finished goods, and auxiliary materials (Jacobs & Chase, 2018). Effective inventory management provides several benefits for companies, including the ability to meet customer demand promptly, reduce ordering and storage costs, and improve overall operational efficiency (Stevenson, 2012).

Stock discrepancy or inventory inaccuracy is defined as the difference between inventory records stored in an information system and the actual physical inventory available in the field. According to Fleisch and Tellkamp (2005), inventory inaccuracy can reach 30–40% in certain retail industries, while in manufacturing environments, the level varies depending on product complexity and the inventory management system applied. DeHoratius and Raman (2008) identified four primary categories of causes, namely transaction or recording errors, inventory loss due to shrinkage, inaccuracies in physical counting processes, and unrecorded product damage. Additional contributing factors include poor documentation discipline, unorganized storage areas, and inadequate tracking systems (Sahin & Dallery, 2009). Kang and Gershwin (2005) stated that inventory inaccuracies can result in incorrect production and procurement decisions, increased operational costs, reduced customer service levels, and decreased company profitability.

Lean manufacturing is a management philosophy that focuses on eliminating waste within production systems while maximizing value creation for customers. This philosophy originated from the Toyota Production System (TPS) developed by Toyota Motor Corporation. Ohno (1988) identified seven types of waste (muda) that should be eliminated: overproduction, waiting, transportation, overprocessing, excess inventory, unnecessary motion, and defects. Liker and Meier (2006) later added an eighth type of waste, namely underutilization of human talent. Various lean tools have been developed to support the implementation of this philosophy, including Value Stream Mapping (VSM), 5S/6S, Kanban, Kaizen, and Total Productive Maintenance (TPM).

The 5S methodology is one of the fundamental tools in lean manufacturing that originated in Japan and is widely applied to improve workplace efficiency, safety, and quality. The five elements of 5S consist of Seiri (Sort), Seiton (Set in Order), Seiso (Shine), Seiketsu (Standardize), and Shitsuke (Sustain). Although 5S implementation has proven effective, the addition of a sixth element, Safety, to form 6S is necessary based on the understanding that occupational safety is a fundamental aspect that must be explicitly integrated into continuous improvement systems rather than treated merely as an indirect outcome of 5S implementation. The primary difference between 5S and 6S lies in the explicit integration of safety as a separately planned, measured, and evaluated element supported by specific performance indicators, dedicated audits, and structured improvement programs.

Digitalization has become an essential trend in modern industrial environments, including inventory management systems. In this context, digitalization may involve the implementation of integrated information systems, automatic identification technologies such as barcodes or QR codes, real-time tracking systems, and Internet of Things (IoT) applications. Digitalization enables real-time visibility of inventory conditions, which is essential for fast and accurate decision-making. Therefore, integrating digital systems with improvement methodologies such as 6S can create strong synergies, where digital data provide objective information to support improvement decisions, while 6S establishes the organizational structure and discipline required to ensure effective system utilization.

DMAIC is an acronym for Define, Measure, Analyze, Improve, and Control, representing a structured methodology within the Six Sigma approach for process improvement

(Pyzdek & Keller, 2014). This methodology was developed at Motorola and later popularized by General Electric. The Define phase focuses on clearly identifying problems, project objectives, and customer requirements. The Measure phase evaluates current process performance using relevant metrics. The Analyze phase identifies root causes through tools such as Pareto charts, fishbone diagrams, and root cause analysis. The Improve phase involves implementing solutions designed to address identified root causes. Finally, the Control phase ensures that implemented improvements are sustained over the long term through updated standard operating procedures, monitoring systems, and continuous evaluation.

METHOD

This study used a quantitative approach supported by qualitative descriptive analysis and was designed as a case study conducted in the material warehouse area of a printer manufacturing company in Indonesia (Jiménez et al., 2015). The problem-solving framework applied was DMAIC (Define, Measure, Analyze, Improve, Control), which supported problem identification, initial condition measurement, root cause analysis, improvement proposal development, and continuous monitoring of improvement outcomes. The research objects included material storage areas, inventory recording systems, and personnel involved in stock management activities, such as warehouse operators, warehouse administrators, and related staff. The study focused on storage area organization, inventory accuracy, material recording and transaction processes, storage location compliance, 6S implementation, and workplace safety aspects. The research did not cover procurement optimization or material demand forecasting analysis.

Data Collection Sources and Techniques

The data sources in this study consist of primary data and secondary data that are used in a complementary manner. Primary data was obtained directly from the field through observation of the condition of the inventory area, interviews with warehouse operators, stock admins and supervisors, and filling out checklists or auditing the condition of the storage area. Secondary data is obtained from company documents such as stock data, stock discrepancy reports, stock taking data, standard operating procedures, storage area layout, and supporting scientific literature. The data collection technique is carried out in five ways, namely: (1) direct observation of material storage conditions, the flow of goods movement and the application of 6S; (2) interviews with parties directly involved in inventory activities; (3) documentation of stock data, stock difference reports, operational procedures and photos of area conditions; (4) 6S checklist/audit of the elements of sort, set in order, shine, standardize, sustain, and safety; and (5) stock discrepancy measurement by comparing system stock data and actual physical stock conditions in a certain period.

DMAIC-Based Research Procedures

In the Define stage, the researcher identifies the main problems in inventory management, namely stock discrepancy, establishes the focus and scope of the research, and identifies the data needs for the next stage. The Measure Stage was carried out to collect preliminary data describing existing conditions, including stock discrepancy figures, storage conditions, material search time, procedural compliance, and the results of the initial 6S audit, which were used as a baseline in assessing the effectiveness of repairs. The Analyze stage was carried out to identify the root cause of stock discrepancy using a fishbone diagram with a 6M category (Man, Method, Material, Machine/System, Measurement, Environment) followed by a 5 Why analysis in each category, as well as a Pareto chart to determine the priority of the dominant causes.

The Improve stage prepares a draft improvement proposal in the form of a digitized 6S system, including rearrangement of storage areas, material grouping, label standardization, use of barcodes/QR codes, implementation of digital checklists, improvement of recording procedures, and strengthening safety aspects. The Control Stage develops a control mechanism so that the results of improvements can be maintained on an ongoing basis, including the preparation of SOPs, routine 6S audits, the development of control checklists, and periodic monitoring of stock discrepancy.

Data Analysis Techniques

Data analysis was carried out with a complementary descriptive and quantitative approach. Descriptive analysis is used to explain the actual condition of the inventory system without making extensive generalizations, while quantitative analysis is used to process numerical data related to the level of stock discrepancy, 6S audit scores, and potential to improve inventory management efficiency. The amount of stock discrepancy is calculated based on the difference between the system stock and the physical stock, with the percentage of discrepancy obtained from the division of the difference to the system stock multiplied by 100%. Root cause analysis is carried out using fishbone diagrams, the 5 Whys method, and other relevant QC 7 tools, so that the designed remedial solution not only addresses the symptoms of the problem but also touches the root cause (Mabusela et al., 2025).

RESULTS AND DISCUSSION

Initial Inventory Management Conditions

Based on initial observations, it was found that inventory management in the research area had not been running optimally. Some of the main problems identified are still parts that are placed incorrectly according to the location, non-uniform location labels, mixed goods between items, delays in updating transactions to the system, and not optimal visual standards on shelves and storage areas. These conditions cause operators to take longer to find materials, increase the risk of misretrieval of goods, and trigger mismatches between physical stock and system records. One of the initial conditions of the storage area found, namely minimal shelf lighting that makes it difficult to visually identify the process, is shown in Figure 1.

Figure 1. Initial Condition of Storage Area with Minimal Lighting

The results of the initial inventory also show that stock discrepancy is not an incidental occurrence, but a problem that occurs repeatedly over several periods, especially in fast-moving items, items with dense storage locations, and items that have similarities in shape or size. Based on the results of initial interviews with the warehouse and inventory control, information was obtained that the most dominant problem was the high stock discrepancy that appeared repeatedly during stock taking and the investigation of material needs for production, with varying levels of handling difficulties as summarized in Table 3.

Table 1. Identify Key Inventory Management Issues

Yes	Problem	Difficulty Level	Rank
1	Discrepancy data stocktaking	Medium	1
2	Employees do not comply with SOPs	Difficult	2
3	Lead time of the receiving unloading process	Medium	3

The difficulty level assessment and ranking in Table 3 were obtained from impact assessments on eight operational criteria (quality, cost, delivery, safety, moral, productivity, technology, and environment) on a scale of 1 (low impact) to 3 (high impact). The stock discrepancy issue ranks first because it has a wide impact on almost all criteria, especially data quality, cost, and delivery accuracy. These problems not only have an impact on the accuracy of inventory data, but also cause operational waste in the form of searching for goods, re-investigating transactions, adjusting system data, delays in meeting production line needs, and the potential for false shortages and false overstock.

Historical data prior to the implementation of the improvement showed that the level of stock discrepancy was at a high level during the period June to December 2024, as presented in Table 4.

Table 2. Stock Discrepancy Data Before Repair

Moon	Qty System	Qty Discrepancy	Percentage Discrepancy	Inventory Accuracy
Jun-24	10.899	3.743	34,3%	65,7%
Jul-24	11.155	3.840	34,4%	65,6%
Aug-24	11.767	4.172	35,5%	64,5%
Sep-24	11.391	4.190	36,8%	63,2%
Oct-24	11.529	4.143	35,9%	64,1%
Nov-24	11.757	3.972	33,8%	66,2%
Dec-24	11.912	4.246	35,6%	64,4%
Average	11.487,14	4.043,7	35,53%	64,5%

The data in Table 4 shows that the stock discrepancy rate before repair is at an average of 35.53%, with an inventory accuracy of only 64.5%. This value indicates that most of the materials inspected have a mismatch between the physical stock and the system, which shows that the inventory control system is not yet effective.

Measure Stage

The measure stage is carried out to see real conditions before repairs through observation, 6S audits, recording work time, stock taking sampling, and identification of unsafe conditions. The 6S audit was conducted on two groups of warehouse areas, namely incoming areas, small materials and temporary storage (1st Floor), and finished goods and large materials (3rd floor), with the results as presented in Table 5.

Table 3. 6S Audit Score Before Repair

Area	Spell	Set in Order	Shine	Standardize	Sustain	Safety	Total	Average
Incoming Area, Small Part & Temporary Storage (1st floor)	0	11	3	9	3	0	26	4,3
Finish Goods & Big Part (3rd Floor)	0	11	4	3	3	0	21	3,5

The audit results showed that the weakest elements were set in order and standardize, which indicates that the warehouse problem is not only in momentary neatness, but especially in the absence of consistency, strong visual standards, and continuous behavioral control. Measurements of 12 material search events during the observation period using stopwatches showed a high variation in time as presented in Table 6, indicating that the location and identification systems have not been able to provide certainty for the operator.

Table 4. Material Search Time Before Repair

Parameters	Value
Number of search samples	12 cases
Fastest time	30 minutes
Longest time	2.5 hours (150 minutes)

Observations of the material also show that some of the discrepancy occurred due to misplacement, with details of the types of findings presented in Table 7. A form of misplacement occurs not only because the goods are placed in the wrong location, but also because the goods are stored in temporary areas without a clear status, inadequate location labels, and mixing between items, which shows that the root of the stock discrepancy problem comes not only from recording errors but also from the weak control system of the storage location.

Table 5. Data Misplacement Before Repair

Types of Findings	Number of Cases
Item is in another location but still in the correct area	21
Items are in other areas	13
Items without location tags	7
Mixed goods between items	6
Items in temporary areas without status	9
Total	56

The safety aspect is measured through a simple inspection of the physical condition of the work area, with the findings shown in Table 8. The findings show that the condition of the warehouse before repairs still contains a number of potential hazards, suggesting that area irregularities not only impact stock efficiency and accuracy, but can also increase the risk of work accidents, making the integration of safety into the 6S approach in this study particularly relevant.

Table 6. Safety Findings Before Repair

Types of Findings	Number of Cases
Goods closing the transfer path	6
Rack without load limit marking	3
Material is placed too high / not ergonomic	4
Dirty/dusty/slippery floor area	3
Unorganized cables	1
No adequate visual safety marking	2
Total	19

Analyze Stage

From the measurement results, the classification of the causes of stock discrepancy was carried out using Pareto analysis as presented in Table 9.

Table 7. Pareto Analysis of the Causes of Stock Discrepancy

Causes	Frequency	Percentage	Cumulative
Misplacement	56	38,6%	38,6%
Delay/no transaction input	31	21,4%	60,0%
Labels/locations are unclear	19	13,1%	73,1%
Mixed / wrong goods	15	10,3%	83,4%
Uncontrolled temporary storage	12	8,3%	91,7%
Counting/manual errors	8	5,5%	97,2%
Miscellaneous	4	2,8%	100%

Pareto analysis shows that the three dominant causes, namely misplacement, transaction delays/non-inputs, and unclear labels/locations, account for more than 70% of the total discrepancy. Thus, the focus of improvement is directed at area arrangement, location standardization, mutation transaction discipline, and control digitization.

To trace the underlying factors causing high stock discrepancy, a fishbone diagram approach with 6M categories (Man, Method, Material, Machine/System, Measurement, and Environment) as shown in Figure 2 is used, which groups eighteen causes of stock discrepancy into six main categories.

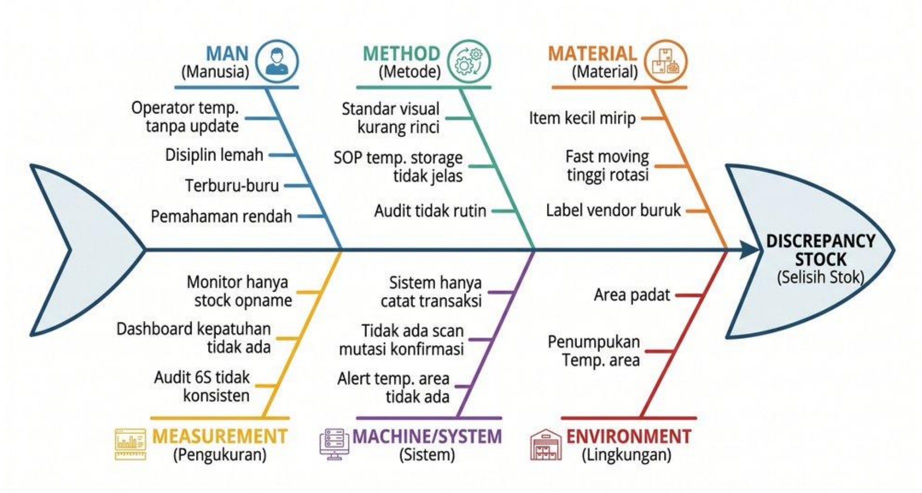

Figure 2. Fishbone Root Cause Analysis Diagram Stock Discrepancy

The Man category has the main cause in the form of operators who put goods in temporary locations without system updates due to the absence of clear temporary storage procedures and monitoring. The Method category highlights the weak visual storage standards due to the lack of visual control SOPs and location compliance KPIs. The Materials category indicates that many items that are small and similarly shaped are often misplaced because the storage layout has not been designed based on the material's characteristics. The Environment category revealed that certain areas were too congested due to the absence of a 6S culture and periodic sort audits. The Measurement category shows that the monitoring of discrepancy is only carried out during stock taking because there are no daily indicators and digital checklists. The Machine/System category reveals that the warehouse's digital system only functions to record transactions without location verification capabilities because there is no QR code or barcode available at each shelf location.

As a synthesis of all 6M and 5 Why analyses of each category, six main root causes and priority solutions implemented at the improved stage are summarized, as presented in Table 10.

Table 8. Root Causes and Priority Solutions

Yes	Main Root Causes	Categories	Solution
1	No time-based temporary storage control system	Human/Method	Tag status temporary
2	Absence of KPIs and visual control compliance audits	Method / Measurement	Visual standards + weekly audits
3	Layout is not based on material characteristics	Material/Environment	Zoning by size & frequency
4	Absence of 6S culture and periodic audits	Environment	Formal 6S + PIC area program
5	The measurement system does not support real-time monitoring	Measurement	Digital checklist + dashboard
6	Location identification is not yet digital and standard	System	QR code location

Table 10 shows that the six root causes are systemic and interrelated between categories. There is no one dominant factor absolutely, but a combination of weak site control systems, lack of visual standards, lack of real-time monitoring, and the lack of a culture of warehouse orderliness. To compare the actual conditions with the target conditions to be achieved, gap analysis is carried out as shown in Table 11.

Table 9. Gap Analysis of Actual Conditions and Target Conditions

Aspects	Actual Condition	Target Conditions	Gap
Location Labels	Some of it is unclear	All locations have standard labels	Height
Temporary area	Out of control	There are statuses, time limits, and monitoring	Height
Compliance	Not consistent yet	100% according to location	Height
6S Audit	Manual and non-routine	Digital, routine, and documented	Height
Safety marking	Limited	Clear and consistent	Medium

The results of the analysis showed a considerable gap between actual conditions and expected conditions, especially in the aspects of location labels, temporary area control, compliance with SOPs, and 6S audits. This condition shows that the problem of stock discrepancy is closely related to the weak visual control system and the lack of optimal use of digital mechanisms to support operational discipline, so the designed intervention must be able to close the gap directly.

Improve Levels

Based on the results of the root cause analysis, a repair plan was prepared in the form of the implementation of digitized 6S which includes rearrangement of storage areas, standardization of locations, labels and visual controls, cleaning and marking of work areas, creation of work standards and placement SOPs, digital-based 6S audits, addition of explicit safety aspects, use of barcodes/QR codes for specific locations and items, as well as status- and age-based temporary area controls.

The Sort activity is carried out by separating active items, inactive items, return materials, unidentified items, and obsolete items, with the results shown in Table 12. The sorting results cause the storage space to be more spacious and make it easier to identify the location, so that the chance of misstorage decreases.

Table 10. Sort Implementation Results

Categories	Number of Items
Active items keep saved	1.074
Items moved to slow moving	86
Return/hold items are separated	24
Items without identity are retraced	19
Obsolete/unused items moved	47

Improvements at the Set in Order stage include creating standard location codes, labeling of shelves and material placement places, separating material paths, assigning temporary areas with status tags, and using label scans for location validation. The results of the rearrangement of the storage location are shown in Figure 3, with a standard example of the location of the assigned part presented in Table 13.

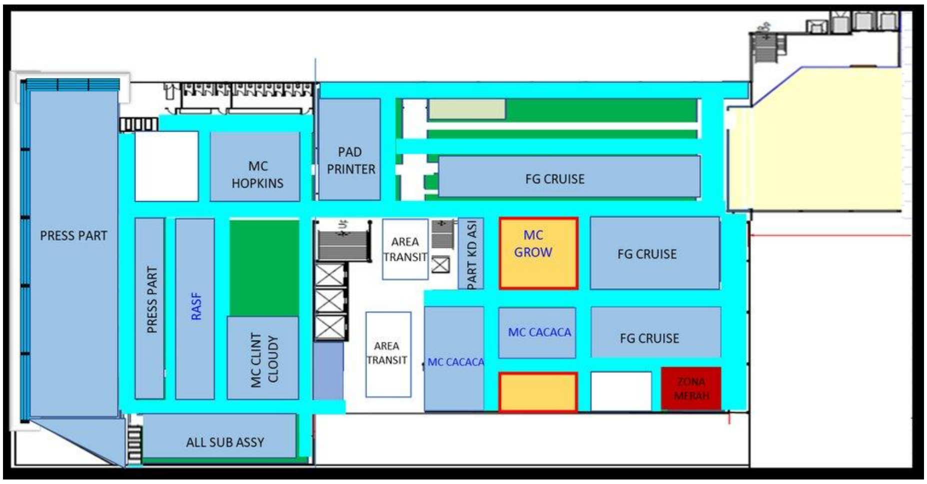

Figure 3. Layout for Determining the Location of Placement of Repaired Parts

Table 11. Example of Standard Location of Parts

Yes	Part Code	Copyright © 2019 T	Area	Details
1	1879205-01	Housing, Panel, Upper	D01	001
2	1879204-01	Housing, Panel, Lower	D01	002
3	1879203-00	Cover, IF	D01	003
4	1900836-00	Cover, Ink Eject; C	D01	004
5	1704409-00	Spur Gear, 21	D01	005

With these changes, operators have a clearer location reference so that the process of storing and retrieving materials becomes more directed. The Shine phase includes a thorough cleaning of the warehouse area, rearrangement of the moving line, removal of dust on the racks, and the preparation of daily and weekly cleaning schedules, which make it easier to visually inspect misplaced items or damaged labels. The Standardize stage is carried out through the creation of storage and collection SOPs, standard label formats, visual instructions in each area, aging temporary area rules, and digital checklists for daily audits, which serve as a link between physical improvement and process sustainability.

To maintain sustainability (Sustain), a weekly digital 6S audit, a brief briefing at the beginning of the shift, the person in charge of the area, monitoring findings and due dates for improvements, as well as monthly evaluation of stock discrepancy is established. The addition of safety aspects is realized through marking safe pedestrian paths and material handling, marking shelf capacity, prohibition of storage above safe limits, fire extinguishing and emergency access areas marked, and marking of risky materials. Thus, a more organized warehouse also becomes safer and more operationally stable.

The digital system designed in this study includes a 6S audit checklist, a database of findings per area, and a 6S score dashboard as shown in Figure 4. All components of the system are integrated into a single data-driven platform to ensure that the flow of information runs in real-time, so that this system not only functions as a documentation tool, but also as a decision-making tool for management through trend analysis on the dashboard.

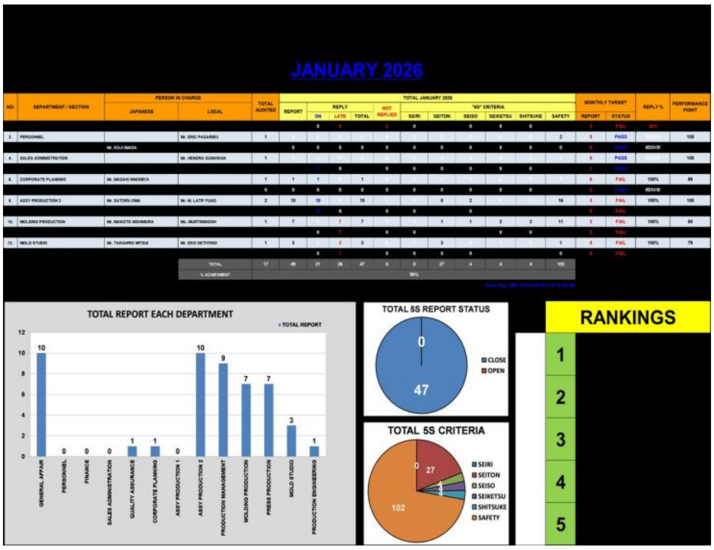

Figure 4. Dashboard Audit 6S Digital

Control Stage

The control phase aims to ensure that all initiatives that have been implemented can run in a sustainable manner, with the main focus being on creating a monitoring system that is able to detect irregularities early. To prevent repairs from returning to the old condition, a control mechanism was prepared in the form of weekly 6S audits, weekly and monthly discrepancy recaps, daily temporary area monitoring, and monthly reviews by supervisors. The mechanism is designed to create a layered layer of surveillance ranging from the daily to monthly levels, so that any irregularities are not only detected but also documented in the process.

As a parameter of success in maintaining post-repair performance, a number of control indicators (KPIs) are set that are monitored periodically, namely inventory accuracy, number of discrepancy per month, 6S audit score, number of misplacement cases, material search time, number of unsafe conditions, as well as compliance with the closure of audit findings. These indicators serve as quantitative measuring tools to assess the health of the post-implementation system, so that the trend of increasing inventory accuracy and decreasing material search time is clear evidence that improvements have a positive impact on efficiency.

Results After Implementation of Improvements

After a series of improvements are implemented based on the root cause analysis, observation and data collection are carried out over a certain period to measure the effectiveness of the solution. Monitoring of the level of discrepancy was carried out consistently in the period from January to April 2025, and showed a positive trend where the percentage of discrepancy continued to decrease every month until it reached a low of 25.10% in April, with an average overall decrease from 35.53% to 29.70% and an increase in inventory accuracy from 64.5% to 70.3%.

In addition to administrative accuracy, physical improvements through the rearrangement of storage locations also have an impact on reducing misplacement cases, as presented in Table 14.

Table 12. Comparison of Misplacement Before and After Repair

Types of Findings	Before	After
Item is in another location but still in the correct area	21	11
Items are in other areas	13	7
Items without location tags	7	1
Mixed goods between items	6	2
Items in temporary areas without status	9	2
Total	56	23

The data in Table 14 shows a decrease in misplacement cases by 58.93%, from 56 cases to only 23 cases, which indicates that standardization of labeling and freight flow discipline has succeeded in minimizing irregularities in warehouses. Success in reducing misplacement rates directly contributes to operational speed, as shown by the comparison of material search time durations in Table 15.

Table 13. Comparison of Material Search Time Before and After Repair

Parameters	Before	After
Number of search samples	12 cases	12 cases
Fastest time	30 minutes	15 minutes
Longest time	2.5 hours (150 minutes)	1 hour (60 minutes)

The observation results showed an increase in the efficiency of the search time, where the longest time needed was reduced from 150 minutes to 60 minutes. This decrease proves that obstacles in the search for materials have been eliminated through systematic location planning, the implementation of visual control, and the strengthening of digital identification. The sustainability of operational improvements is measured through a 6S standard assessment conducted again in 2025, with the results shown in Table 16.

Table 14. 6S Audit Results After Repair

Area	Year	Spell	Set in Order	Shine	Standardize	Sustain	Safety	Total	Average
Incoming Area, Small Part & Temporary Storage (1st floor)	2024	0	11	3	9	3	0	26	4,3
	2025	0	8	3	5	3	0	19	3,2
Finish Goods & Big Part (3rd Floor)	2024	0	11	4	3	3	0	21	3,5
	2025	0	10	3	2	3	0	18	3,0

The audit results in Table 16 show a fairly good decrease in the average score of the findings, from 4.3 to 3.2 in the 1st Floor area and from 3.5 to 3.0 in the 3rd Floor area, where a lower score indicates fewer and fewer non-conformance findings. Although the Sustain aspect still needs further attention, overall the 6S work culture has been well implemented across the entire warehouse line. As an integral element of the 6S, the occupational safety aspect is specifically evaluated to ensure that the risk of work accidents due to environmental conditions has been minimized, with the results shown in Table 17.

Table 15. Safety Findings Before and After Repairs

Types of Findings	Before	After
Goods closing the transfer path	6	3
Rack without load limit marking	3	1
Material is placed too high / not ergonomic	4	1
Dirty/dusty/slippery floor area	3	1
Unorganized cables	1	0
No adequate visual safety marking	2	0
Total	19	6

The implementation of the fix succeeded in reducing the findings of unsafe conditions from 19 findings to only 6 findings, which shows that the integration of safety as an explicit element in the 6S program has a real impact in creating a safer and more ergonomic working environment for operators. In summary, a comparison of all key performance indicators before and after the implementation of improvements is presented in Table 18.

Table 16. Summary of Comparison of Key Performance Indicators Before and After Implementation

Indicator	Before	After	Changes
Average stock discrepancy	35,53%	29,70%	Down 5.83 percentage points
Inventory accuracy	64,5%	70,3%	Up 5.8 percentage points
Longest material search time	150 minutes	60 minutes	Down 60.0%
Average score of 6S audit (1st Floor)	4,3	3,2	Down 25.6%
Number of misplacement cases	56 cases	23 cases	Down 58.9%
Number of unsafe condition findings	19 findings	6 findings	Down 68.4%

The Effect of Digitized 6S on Stock Discrepancy

The results of the study show that the application of digitized 6S is able to reduce stock discrepancy. This decline occurred because improvements were not only directed at the physical arrangement of the warehouse area, but also at strengthening the control system, standardization, and operational discipline. In the initial condition, stock discrepancy is often triggered by misplacement, unclear labels, uncontrolled temporary areas, and input errors. After repairs, these causes are reduced as the storage location becomes clear, the status of the goods is easier to trace, and the area audit is carried out more consistently. This success shows that the problem of stock accuracy cannot be solved by simply taking stock or correcting system data, but must touch the interaction between people, methods, work areas, and control systems.

Influence on Inventory Management Efficiency

The decrease in material search time indicates that the efficiency of inventory management has improved markedly. Before repairs, operators spend a lot of time looking for parts that are not in the right location. Once the rearrangement of location, labeling, zoning, and visual control is implemented, the search process becomes much faster and more consistent. From a lean point of view, these results show a reduction in waste motion and waiting, so that digitized 6S not only has an impact on stock accuracy, but also on warehouse operational productivity and support for the production process.

The Role of Standardize, Sustain, and Safety Aspects

One of the important findings of this study is that the success of improvement is also influenced by the elements of standardize and sustain. In the initial condition, the warehouse area actually had a basic zone division, but there was no strong visual standardization and no audit mechanism that forced consistency, so operators tended to revert to old habits. Once SOPs are clarified, labels are standardized, digital checklists are implemented, and area responsibilities are clarified, compliance levels increase, indicating that work area improvements will only last if accompanied by consistent process standardization and control mechanisms. This study also shows that the addition of safety aspects in 6S provides broader benefits than the conventional 5S approach, because a safe and organized area makes it easier for operators to read labels, pick up goods correctly, and return goods to the right location, so that safety is not only an aspect of occupational safety compliance, but also part of the process stabilization system.

The Role of Digitalization and Factors Supporting Success

The digitalization in this study is not intended to replace the company's main inventory system, but to strengthen the discipline of 6S implementation and increase the visibility of implementation in the field. Digital checklists, monitoring aging temporary areas, and discrepancy by location recaps have been proven to help monitoring run faster and more documented, so that management can see violation trends, the most problematic areas, and the progress of improvements more objectively. Some of the factors that support the success of this research include the support of warehouse supervisors and leaders, the involvement of operators in determining layouts and labels, focus on improvement on dominant causes, the use of simple but effective visual controls, and the existence of post-implementation control mechanisms.

Research Limitations and Implications

Although the results of the study show positive improvements, this research still has limitations, namely it was only carried out on one printer manufacturing company so that the results are contextual, the post-implementation evaluation period is still relatively limited, the digitalization designed is still at the level of strengthening operational control and has not been fully integrated with all ERP modulescompanies, as well as some cost impact data are still in the form of operational estimates. Practically, this study confirms that the stock discrepancy in manufacturing companies can be effectively lowered through comprehensive improvements that include area arrangement, standardization, implementation of digital audits, and explicit attention to safety aspects, with the effectiveness of a validated approach through cost reduction) that far outweighs the cost of implementation, so this approach is highly recommended as a model of improvement for other warehouse areas facing similar issues. Academically, this study shows that the development of 5S into 6S and its integration with digitalization can expand the function of the lean approach from just workplace structuring to a more comprehensive operational control system, as well as reinforcing the view that the problem of stock discrepancyIt needs to be addressed not only as a recording issue, but as a work system and operational behavior issue.

CONCLUSION

This study concluded that the initial condition of inventory management in the studied printer manufacturing company was characterized by relatively high stock discrepancies, low inventory accuracy, extended material search times, frequent material misplacement, and workplace conditions that had not fully met organizational and safety standards. The main contributing factors included material placement errors, transaction recording errors, unclear labeling and storage locations, weak temporary storage control, and suboptimal implementation of standardization, sustainment, and safety practices. The implementation of digitized 6S through storage area organization, location and label standardization, improved storage procedures, digital audits, temporary storage area control, and strengthened safety practices successfully improved overall inventory management performance. The improvements were demonstrated by a reduction in stock discrepancy from 35.53% to 29.70%, an increase in inventory accuracy from 64.5% to 70.3%, a reduction in material search time from 150 minutes to 60 minutes, a decrease in 6S audit findings score from 4.3 to 3.2, a reduction in misplacement cases from 56 to 23 cases, and a decrease in unsafe condition findings from 19 to 6 findings. These results indicated that the research objectives had been achieved by demonstrating that digitized 6S was an effective approach for improving inventory management efficiency while strengthening workplace safety.

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