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Warehousing Model Based on Inventory Management, 5s and SLP To Improve Picking Time in an SME in the Metalworking Sector

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Abstract

The metalworking sector has experienced continuous growth in production over recent years, fueled by the rise in industrial exports and associated activities. As a result, evaluating production processes has become increasingly important. One of the most significant challenges for companies in this sector is the warehouse picking process. A key factor in this process is the time required for completion, as excessive delays can lead to production bottlenecks. This study proposes the implementation of Lean Manufacturing tools, Systematic Layout Planning (SLP), and barcode technology to optimize picking time in the warehouse of a small or medium-sized metalworking enterprise. Following the implementation of these tools, the company successfully redesigned the warehouse layout, achieving a 71.15% reduction in picking time and eliminating rework.

Keywords
Warehouse, Picking, Lean Manufacturing, SLP, Barcode

1. Introduction
The manufacturing industry falls under the secondary sector of the economy and includes various subsectors, such as textiles, agribusiness, mining, steel, woodworking, oil, and metalworking. The metalworking sector plays a crucial role in the global economy. The countries with the strongest presence in this industry include the United States, Germany, Spain, and Japan (Di Natale et al. 2017). Although Peru is not ranked among the most developed countries in this sector, it has achieved an annual growth rate of 10.2% and accounts for 13.6% of the total manufacturing industry (Institute of Economic and Social Studies, 2018). Additionally, it represents 1.7% of Peru's GDP (Institute of Economic and Social Studies 2019). An important factor is that the metalworking sector remains closely linked to all areas of the economy, including mining and construction, which depend on its various products, such as machinery, components, and equipment (Tavera Colonna 2020). According to Srisuk and Tippayawomg (2020), industries must reduce costs and increase profitability in response to the recent economic crisis. For this reason, they recommend process improvements. A review of the literature revealed that, in various case studies related to the metalworking

sector, a recurring issue is found in warehousing. This is because warehouses are often not considered a source of value in the production process (Bonilla et al. 2020).There is an issue with inbound and outbound activities in the warehouse, which can account for up to 65% of operating costs. Improving warehouse processes would have a positive impact on all related areas, including logistics, administration, and production (Duque et al. 2020). Therefore, it is essential to address this issue, as it is one of the main causes of delays in organizations. It is worth noting that proper warehouse organization directly benefits production and order assembly, ultimately improving picking time (Andrada & Biscocho 2019).

1.1 Objectives

The study aims to demonstrate that the implementation of inventory management, SLP, and 5S will improve picking time in an SME within the metalworking sector.

2. Literature Review

2.1 Picking Time in the Metalworking Sector

One of the reviewed studies proposes a warehouse improvement proposal aimed at optimizing the picking process time in a dairy company in the Republic of Croatia. The study began with the development of a flowchart to identify the activities carried out in the warehouse. Notably, at this stage, the research identified that picking is the most costly and critical activity, accounting for 55% of total warehouse costs. To improve this process, the study implemented data collection, redesign, and continuous activity monitoring. After applying the proposed improvements, the results showed enhanced efficiency and effectiveness in the picking process. The authors emphasize that a wide range of methods can be used to improve such processes. However, they highlight that data collection is essential for ensuring effective implementation. Furthermore, the constant evaluation of KPIs is crucial for detecting potential errors, proposing new solutions, and fostering continuous growth (Habazin J. et al. 2016).

2.2 SLP in a Metalworking Warehouse

This research highlights the main issue faced by a manufacturing company in Indonesia: the distance operators must travel from the warehouse to the production area, which exceeds 29 meters and takes more than 10 minutes per trip. To address this problem, the authors implemented Systematic Layout Planning (SLP) to reduce the distance between these two areas, ultimately improving operational costs. Two new layout designs were proposed, both of which reduced the distance and increased productivity. However, the second alternative offered a more structured process, making it the preferred option and leading to satisfactory results (K. Bintang Bagaskara et al. 2020).

2.3 5s in the Metalworking Sector

The 5S methodology is a key tool within the Lean Warehousing approach, aimed at improving warehouse organization and efficiency. In the case of Company AT, its implementation led to a significant reduction in return rates, decreasing from 12.10% to 5.5%. This improvement was achieved through measures such as identifying and eliminating unnecessary items, marking work areas, and establishing regular audits. Additionally, picking time was reduced from 5 to 3 hours, and the percentage of unfulfilled orders due to stock shortages decreased from 28.64% to 22%.The integration of the 5S methodology with other Lean tools not only enhanced operational efficiency but also optimized the company's gross margin, setting a benchmark for future implementations in the sector.

2.4 SLP and Lean Tools in the Metalworking Sector

One of the reviewed research studies presents a proposal for improving the layout design of a manufacturing plant for electrical equipment, specifically high- and low-voltage switches, with the aim of increasing productivity and reducing operating costs. This study conducted a comprehensive analysis of material flow, departmental layout, and interactions between different production processes. The Systematic Layout Planning (SLP) technique was used to collect and analyze data, and various design alternatives were evaluated. In addition to SLP, lean tools such as Just-In-Time (JIT), Kanban, Kaizen, and 5S were implemented, helping to optimize processes and improve operational efficiency. The combination of SLP with these lean tools resulted in greater efficiency in material flow, a reduction in manufacturing time, and an increase in production rates. As a result of implementing a new layout and integrating lean tools, a significant improvement in material flow was observed, with a 30% reduction in transportation costs. Productivity increased by 10%, while workplace safety and ergonomics also improved, contributing to a more efficient work environment. The authors emphasize that although the redesign process is lengthy and requires detailed research, the long-term benefits—such as reduced operating costs and increased layout flexibility—justify the effort (Naqvi et al. 2016).

3. Methods

This article presents a case study based on a specific company in the commercial sector, employing a combination of methods for its analysis. The proposed model takes high picking times in the warehouse as **input** and aims to achieve a significant reduction in this indicator as **output**. To accomplish this, a structured approach is proposed, consisting of three main components.

The first component, "**Diagnosis**", assesses key performance indicators (KPIs) and utilizes various methodological tools, including a flowchart for process visualization, a Value Stream Map (VSM) to identify bottlenecks, a Pareto diagram to quantify and determine root causes, and a problem tree to map out critical factors along with their corresponding solutions. Through this analysis, it was determined that high picking times are directly linked to excessive travel distances (caused by poor warehouse layout), disorganized materials and tools (making them difficult to locate and retrieve), and a lack of inventory control.

The second component, **"Improvement Proposal,"** focuses on identifying and applying engineering-based solutions to optimize performance indicators. In this regard, three key strategies were selected to enhance warehouse delivery times: ABC classification, 5S methodology, Systematic Layout Planning (SLP).
Finally, the third component, **"Simulation and Pilot Testing,"** aims to validate the impact of the proposed strategies through a pilot implementation of the 5S methodology, complemented by a simulation using Arena software. This will allow for a comparative analysis of key indicators before and after implementation, assessing the effectiveness of the proposed model.

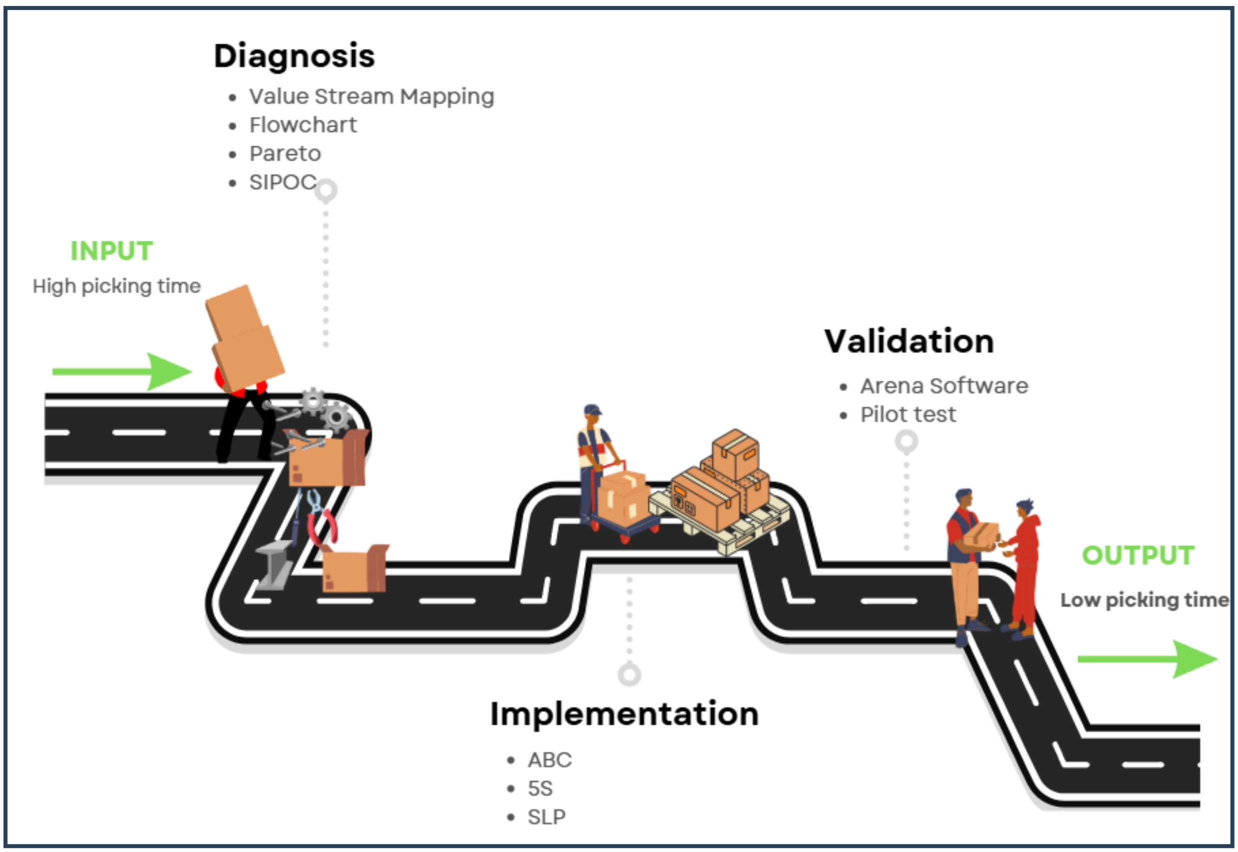

Figure 1. Proposed model

4. Data collection

For data collection in this research, various methodological tools were employed. First, interviews were conducted with staff members to identify the process with the greatest opportunities for improvement. Subsequently, an extensive literature review was carried out to understand and contextualize the issue.The observation method was then applied to measure time consumption and determine which activities within the picking process required the most resources. Based on this data, a Value Stream Mapping (VSM) was developed, providing a clear visualization of processing times and activities within a single diagram. Next, a Pareto diagram was constructed to prioritize key issues based on recorded time measurements. To further analyze the root causes of these inefficiencies, an Ishikawa diagram was used, enabling the identification of factors contributing to process inefficiencies.

Finally, all collected information was consolidated into a problem tree, which served to diagnose the most suitable methodologies for addressing each challenge. The findings highlighted the implementation of 5S, ABC classification, and Systematic Layout Planning (SLP) as the most effective solutions.

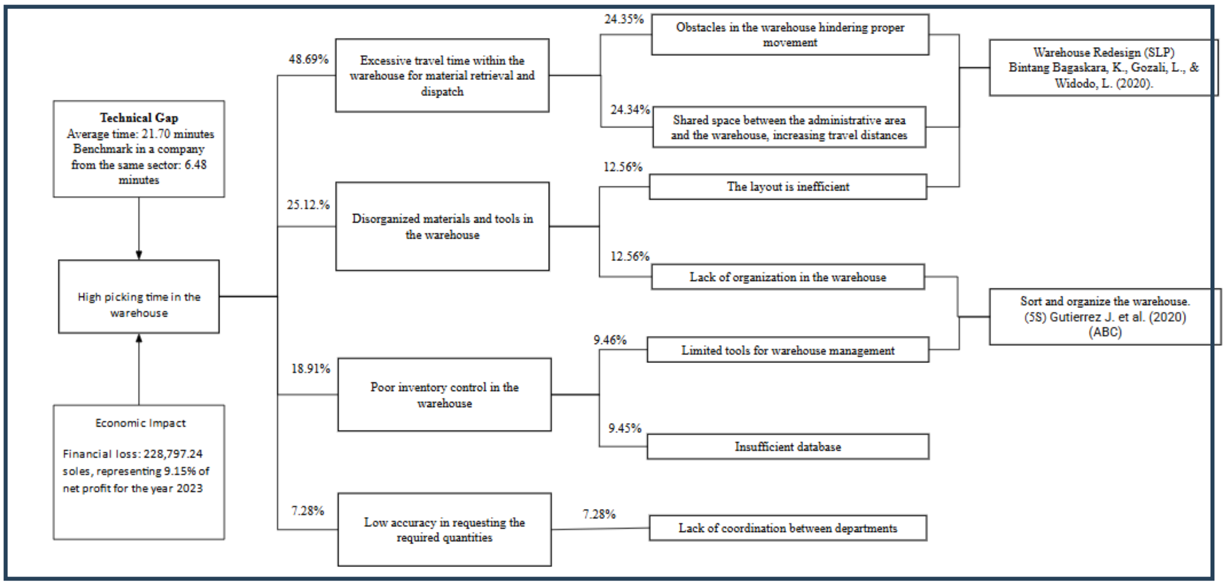

Figure 2. Problem's tree

4.1. Implementation of ABC Method, 5S and Systematic Layout Planning

To enhance efficiency in warehouse picking, the 5S methodology, ABC method, and Systematic Layout Planning (SLP) were implemented to address the main factors impacting this process. Three key issues were identified: Lack of proper inventory control, disorganization in material placement, excessive travel time within the warehouse.
These inefficiencies hinder the fast and accurate retrieval of products, causing operational delays, order fulfillment issues, and increased workload for warehouse staff.

To assess the extent of the problem, a detailed time study was conducted to measure the performance of each activity related to material retrieval and dispatch. The analysis considered variables such as necessary breaks, worker fatigue, and the impact of prolonged standing postures. Over the course of a week, execution times for each task, from order request to material delivery, were recorded. This allowed for the identification of inefficiencies and provided crucial insights for developing improvement strategies to optimize warehouse organization, reduce picking times, and enhance operational management. The picking process begins with the reception and verification of the order by the warehouse operator. Once the request is confirmed, the product's exact location is identified within the database. The operator then proceeds to the designated area to select the requested item, ensuring correct identification and availability. Afterward, the order is prepared and recorded in the system, maintaining accurate inventory control. Finally, the product is delivered to the requesting operator, completing the dispatch cycle in an efficient and organized manner. Through a detailed time analysis and the application of the corresponding calculations, it was determined that the current standard time required to complete the entire picking process is 21 minutes and 42 seconds. This duration encompasses not only the execution of each task but also the operator's movement between different warehouse stations. The identified time is considerably high, particularly given that during this period, the operator remains idle while waiting for the order, which can negatively impact productivity and operational efficiency.

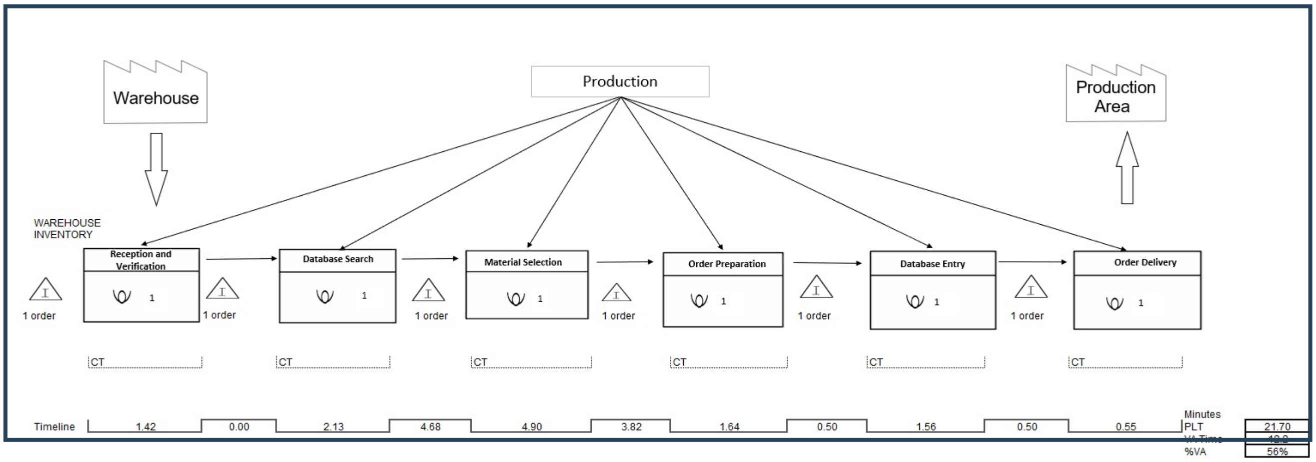

Figure 3. Value Stream Mapping

Based on these findings, the need to optimize the process became evident to reduce search and retrieval times, enhance warehouse organization, and streamline operations. To achieve this, three strategic tools were implemented to improve inventory management and minimize workflow delays. ABC Method: An in-depth review of the company's initial documentation revealed the absence of a structured classification system for managing warehouse orders. As a result, the ABC methodology was implemented to group and classify orders based on their turnover rate. This approach will help prevent stockouts of high-demand products. Additionally, by restructuring the warehouse layout, it will be easier to identify and prioritize items requiring greater attention, thereby streamlining order retrieval processes and optimizing search efficiency.

5S Methodology: Prior to implementing the 5S methodology, the warehouse exhibited a compliance rate of only 19.13%, highlighting issues such as disorganization, lack of control, and the absence of standardized procedures. Seiri facilitated the elimination of unnecessary materials, freeing up space and minimizing obstructions. Seiton improved organization through labeling and strategic storage, optimizing product retrieval. Seiso ensured cleanliness and proper maintenance of tools and equipment. Seiketsu established key standardized processes, promoting a more structured and efficient workflow. Finally, Shitsuke reinforced discipline through training programs and regular audits, ensuring continuous adherence to best practices.
As a result of these systematic improvements, the warehouse underwent a significant transformation, achieving a notable reduction in picking time and establishing a more efficient, structured, and orderly system.

Systematic Layout Planning: It was determined that the warehouse layout was inefficient, as the administrative area and storage zone shared the same space, causing interferences and disrupting workflow. The shelving units were arranged without a clear organizational criterion, forcing workers to navigate long and disorderly paths. Additionally, administrative filing cabinets and documents were intermingled with stored materials and products, further hindering movement. During a picking process assessment, it was observed that workers had to pass through unrelated areas, increasing search times and negatively impacting productivity.

To establish a solid foundation for process optimization, the current performance indicators were obtained from operational data and field records. Distance and time measurements were taken based on information provided by operators and direct time tracking. These values will serve as a baseline for process optimization through simulation and continuous improvement, the results of which will be presented below.

Picking Time: 21.7 minutes

Average travel time: $\frac{\sum \quad Actual\ travel\ time}{Number\ of\ measured\ orders} = 9.5 \text{ minutes}$

Average travel distance: $\frac{\sum \quad Actual\ travel\ distance}{Number\ of\ measured\ orders} = 89.7 \text{ meters}$

5. Results and discussion

The improvements were implemented through a two-week pilot test, during which all proposed guidelines and optimizations were applied. As a result, new average times were established for each activity.
Following the optimization, the total process time was reduced to 11 minutes and 26 seconds, demonstrating a significant improvement. This outcome can be attributed to a more efficient warehouse layout, improved organization of spare parts, an optimized workflow, and a reduction in customer service times.

Table 1. Standard time for activities after upgrading

No	Operation	Standard Time after the upgrade	Responsible
1	Order Reception	1 minutes and 42 seconds	Operator
2	Material Search	2 minutes and 33 seconds	Operator
3	Order Preparation	1 minutes and 30 seconds	Operator
4	Delivery	1 minutes and 18 seconds	Operator
5	Transfers	4 minutes and 23 seconds	Operator

The pilot implementation of the 5S methodology led to a significant transformation in warehouse management, enhancing organization, safety, and operational efficiency. Unnecessary materials were eliminated, optimizing space and reducing the time spent searching for supplies. Additionally, visual management systems were introduced for inventory control, facilitating stock level identification and minimizing picking errors. The standardization of processes and staff training ensured the sustainability of these improvements, fostering a culture of order and continuous improvement. As a result, warehouse compliance increased from **11.67%** to **65%**, establishing a more efficient and structured work environment.

Figure 4 . 5's Before and After

The aim is to enhance warehouse order and efficiency by applying the ABC method, which organizes materials according to their level of importance and turnover. The ABC classification is widely employed in inventory management for items with multiple references, enabling the prioritization of supplies based on their operational impact [13]. In this analysis, it was determined that materials and supplies, along with equipment and tools, belong to category A, as they account for the highest turnover rate and are critical to operations. Complementary processes were assigned to category B, reflecting a medium turnover rate, while consumption and operational items were classified as category C due to their low turnover. This information allowed for the strategic placement of materials on shelves according to their frequency of use, thereby reducing unnecessary operator movement and optimizing work times.

Table 2. ABC's results

Categories	**%**	**% Accumulated**	**Classification**
Materials and supplies	34.85%	34.85%	A
Equipment and tools	42.12%	76.97%	A
Complementary processes	16.77%	93.74%	B
Consumption and operation	6.26%	100 %	C

In the warehouse, the SLP method was implemented to optimize space distribution. The shelving units were strategically arranged to facilitate operator movement, utilizing a support cart for material handling. The placement of storage racks was determined based on the ABC rotation analysis, aiming to minimize travel distances and enhance efficiency. Additionally, a complete separation between administrative staff and the storage area was established, with the latter being enclosed to prevent interference, reduce delays, and eliminate unnecessary movement.
Through the application of SLP, a clear demarcation of reception, delivery, preparation, and storage areas was achieved. Furthermore, the number of shelving units was increased, and new zones were created, including a recycling area and a designated parking space for the support cart. These improvements significantly reduced travel time and material search efforts, leading to a more efficient and streamlined operation.

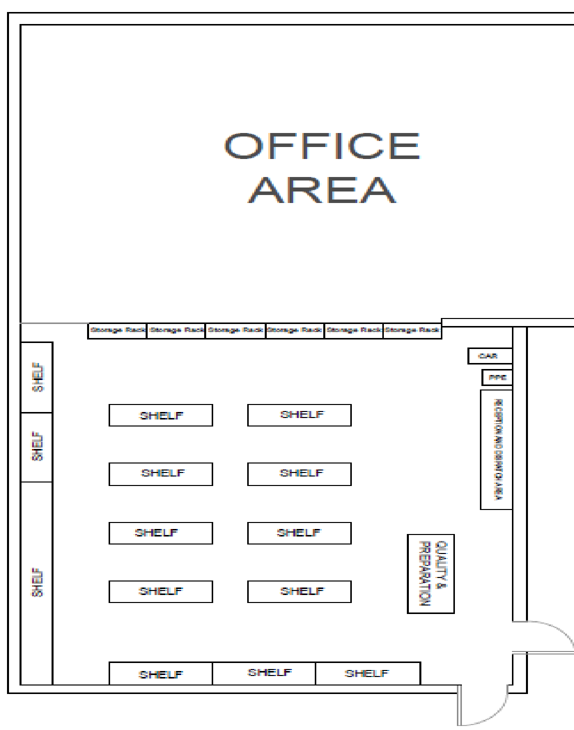

Figure 5. Layout Warehouse after improvements

The relational diagram illustrates the connection between the warehouse areas: Administrative Area, Materials Area, Tools and Accessories, Recycling and Finished Products, Preparation and Verification, Reception and Dispatch, and Parking. The "X" denotes the complete separation of the administrative area, while the letters U, A, I, and E represent different priority levels in the proximity of zones to optimize movement, reduce search times, and enhance the operational flow within the warehouse. This organization enables a more efficient layout, ensuring improved mobility and better space utilization.

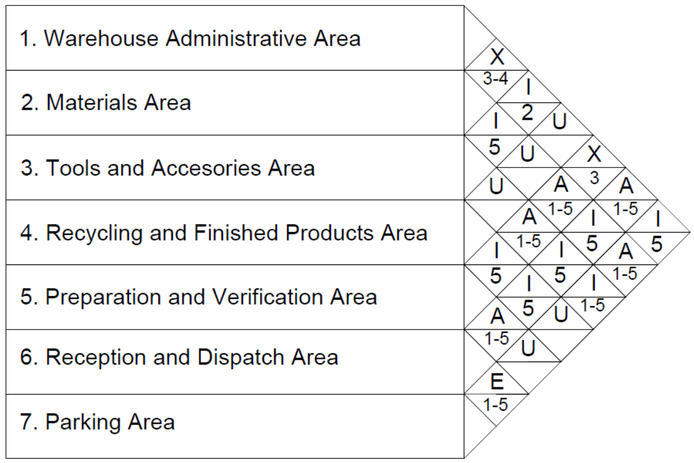

Figure 6. Relationship between activities

5.1. Numerical Results

After implementing the methodologies and conducting the simulation, the following results were obtained:

- Picking Time: 11.44 minutes
- Average travel time : $\frac{\sum \quad Actual\ travel\ time}{Number\ of\ measured\ orders} = 4.39$ minutes
- Average travel distance : $\frac{\sum \quad Actual\ travel\ distance}{Number\ of\ measured\ orders} = 33.35$ meters

5.2. Graphical Result

Through the application of the tools, we were able to obtain the following graphic results:

Figure 7. Assessment of the 5's Before and After

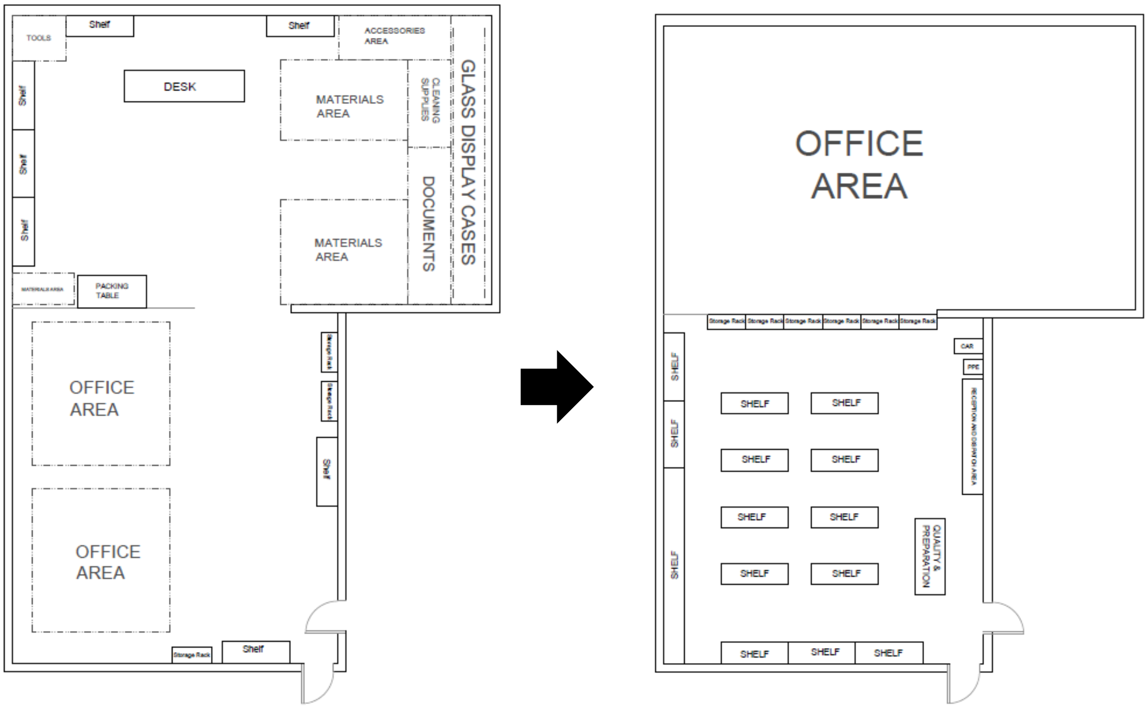

Figure 8. Layout Warehouse Before and After

5.3 Validation

The proposed model was validated through a pilot test of the 5S methodology in a material and tool pickup area, along with a simulation in Arena software applied to SLP and ABC analysis. The optimal number of replications (N=30) was determined to minimize the margin of error. By running the initial and final scenario simulations, it was confirmed that the proposed scenario demonstrates a significant improvement.

Table 3. Comparison of indicators between scenarios

Indicator	Initial Situation	Improved Situation	% of improvement
Picking Time	21.70 minutes	11.44 minutes	47.5%
Average Travel Time	28.38 minutes	4.39 minutes	84.53%
Travel Distance	89.7 meters	33.25 meters	62.93%

6. Conclusion

The metalworking sector faces inefficiencies in the picking process, leading to delays and additional costs. To optimize this process, tools such as Lean Manufacturing, SLP, and barcode systems were implemented, achieving a 71.15% reduction in picking time and eliminating rework.

The warehouse redesign, incorporating 5S, ABC, and SLP, enhanced space utilization, reduced search times, and streamlined material flow. As a result, the picking time decreased from 21.7 to 11.4 minutes, significantly enhancing operational efficiency.

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