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Improving Productivity through the Implementation of Lean Manufacturing and SLP Tools in a Footwear SME

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Abstract

In Peru, a lack of technological investments and training contributes to low productivity in the footwear industry. The study presents a comprehensive project to improve the productivity of a Micro and Small Enterprise (MSE) in Peru's footwear industry, using Lean Manufacturing tools. The methodology includes TPM for inefficient material distribution, 5S for policy procedures and underutilized spaces, and SLP for disorder in work areas. Pilot tests of 5S demonstrate significant improvements, and the implementation of TPM aims to avoid accidents and enhance equipment efficiency. The resulting 80% increase in overall company productivity is supported by positive economic evaluations, including a Net Present Value (NPV) of 26,858.27 PEN, an Internal Rate of Return (IRR) of 62%, a Payback Period (PRI) of 2.39 years, and a Benefit-Cost Ratio (B/C) of 2.27. Overall, this integrated approach proves successful in elevating the company's overall efficiency.

Keywords
Footwear, TPM, 5S, SLP and productivity

1. Introduction

Globally, the footwear industry grapples with notable productivity challenges. In Ecuador, research at a university highlighted issues such as delays in leather footwear production, with a qualitative methodology revealing a real-time process duration of 105.82 minutes for a pair of shoes. In Ambato, a lack of process management contributed to a reduction in orders and delivery delays. With applied Lean Manufacturing methodologies and tools like 5S and TPM, the production increased from 150 to 197 pairs per day.
The University Católica del Ecuador aimed to improve quality and productivity, conducting qualitative research using tools like process maps. In Cali, manual cutting processes led to extended production times, with a quantitative study using Lean Manufacturing and SLP revealing a reduction in footwear production time from 46.3 to 30 minutes per pair.

Shifting focus to Peru, the footwear industry has played a pivotal role in both employment and manufacturing production in recent years. Despite continuous growth in footwear production, productivity remains a significant challenge for the Peruvian footwear industry, impacting its competitiveness in the region. This improvement project aims to delve into the current state of a Micro and Small Enterprise (MSE) in Peru's footwear industry, and apply lean manufacturing tools to surmount productivity obstacles.

Key factors affecting productivity in the Peruvian footwear industry include a lack of investments in technology and modern machinery. Limited access to modern technologies hampers the industry's capacity to improve efficiency and reduce production costs. Additionally, insufficient training and education of workers contribute to lower productivity, as they lack the necessary skills for operating modern machines and performing complex tasks.

Innovation gaps in production processes and inefficient space distribution also pose challenges to productivity in the Peruvian footwear industry. Many companies still use traditional, inefficient processes, and a lack of access to information and resources further hinders productivity improvement efforts.

The successful implementation of Lean Manufacturing tools, such as 5S, TPM, and SLP, holds great promise for a Peruvian footwear MSE. Various reviewed articles provide compelling evidence that the application of these tools enhances efficiency, quality, and productivity in the footwear industry.

For instance, Chinchay-Morales et al. (2022) propose an improvement model incorporating Lean Manufacturing tools like 5S, line balancing, and standardized work. The results demonstrate a significant reduction in cycle time, the number of defective products, and an increase in On-Time In-Full (OTIF) order fulfilment indicators. Similarly, Reyes et al. (2018) explore the implementation of Total Productive Maintenance (TPM) in the footwear industry in Ecuador. The application of the proposed model shows an average increase in production standards and a noteworthy reduction in human errors, underscoring TPM's effectiveness in enhancing production processes. Additionally, Calderon et al. (2022) highlight the design of engineering tools such as 5S, FMEA, Control Chart, and Preventive Maintenance to reduce operational costs in a footwear company. The results reveal an uptick in units produced and a decrease in defective, reprocessed, and rejected units, affirming the cost-effectiveness of implementing these tools.

The reviewed articles provide robust evidence that the implementation of Lean Manufacturing tools, including 5S, TPM, and SLP, would be successful in a Peruvian footwear MSE. These tools would enhance the company's efficiency, quality, productivity, and profitability, concurrently reducing unproductive times, errors, and operational costs.

The scientific article is structured as follows: literature review, in which the theoretical framework of the problem to be studied is reviewed by means of studies carried out by other researchers. Method shows the type of study, through the analysis of the model and its detailed description by indicators; followed by the validation section, which details the results of the evaluations carried out, the implementation and finally the conclusions regarding the stated objectives.

1.1 Objectives

The objective of this study is to implement Lean Manufacturing tools in a Micro and Small Enterprise (MSE) in the footwear industry in Peru with the aim of improving efficiency and productivity in production processes. Specifically, the goal is to increase daily footwear pairs production from 150 to 197 pairs per day and reduce production times per pair from 18.82 minutes to 12.74 minutes. To achieve this objective, a detailed action plan will be developed and implemented, tailored to the needs and available resources of the MSE in Peru, ensuring that the adoption of Lean Manufacturing tools is feasible and practical for the company. The relevance of this project lies in its contribution to enhancing the competitiveness of the MSE in Peru in the local and international market, through increased efficiency and reduced production costs. The improvement program is expected to be executed over a period of six months, with monthly audits to assess progress and make necessary adjustments.

2. Literature Review

2.1. Lean Manufacturing in the footwear industry

The Lean Manufacturing methodology emerges as a transformative approach within the footwear industry, aiming to revolutionize production processes by eliminating wasteful practices and enhancing overall efficiency. According to Munive Silvestre et al. (2022), Lean Manufacturing, with its focus on waste elimination and process efficiency, holds significant promise for the footwear industry. This strategic application addresses critical concerns within the industry, such as prolonged cycle times and a notable number of defective products. The implementation of Lean tools, including 5S, TPM, and standardized work, has been proposed by experts in the field. These tools, when integrated, contribute to a streamlined workflow, leading to substantial reductions in cycle time and defective products. This not only underscores the methodology's positive impact on efficiency but also establishes a foundation for delivering products of heightened quality. Dextre-del-Castillo et al. (2020). propose a six-phase methodology incorporating Lean manufacturing tools and change management to enhance manufacturing capacity, reduce backorders, and improve order deliveries by 82%.Castillo-Castañeda et al. (2021). Focus their study on small and medium enterprises in the footwear sector, aiming for continuous improvement by implementing Lean methodology. Reporting 13% optimization of operators' effective time, a 20% production increment, and a 63% reduction in reprocessing. The impact on work processes leads to a 23.62% increase in productivity in the footwear industry. Zainal et al. (2022) explored the impact of Lean Manufacturing (LM) methods, including Total Productive Maintenance (TPM), Continuous Improvement (CI), and Just-In-Time (JIT), on sustainable performance in Malaysian manufacturing firms. The study found that JIT had the most significant influence on sustainable performance, and Continuous Improvement and TPM were interconnected. The research contributes insights for practitioners and decision-makers to align LM implementation with sustainability goals. Laura-Ulloa et al. (2022) proposed a model for the Peruvian footwear industry, integrating lean manufacturing tools like 5S, line balancing, and standardized work. The implementation resulted in a 27.27% reduction in cycle time, 8.90% decrease in defective products in the assembly area, and a 19.91% decrease in the flooring area. This led to a significant 44.48% increase in the value of On-Time-In-Full (OTIF).

2.2. TPM

Total Productive Maintenance (TPM) emerges as a pivotal strategy within the footwear industry, emphasizing proactive equipment maintenance to prevent failures and minimize downtime. This methodology goes beyond reactive measures, instilling a culture of continuous improvement. Toke and Kalpande (2023) conducted an empirical assessment of key performance indicators (KPIs) of total productive maintenance (TPM) and provided implementation guidelines for business excellence in the manufacturing sector. Noteworthy studies, such as that conducted by Reyes et al., delve into the successful application of TPM models in the footwear industry, resulting in a substantial increase in production standards. The model's effectiveness is further underscored by a remarkable reduction in human errors, affirming TPM's integral role in enhancing production processes. Jain and Jain (2018) highlight the lack of models for TPM implementation and a scarcity of empirical research in the field, stressing the need for a specific model for the manufacturing sector. Ahmed et al. (2018) provide a case study on the improvement of overall equipment efficiency (OEE) through Total Productive Maintenance (TPM) in a textile setting in India. Singh and Singh (2020) focus on justifying TPM pillars for enhancing the performance of the manufacturing industry in Northern India. In this sense, in order to improve its competitiveness, a system was proposed to predict the failures of a production system and to carry out preventive maintenance actions. Samples were taken from 25 productions and 7 activities were established: cutting, stitching, pre fabrication, final preparation, gluing, assembly and finishing. The company produces batches of 90 pairs per day, with a standard time of 274.53 min and a promised productivity of 1.8.

2.3. Methodology SLP

The role of Systematic Layout Planning (SLP) in optimizing the design of facilities and equipment distribution within the footwear industry is paramount. Calderon et al. (2022) underscore the importance of engineering tools such as SLP. Through meticulous planning and implementation of SLP, the study showcases tangible benefits, including increased units produced and decreased defective, reprocessed, and rejected units. The cost-effectiveness of these tools becomes evident, positioning SLP as a strategic methodology for reducing operational costs. The optimization of the production layout minimizes unnecessary movements, decreases material transport times, and improves overall process flow. In essence, SLP contributes to heightened efficiency and productivity, establishing a robust foundation for sustainable growth within the footwear manufacturing sector. Lira-Aquino et al. (2021) focus on improving production process efficiencies through a Lean Manufacturing Implementation Model, including the application of SLP. Paucar et al. (2020) address challenges in the footwear industry, proposing a SLP-based solution to reduce defects, enhance productivity, and optimize processes, validated through a simulation using Arena obtaining a 3.13% decrease in defects and a 38% productivity improvement. E. L. Padilla et al. (2021) proposed a logistics management model for SME footwear marketers, integrating tools such as SLP. The study, conducted in Metropolitan Lima, demonstrated a service level improvement from 55% to 70% through simulation. Kovács (2020) emphasized the need for manufacturing enterprises to enhance cost reduction and efficiency in response to global market competition and fluctuating customer demands. The research focused on developing a novel efficiency improvement method that combines Lean methods with SLP. The study demonstrated the effectiveness of this integrated approach, resulting in significant improvements in efficiency and key performance indicators (KPIs), as well as cost reduction.

2.4. Methodology 5'S

The application of 5S, a fundamental Lean tool, extends beyond mere workplace organization in the footwear industry. Cubas et al. (2022). propose the application of Lean Manufacturing tools, including 5S, to improve the production processes of Calzado Kids in Trujillo. The findings suggest that reduces cycle time and increases production, while tools like 5S contribute to a more organized and efficient environment, emphasizing the principles of Total Quality. These improvements not only contribute to operational efficiency but also have a direct positive impact on the overall quality of the manufactured footwear. Chaudhari and Pawar (2019) provide a comprehensive review of the successful implementation of 5S practices in the Indian manufacturing sector, emphasizing improved productivity and quality. Prabhakar and Pankaj (2019) highlight the positive effects of 5S in streamlining processes, reducing operational costs, and enhancing workplace safety in a study focused on the Indian manufacturing sector. Alipio-Gordillo et al. (2022) conducted a study on Chang S.R.L., a sandal footwear production company, aiming to assess the impact of an improvement plan. Improvement plan 1, comprising 5S, and Poka Yoke. Simulation in Ms. Excel demonstrated a 78.01% reduction, 46% IRR, 1.12% monthly TMAR, and S/. 84,981.08 NPV, indicating project viability with an early return on investment and a cost-benefit ratio of 2.04. Peralta-Quispe et al. (2019) addressed the main issue of an insufficient attention rate to orders in a company, resulting in economic losses attributed to delayed production and defective products. The company's efficiency was assessed at 65%. To enhance productivity, Lean Manufacturing tools were considered, specifically 5S, VSM, and TPM. Following tool application, there was a notable reduction in defective parts and cycle time, leading to a 75% increase in company effectiveness. The 5S methodology, focused on sorting, setting in order, systematic cleaning, standardizing, and sustaining, offers a structured pathway to eliminate inefficiencies and enhance workplace safety. In the ever-evolving landscape of the footwear industry, the implementation of 5S stands as a beacon for promoting cleanliness, organization, and continuous improvement.

3. Methods

The current study focuses on addressing key challenges at a footwear manufacturing company, through an integrated approach using 5S, Systematic Layout Planning (SLP), and Total Productive Maintenance (TPM). The identified root causes include inefficient material distribution, lack of policy procedures, underutilized production spaces, and disorder in work areas.

In Figure 1, the proposed model is depicted. The methodology proposed for the challenge of inefficient material distribution is TPM. The planning phase involves a meticulous diagnosis through Value Stream Mapping (VSM) to identify processes outside the acceptable range. This is followed by the measurement of current indicators such as quality, on-time deliveries, and OEE. The selection of TPM tools, aimed at boosting productivity and order fulfilment, is the subsequent step. Furthermore, the formation of a TPM committee and training in proactive maintenance are integral components of this phase. In the implementation stage, TPM is applied to eliminate obsolescence and enhance machinery efficiency, alongside the development of detailed and comprehensive operation sheets. Execution of autonomous maintenance is prioritized to prevent failures and improve overall availability. The verification phase includes a thorough review of indicators to ensure the anticipated results, coupled with continuous monitoring and the application of additional control measures.

Turning to the second challenge, the lack of policy procedures and underutilized production spaces, the 5S methodology is deployed. In the planning phase, a diagnosis is conducted through an updated Value Stream Mapping (VSM) to identify areas lacking policy procedures and underutilized spaces. The subsequent implementation involves the application of the first three S's (Sort, Set in Order, Shine) to eliminate unnecessary elements and organize space. Development of standardized policy procedures and training of operators in autonomous maintenance are crucial components of this phase. The verification stage includes a review of indicators to ensure efficiency and order in work areas, accompanied by continuous monitoring and necessary adjustments.

Lastly, the disorder in work areas is addressed through SLP. The planning phase entails a diagnosis of the current disorder in work areas, identifying inefficiencies in distribution and storage. In the implementation phase, SLP is applied to optimize equipment distribution and production areas, establishing policies for material classification and location. Personnel are then trained on the new arrangement and efficient space utilization. The verification phase involves a comprehensive review of indicators to ensure improvements in efficiency and a reduction of disorder, with ongoing monitoring and adjustments. The proposal model is shown below in Figure 1.

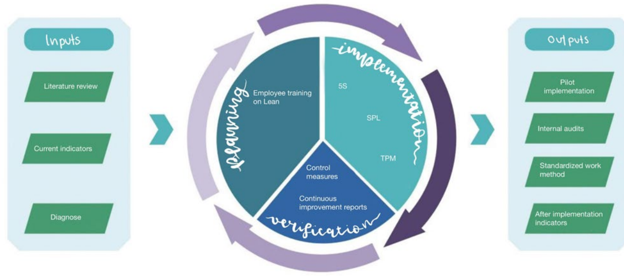

Figure 1. Proposed model

3.1. Information on the study process

The SME has three levels, as per the developed layout diagram. At the first level, there is the leather and sole warehouse, causing an excessive travel distance when requesting material for cutting located on the third level. Furthermore, there is inefficient distribution between the second and third floors, leading to material recirculation through other areas before delivery. The presence of well-maintained machines in the areas, although not used, reduces the process's usable space, causing material transportation to take more time than necessary. Improper waste management and a lack of order are evident, as materials used are initially classified by models and sizes, but at the end of the process, they are mixed and stored without proper classification, requiring additional time for reclassification before starting the process again. Additionally, there is a lack of cleanliness, as it is only conducted at the end of the day, accumulating generated waste around. The absence of coordination and standardization of different produced models results in some workers operating while others wait for materials, causing delays throughout the process, especially in the lasting area.

4. Data collection

At this stage, we are collecting the necessary data to gather relevant information for our improvement project. We gathered information both qualitatively and quantitatively. We created different forms for interviews and survey formats to collect data in the leather shoe production area. Additionally, we used the Pareto method, shown in figure 2, to find the main problems in defective products. We also used the Ishikawa diagram and created a problem tree to figure out the root causes of the problems.

After analyzing the information, we decided on the tools to use in the project: 5S for improving organization and cleanliness, TPM to reduce machine failures, and SLP to cut down travel distance and bottlenecks. All these tools will be accompanied by audits and aligned with a continuous improvement approach to help enhance productivity.

Figure 2 displays the Pareto diagram for identifying the main problems.

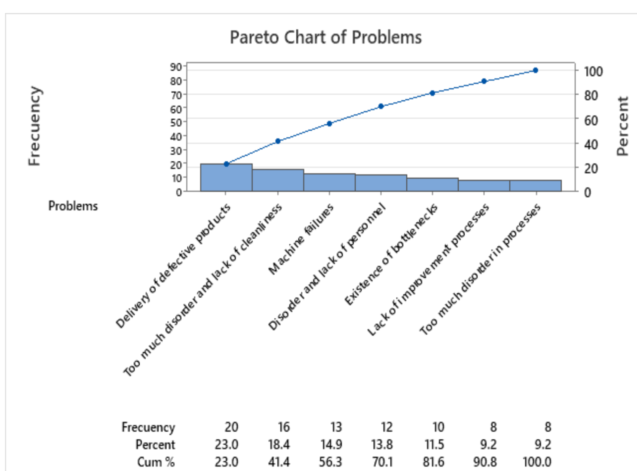

Figure 2. Diagram of the results

Over a six-month period, the main issues affecting operations have been identified and recorded. Figure 2 provides a detailed overview of these critical challenges, including the delivery of defective products, excessive disorder and lack of cleanliness, as well as the existence of bottlenecks in processes. These issues have undergone thorough analysis to understand their root causes and assess potential solutions with the aim of enhancing efficiency and overall performance quality.

4.1. Implementation of 5S and Autonomous Maintenance

Improving the leather footwear manufacturing process is achievable through the application of the 5S methodology. This involves classifying, organizing, cleaning, standardizing, and maintaining discipline. In our project within a Micro and Small Enterprise (MSE) specializing in footwear production, we aim to enhance productivity by implementing this lean manufacturing tool, particularly in the areas of die-cutting, leather storage, and sole storage.

Essential Steps of the Pilot Test:

a) Selection of the Experimental Area: A representative zone within the footwear company was carefully chosen to conduct the pilot test. This decision was based on the area's impact on production time, allowing for a comprehensive evaluation of the benefits arising from the application of the 5 "S."
b) Formation of the Experimental Team: A test team was constituted, consisting of employees from various departments and hierarchical levels. The diversity of this team ensured a comprehensive and diverse perspective during the implementation of the 5 "S."
c) Initial Assessment: The test team conducted a thorough assessment of the current state of the selected area, utilizing the principles of the 5 "S." Areas for improvement were identified, and an initial benchmark was established to measure changes.
d) Implementation of the 5 "S": The stages of the 5 "S" were carried out in the experimental area: Sorting (Seiri), Set in Order (Seiton), Shine (Seiso), Standardize (Seiketsu), and Sustain (Shitsuke). Each stage was progressively implemented, with a focus on training and active staff participation.
e) Monitoring and Evaluation: Throughout the pilot phase, regular meetings were conducted to assess progress and make adjustments as needed. Data on efficiency, waste reduction, and staff satisfaction were gathered.
f) Documentation and Communication: All procedures and standards developed during the pilot experimentation were documented. These documents served as a reference for future implementation across the organization. Additionally, the results and lessons learned were shared with the rest of the company.
g) Pilot Experimentation Results: The pilot experimentation demonstrated significant improvements in the selected area. There was an increase in operational efficiency, a noticeable reduction in waste, and a more organized and secure work environment.

IMPLEMENTATION OF DIE-CUTTING AREA
We initiated the enhancement process in the die-cutting area, a pivotal stage that marks the commencement of the production cycle. Within this zone, an absence of a designated location for cutting tools was noted. Observable signs of disorganization and untidiness included material remnants on shelves, tools displaced from their assigned spots, and damaged or unused die-cut pieces. By implementing the 5 'S' methodology, we effectively arranged the area, assigning specific positions for tools and ensuring order on shelves, as well as maintaining a clean floor free of material remnants utilized in the process.

IMPLEMENTATION OF PLANT STORAGE AREA
In the initial phase, a meticulous evaluation of the plant and material inventory within the warehouse was conducted. Items deemed obsolete or infrequently utilized were identified and subsequently either eliminated or relocated. This resulted in a noteworthy reduction in clutter and freed up valuable space to accommodate essential plants and materials. Each variety of plant and material was systematically arranged in allocated positions, featuring clear and easily distinguishable labels. Suitable shelves, boxes, and storage systems were introduced to guarantee a systematic arrangement, thereby enhancing efficiency in locating items and facilitating effective inventory management.

IMPLEMENTATION OF LEATHER STORAGE AREA
Our approach commenced with a thorough examination of our inventory of leather materials. Identification of obsolete, damaged, or minimally demanded materials led to their removal from the warehouse, liberating significant space and contributing to a reduction in clutter. Subsequent to the selection process, the remaining leather materials

were systematically organized. Each category of leather was assigned a specific location accompanied by clear and prominent labels. The incorporation of shelves, racks, and storage systems facilitated swift access and identification of materials, streamlining the overall storage process.

Implementation of TPM

Avoiding accidents, reducing environmental impact, enhancing overall equipment efficiency, optimizing costs throughout the life cycle, eliminating failures, promoting autonomy in maintenance, increasing quality and productivity, and strengthening staff skills and knowledge are some of the key activities. These include the implementation of preventive techniques such as preventive and predictive maintenance, Total Productive Maintenance (TPM), maintenance-free design, reliability engineering, and maintainability engineering. Additionally, efforts are made to eliminate the six major sources of loss, train operators and maintenance personnel, promote autonomous maintenance, and encourage collaboration in small groups. The main benefit lies in elevating the technological level of the company.
During the TPM pilot tests:

a) We introduced preventive and predictive maintenance practices on a set of selected equipment or machines within the company.
b) We kept a record of maintenance interventions, reduced downtime, improved equipment lifespan, and other key TPM indicators.
c) Maintenance practices were based on TPM best practices and were thoroughly documented.
d) The standard reference for the TPM validation methodology was literature and recognized guidelines in implementing TPM in industrial settings.

Table 1 displays the parameters required for calculating the cost of poor quality due to failures in the assembly and finishing machines over the course of one year.

Table 1: Parameter of TPM

Parameter	Value
Mean Time Between Failures (MTBF)	240 hours
Operating Time	
Mean Time To Repair (MTTR)	24 hours
Preventive Inspections per year	0 PEN
Time for Preventive Inspection	8 hours/day
Preventive Replacement Cost	150 PEN (labor)
Unscheduled Maintenance Costs (parts)	0 PEN
Labor Cost (parts replacement)	530 PEN
Cost for each hour the machine is not operational	480 PEN
Cost for poor quality due to equipment failure	2738.4 PEN
Total cost of poor maintenance	10040 PEN
Number of failures	10 failures/year

Table 2 presents the calculation of the Overall Equipment Efficiency (OEE) for the assembly and finishing machine.

Table 2 : OEE per Line

Line	Failures	MTTR	Capacity (u/h)	Performance	Quality	Availability	OEE
Aparado	5	24	12	90%	81%	83%	61%
Assembly	3	24	36	87%	89%	84%	65%
AVERAGE OEE							62%

Implementation of SLP

The SLP method development process began by identifying an issue related to material transportation due to inefficiencies in plant layout. The problem stemmed from the distances and locations of areas within the company. To address this issue and reduce non-value-added times, the decision was made to apply the SLP method. The primary need was to optimize the layout of areas based on material movement to enhance the overall process.
Before initiating the SLP method development, constraints related to the infrastructure of the production process were identified, limiting the ability to make changes in certain areas. Specifically, relocating the assembly area was not feasible due to the machine's weight and its infrastructure.
The first step in method development involved determining the flow of products at each stage of the process. This encompassed representing distances and times, along with the sequence in which each area was involved.
A matrix of origin-destination detailing the distances and times between each area in the leather footwear production process was crafted, Table 3 displays the initial distances between areas within the footwear company in meters and the corresponding travel times in minutes.

Table 3: Initial distance between areas

Departure Area	Destination	Distance (Meters)	Time (Minutes)
Warehouse R.M.	Cutting	60.0	1.8
Cutting	Painting	42.6	1.02
Painting	Roughing	7.2	0.15
Roughing	Assembling	20.4	0.70
Assembling	Preparing	6.4	0.19
Preparing	Binding	8.2	0.48
Binding	Mounting	17.2	0.62
Mounting	Finishing	8.9	0.27
Finishing	Warehouse F.G.	10.1	0.43
TOTAL	-	181.0	5.84

Figure 3 illustrates the proposed simulation model outlining the production stages, aiming to assess the impact of the improvement on production time.

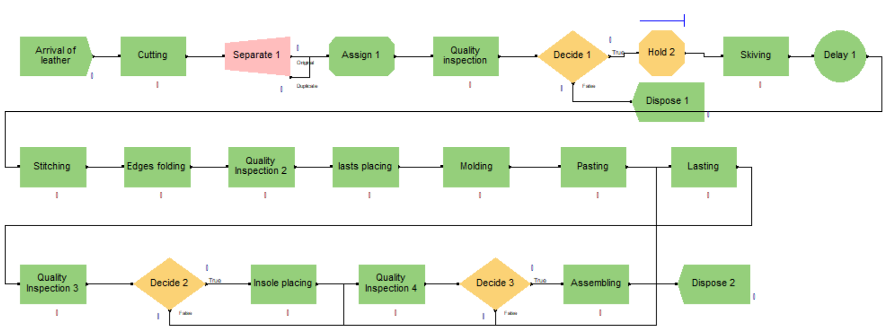

Figure 3. Simulation of travel time between areas

Table 4 presents the results obtained before and after the improvement.

Table 4 : Proposal distance between areas

Proposals	Total Distance (Meters)	Total Time (Minutes)
Current Situation	245.8	7.39
Proposal	138.4	4.3

5. Results and Discussion

The table presents a weekly breakdown of results for each stage of the 5S methodology over a four-week period. The "Sort" stage (seiri) shows an increase from 2 in week 1 to 8 in week 4. Similarly, "Set in order" (seiton) progresses from 2 to 9 over the same period. "Shine" (seiso) and "Standardize" (seiketsu) also demonstrate continuous improvement, with "Shine" increasing from 3 to 9 and "Standardize" progressing from 1 to 8. The "Sustain" (shitsuke) stage sees growth from 1 to 9.
In terms of the overall total, there is a positive trend, with scores rising from 9 in week 1 to 43 in week 4. The target per "S" is set at 10, and by the final week, the cumulative score surpasses this target, indicating successful progress in implementing and sustaining the 5S methodology. The results suggest a commendable effort in enhancing organization, cleanliness, and efficiency within the evaluated system.

Table 5: Pre and Post implementation

		WEEK 1	WEEK 2	WEEK 3	WEEK 4
S1	Sort (seiri)	2	4	7	8
S2	Set in order (seitón)	2	3	7	9
S3	Shine (seiso)	3	5	8	9
S4	Standardize(seiketsu)	1	2	6	8
S5	Sustain (shitsuke)	1	2	6	9
	TOTAL	9	16	34	43
	TARGET PER "S"	10			

The statistical analysis indicates that, over the four weeks of monitoring, there was a consistent increase in the total number of identified defects, with the total number of defects ranging from 26 to 33 defects per week. The most common types of defects were "Leather Scraping" and "Poor Gluing of the Upper," which exhibited a progressive increase each week. This suggests that these aspects of the production process require immediate attention and corrective measures. While there was a slight increase in "Improper Assembly," it was in "Leather Scraping" and "Poor Gluing of the Upper" where the most notable increase was observed.

Table 6 : Defects found in the 5 weeks.

Defects found	Description	Week 1	Week 2	Week 3	Week 4	Total
Total 30 days	Pre -	26	32	31	33	122
Total 30 days	Post -	7	5	6	5	23

Table 7, representing the initial and final maintenance audit, indicates a moderate level of performance across various components, with a total score of 38.70. Notably, Maintenance Supplies received a low score of 24.66, highlighting an area for improvement. In Table 7, the Improved Maintenance Audit reflects significant enhancements in all components, with scores rising notably, especially in Maintenance Supplies, from 24.66 to 76.00. The total score increases substantially to 72.67, underscoring comprehensive improvements in Maintenance Organization, Planning, Execution, Staff Skill, Supplies, and Administration.

Table 7: The audit of maintenance

	Score		
Components	Initial	Improved	Weighted score
Maintenance Organization	43.48	67.00	100
Maintenance Planning	45.57	72.00	100
Maintenance Execution	39.34	68.00	100
Maintenance Staff Skill	39.69	72.00	100
Maintenance Supplies	24.66	76.00	100
Maintenance Administration	39.47	81.00	100
Total	38.70	72.67	-

5.1. Cost analysis

By implementing the 5S tool, a noticeable reduction in initial losses was achieved, which amounted to 10,994.17 PEN due to an unproductive time of 6.2 hours. These figures were significantly reduced to an estimated loss of 1,410.00 PEN, accompanied by a decrease in unproductive time to 0.8 hours. This resulted in a total economic benefit of 9,584.17 PEN.
Through the implementation of the TPM proposal, a significant reduction in initial losses was achieved, amounting to 14,483.75 PEN due to 37 failures per year and 35 hours lost. These figures were substantially reduced to an estimated loss of 2,146.88 PEN, with the number of failures reduced to just 7 per year, accompanied by a decrease in hours dedicated to corrective maintenance, which were reduced to 7.5 hours. This improvement resulted in a total economic benefit of 12,336.88 PEN. The implementation of the 5S methodology resulted in a benefit of 9,584.17 PEN, while the use of TPM contributed with a benefit of 12,336.88 PEN. The introduction of a training plan generated a benefit of 3,240.00 PEN, and, finally, the SLP tool provided an economic benefit to the company of 3,153.52 PEN.
Finally, as a consequence of achieving the overall objective, which focuses on increasing the company's productivity, this information was obtained from the analysis of the annual working time of the 11 employees and the initial diagnosis of each of the proposed tools. As a result of these efforts, an impressive 80% increase in the company's overall productivity was achieved.
Specifically, through the implementation of the 5S methodology, a productivity increase of 87% was achieved. On the other hand, the adoption of TPM resulted in an 81% increase. The supporting tool, a training plan, contributed to a 69% increase in productivity. Lastly, the implementation of the SLP led to an 81% increase in the company's overall production efficiency. Table 8 shows the cost of implementing the tools.

Table 8: Investment for the Implementation of the Improvement Proposal

Root Cause	Investment
Investment - 5S Implementation	1520.00 PEN
Investment - TPM Implementation	1050.00 PEN
Investment - Training Plan Implementation	150.00 PEN
Investment - SLP Implementation	800.00 PEN

5.2. Validation

The table 9 highlights the transformative impact of implementing specific tools on productivity improvement. Notably, addressing issues such as a lack of order and cleanliness, absence of preventive maintenance plans, insufficient training, and non-existent productive procedures led to significant reductions in initial losses and waste. For instance, the 5S methodology and TPM contributed to remarkable decreases in downtime and failures, resulting in economic benefits. The introduction of a training plan and the use of the SLP tool further enhanced productivity. The Overall Equipment Efficiency (OEE) demonstrated a substantial increase from 62.2% to 82%, underscoring the comprehensive success of the implemented strategies in elevating the overall efficiency of the company.

Table 9: Root cause analysis

Root Cause	Without Tool	With Tool	Initial Productivity	Final Productivity	Productivity Variation
Lack of order and cleanliness in work areas	6.2 hours lost	0.8 hours lost	0.024463 hours lost	0.003090804 hours	87%
Lack of preventive maintenance plan	37 failures/year	7 failures/year	0.14599116 failures/year	0.027619949 failures/year	85%
Lack of a training plan	118 units waste	37 units waste	0.47 units waste/hour	0.14599116 units waste/hour	69%
Non-existence of productive procedures	90 units waste	17 units waste	0.3551136 units waste	0.06707702 units waste	81%
OEE	62.2%	82%	-		

6. Conclusions

The implementation of Lean Manufacturing tools, including 5'S and TPM, in a Peruvian footwear industry company resulted in significant reductions in initial losses and unproductive time. The 5'S approach decreased initial losses from S/. 10,994.17 to an estimated S/. 1,410.00 and reduced unproductive time from 6.2 to 0.8 hours, while TPM lowered initial losses from S/. 14,483.75 to an estimated S/. 2,146.88, reduced failures from 37 to just 7 per year, and decreased corrective maintenance hours from 35 to 7.5 hours. These improvements, coupled with training initiatives and other tools, led to a 30% profit margin compared to the initial 20%. Through the utilization of an Ishikawa Diagram, an initial analysis of the company's production areas was conducted, identifying root causes such as a lack of organization and cleanliness, absence of a preventive maintenance plan, lack of a training program, and absence of production procedures. To address these issues within the lean manufacturing framework, improvements were made, including the implementation of the 5S methodology, which reduced unproductive time from 6.2 to 0.8 hours per year, and the use of TPM, which reduced failures from 37 to just 7 per year. Additionally, a training plan decreased losses from 118 to 37 units annually, and SLP implementation reduced rework and losses from 90 units to 17 units per year, significantly boosting productivity. An economic evaluation confirmed the feasibility and profitability of these lean manufacturing improvements, with a Net Present Value (NPV) of PEN 26,858.27, an Internal Rate of Return (IRR) of 62%, a Payback Period (PRI) of 2.39 years, and a Benefit-Cost Ratio (B/C) of 2.27, validating the project's financial viability.

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