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# Improving Textile Productivity through Lean Manufacturing: A Case Study in A Peruvian SME Company

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## Abstract

The textile industry is a key contributor to Peru's economy, representing 6.4% of the national manufacturing GDP and generating over USD 1.3 billion in exports annually (PromPerú, 2022; MINCETUR, 2023). In response to increasing global competition, particularly from Asia, Peruvian textile companies must enhance their efficiency and quality standards. The study applied three core Lean techniques—5S, Poka Yoke, and Kanban—to optimize production, eliminate waste, and improve process control. The project included employee training, reorganization of workspaces, use of visual tools, and error-prevention systems. After three months, the company saw a 7% increase in productivity, 9% improvement in product quality, and 15% rise in customer satisfaction, based on internal KPIs and survey data. The results demonstrate that Lean principles, traditionally applied in large-scale industries, can effectively improve operations in SMEs within developing countries. This case study highlights how industrial engineering tools contribute to innovation, sustainability, and global competitiveness in traditional sectors like the Peruvian textile industry (Womack & Jones, 2003; Rother & Shook, 2009).

## Keywords
Lean manufacturing, 5S, Kanban, Poka yoke, productivity.

# 1. Introduction

Peru's textile industry faces high international demand, with 74% of exports between 2015 and 2019 being apparel—a figure that increased by 10.8% since 2021. This demand often leads to worker overexertion, causing injuries and high turnover. Despite producing value-added goods like alpaca wool and Pima cotton, domestic production generates only $1.9 million in exports, revealing a significant income gap. According to Acosta et al. (2022), productivity remains low—estimated at 100.9 points or 1.09 tons per hour. Compared to the KPI of the company analyzed in this study, there is a shortfall of 0.95 tons of finished fabric. Additionally, Quispe et al. (2020) report that global textile efficiency averages 80%, while Peru's stands at 75.2%, with the case company performing 12.7% below the national level.

This study focuses on a small textile company founded in 1999, dedicated to dyeing and finishing cotton fabrics, which faces challenges in quality, productivity, and customer satisfaction. The limited application of Lean Manufacturing concepts has led to preventable inefficiencies. Due to the company's size, a lengthy implementation period could affect its production, so a six-week timeframe has been established for applying and testing improvements. Despite this, the proper use of engineering tools can enhance performance in small businesses, especially in emerging economies, by identifying deficiencies and offering practical, low-cost solutions. This research underscores the importance of closing the knowledge gap and demonstrates that, with effective implementation, engineering tools can significantly benefit both administrative and operational processes.

## Objectives

- Identify the key performance indicators to be evaluated for the textile company.
- Implement 5S, POKA-YOKE, and KANBAN according to the textile company's specific problems and needs.
- Evaluate the results of the corresponding key indicators to propose changes in the textile company using post-implementation data comparisons.

# 2. Literature Review

To gain a deeper understanding of the background and the application of engineering tools within the sector, we reviewed relevant academic articles that support and complement the topic under study. In order to ensure a systematic and transparent selection process, the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) diagram was used to filter and identify the most relevant articles aligned with our research foundations (Figure 1). This approach allowed us to focus on studies that directly address our central research question: Why isn't the textile industry more efficient, and what can be done to improve it?

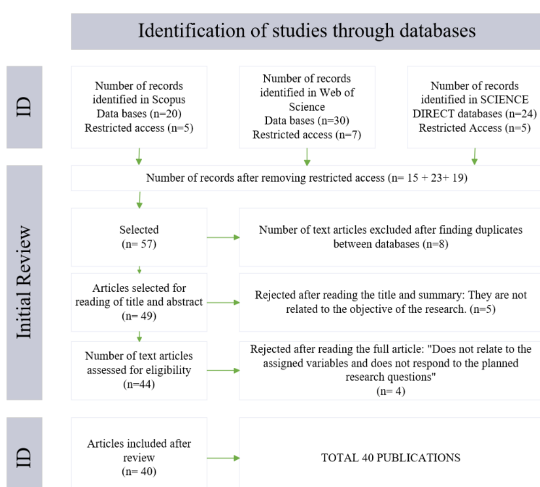


Figure 1. Prism Diagram

The literature review identifies two main approaches: studies focused on the implementation of Lean Manufacturing tools in specific companies, and theoretical research analyzing their impact on the industry. For instance, Quispe et al. (2020) apply TPM and SLP in an SME with significant quantitative results, contrasting with Kumar et al. (2017), who examine the competitiveness of Six Sigma in process industries.

Not all studies focus on the textile sector. Prawira et al. (2018) explore the use of 5S in a mining company, demonstrating the versatility of Lean tools across various sectors. Similarly, Alfaro et al. (2022) and Ames et al. (2019) highlight benefits in the poultry and plastics manufacturing industries, respectively. Other research, such as Dávalos et al. (2023) and Cuggia et al. (2022), delve into the SMED technique and the use of engineering tools in the food industry, emphasizing their relevance in adapting to global challenges such as the pandemic.

Moreover, Lean Manufacturing aligns with the objectives of the circular economy by reducing environmental impact through efficient resource use (De las Heras et al., 2018). However, Marulanda and Gonzales (2017) note that some textile companies have not achieved expected improvements due to a lack of proper understanding by management. In contrast, Sharma and Singh affirm that the correct use of Lean and operations control tools enhances production processes.

## 3. Methods

This research adopts a quantitative and experimental approach, analyzing the main problems and their causes within the company. Administrative and operational staff will also be consulted to supplement the findings with their testimonies. During the initial exploration, the company's documented records of each order it has placed were reviewed, using a sample of 152 orders out of the 650 orders they had in 2023.

To evaluate the results and validate the implementation, it was decided to identify the necessary KPIs for the case. Based on the information obtained, they were determined to be quality, customer satisfaction, and productivity. Based on historical data from the sector and previous measurements of the company's status, a target output was determined at the end of implementation of 85%, 95%, and 75% for the indicators, respectively (Figure 2).

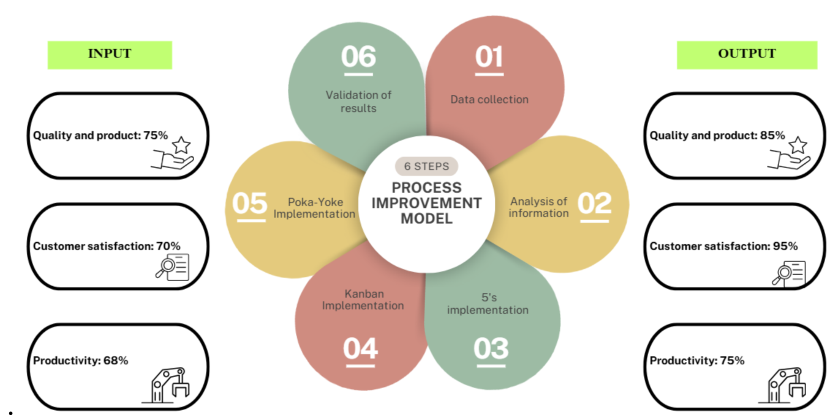


Figure 2. Macro Design

For this project, an implementation model was designed based on the PDCA cycle, which is a management method for implementing continuous improvements.

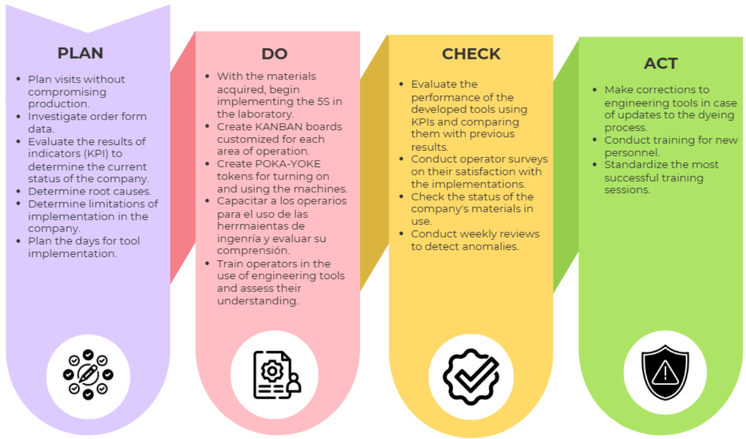


Figure 3. PDCA Process

Our approach focuses on evaluating specific indicators that represent the performance of the implementation of the engineering tools proposed in the production area, where the study was conducted to identify the company's deficiencies (Figure 3).

During the weeks of research, we identified a series of problems that affected production performance and order control. To better visualize the findings, an Ishikawa diagram was created (Figure 4).

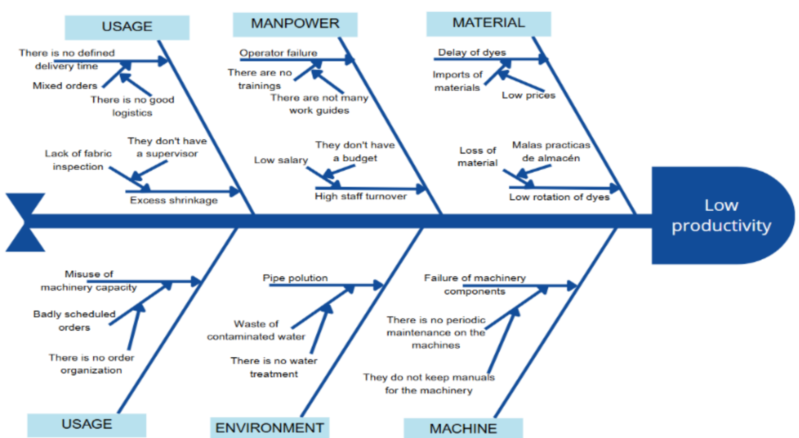


Figure 4. Ishikawa Diagram

The most common are poor production scheduling, operator failures, and material loss, which have a frequency of 40%, 30%, and 30% respectively. Within the problem of material loss, there are sub-causes such as poor working conditions and poor storage practices, which represent 40% and 60%.

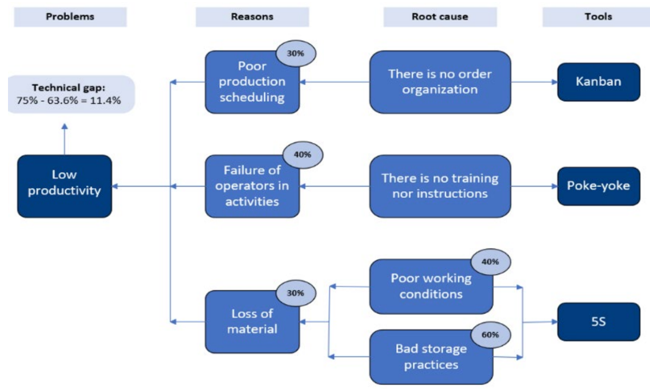


Figure 5. Tree Diagram

Based on the information gathered, the main validation and evaluation indicators identified are quality, customer satisfaction, and productivity (Figure 5).

Lean Manufacturing originated as a philosophy to eliminate waste and add value to production. Over time, it has evolved into a broader model that integrates sustainability and efficiency across the supply chain. As Ben Ruben, Vinodh, and Asokan (2019) state, "Lean manufacturing has evolved to support sustainable practices and value generation across supply chains, especially in resource-intensive industries" (p. 240). This supports the use of tools like 5S, Kanban, and Poka Yoke in industries such as textiles, where minimizing time, errors, and rework is essential for competitiveness.

Abbes et al. (2022) emphasize that Lean Six Sigma, adapted through models like fuzzy logic, can be effectively tailored to the needs of clothing companies, improving productivity and control. Likewise, Ben Ruben et al. (2019) underline Lean's role in reducing waste and promoting sustainability, reinforcing its strategic value beyond tool implementation.

Therefore, the application of three Lean tools is proposed to enhance key indicators in the textile sector by addressing the current problems and leveraging the full potential of each tool.

**POKA-YOKE:** A quantitative and experimental approach was used, analyzing 152 out of the 650 orders received in 2023, and administrative and operational staff were consulted. Poka-yoke, a Japanese technique created by Shigeo Shingo within the Toyota Production System, aims to prevent human errors or detect them immediately. In this case, it will be applied to the correct use of dyeing machines, improving their operation and helping new employees learn to use them more efficiently.

**KANBAN:** This is a management system based on a pre-established production flow. Due to poor planning, the company does not fully utilize machine capacity, which remains between 80% and 85%. This is partly because operators have some freedom in handling production orders, leading to disorganization. Implementing Kanban will help monitor activities and control processes.

**5S:** A Japanese methodology focused on workplace organization and cleanliness: Seiri (sort), Seiton (set in order), Seiso (shine), Seiketsu (standardize), and Shitsuke (sustain). The company shows significant disorder in the laboratory and raw material warehouse, lacking signage and cleaning routines, which causes time loss when locating materials and disorganization of raw fabrics.

## 4. Data Collection

Our research began with an initial visit to the factory to learn about all the steps involved in dyeing and finishing the fabrics, as well as to meet the corresponding administrative and operator staff and understand their responsibilities. After the initial visit, we visited the factory twice a week for a month, during which we collected data and information about the dyeing process and how it varied depending on the type of order or the type of dye used.

During the research period, we analyzed the average time of the live dyeing processes, which we can identify in the following Table 1:

Table 1. Data Collection of AS IS Processes

| | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 | Wee k 6 | Week 7 | Wee k 8 | Week 9 | Week 10 | Units | Distribution |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Prewash | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | minutes | Constat |
| Dyeing | 2.63 | 2.32 | 2.71 | 2.2 | 2.08 | 2.86 | 2.3 | 2.77 | 1.77 | 1.33 | hours | Uniform (1;3) |
| Rinsing I | 0.65 | 0.09 | 0.007 | 0.53 | 0.38 | 0.75 | 0.03 | 0.07 | 0.09 | 0.58 | hours | Uniform (0;1) |
| Softening & Fixing | 1.73 | 1.33 | 1.72 | 1.68 | 1.84 | 1.36 | 1.45 | 1.41 | 1.22 | 1.76 | hours | Triangular (1.04;1.75;1.94) |
| Rinsing II | 0.57 | 0.52 | 0.7 | 0.72 | 0.14 | 0.5 | 0.38 | 0.8 | 0.71 | 0.45 | hours | Uniform (0,1) |
| Spinning | 0.75 | 0.5 | 0.75 | 0.5 | 0.5 | 0.5 | 0.75 | 0.5 | 0.75 | 0.75 | hours | Discrete (0.5;1.75) |
| Ironing | 1.5 | 1 | 1 | 1.5 | 1.5 | 1 | 1.5 | 1.5 | 1.5 | 1 | hours | Discrete (1;1.5) |
| Packaging | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | minutes | Constat |

A statistical study of the variable-time processes in the production area was conducted to determine their distribution.

The dyeing process follows a UNIFORM (1;3) hours distribution, varying by dye type and quantity. After dyeing, rinsing removes excess dye and soap, with a UNIFORM (0;1) hours distribution, depending on the dye's sensitivity. Next is softening and fixing, where chemicals are applied to improve fabric texture and fix the dye. This stage follows a TRIANGULAR (1.04, 1.75, 1.94) hours distribution, influenced by the base material and dye type. A second rinse follows, also with a UNIFORM (0;1) hours distribution, tailored to each dye type. Direct dyes rinse faster than reactive dyes. Then, the fabric undergoes a spin cycle to remove excess water. The duration depends on fabric type, using a DISCRETE (0.5, 0.75) hours distribution—cotton requires more time than synthetic or hybrid fabrics. Ironing comes before packaging, removing wrinkles and moisture. It varies by dye type, especially reactive dyes, and follows a DISCRETE (1, 1.5 hours) distribution. Overall, the industrial dyeing process takes 3 to 8 hours, depending on the dye (direct or reactive) and the requested color (light, medium, or dark). The workflow starts with an order, then a scheduler assigns execution and machine lines. However, delays of 1 to 1.5 hours are common in this scheduling phase (Figure 6 and Figure 11).

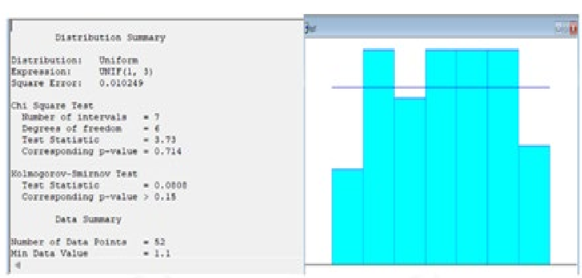


Figure 6. Validation of dyeing data

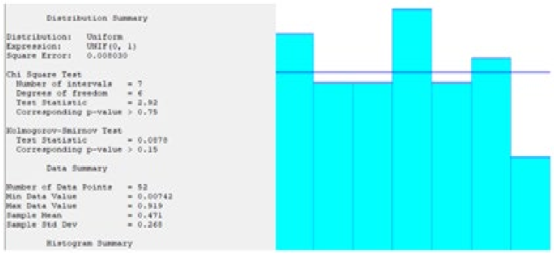


Figure 7. Validation of Rinse I data

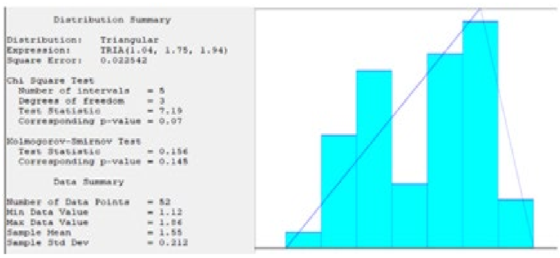


Figure 8. Validation of Rinse II data

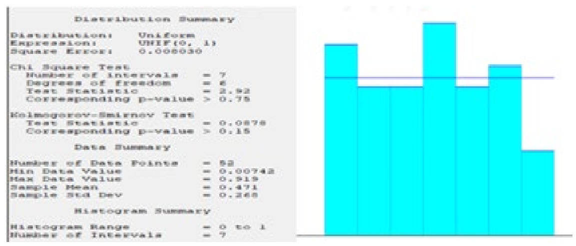


Figure 9. Validation of Softening & Fixing data

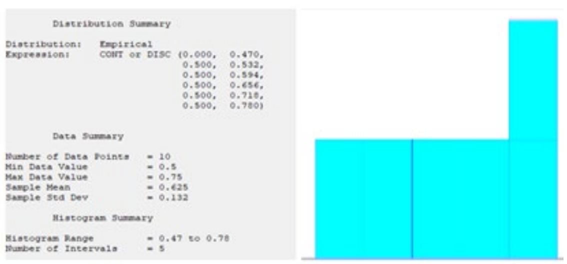


Figure 10. Validation of Spinning data

The dyeing process faces difficulties in managing work orders due to the lack of a standardized and organized system in the offices, leading to downtime and low productivity. The monthly goal is 100 tons of fabric, completing two to four orders per day, but this is not consistently achieved; the annual average is around 800 tons of dyed and finished fabric. The company uses three machine types: jet dye, overflow, and soft flow, with availability times between orders ranging from 18 to 25 minutes. During peak demand, two full shifts are operated, and 1% to 5% of special dye is required per kilogram of fabric. Machines do not always run at full capacity, often operating below or at maximum levels.

A sample of 152 documented orders was taken from a total of approximately 650 orders the company handles annually. It was observed that each order in the sample had more than one problem, which tended to recur in reprocessing and customer returns.

$$n = \frac{N * Z_{\alpha}^{2} * p * q}{e^{2} * (N-1) + Z_{\alpha}^{2} * q * p}$$

$$n = \frac{650 * (1.645)^{2} * 0.93 * 0.07}{(2.99\%) * (650-1) + 1.645 * 0.93 * 0.07} = 151.39 \approx 152$$

Considering the previously evaluated indicators, the representation of the company's status was calculated.

$$KPI: Quality = \frac{38\ orders\ had\ errors}{152\ sample\ orders} = 25\% = 75\%$$

$$KPI: customer\ satisfaction = \frac{31\ orders\ were\ returned}{152\ sample\ orders} = 0.301 = 70\%$$

$$KPI: Productivity = \frac{68\ 000\ kg\ dye\ fabric}{100\ 000\ kg\ raw\ fabric} = 0.68 = 68\%$$

So, with all the information obtained, we planned the physical implementation of the selected tools, which took two weeks and required materials provided by the company.

Our first area of implementation was the dye lab, where dyes are mixed to create the colors needed for orders. A clear lack of order, documentation, and space classification was evident. Therefore, with the help of the lab's main manager, we evaluated the state of the lab based on the 5S standard. The lowest points in the evaluation were observed in the order and cleanliness stages, both with 30%, while classification, discipline, and standardization obtained 40%, 44%, and 50% respectively, demonstrating a low understanding of the concepts of engineering tools by the lab operators.

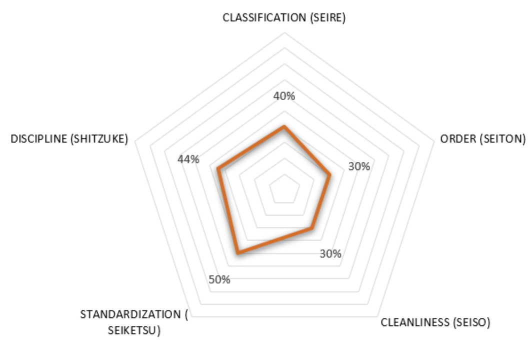


Figure 11. 5S radar

Kanban boards were then created and adapted to each operational area, utilizing the knowledge of the operators in each area. A total of six boards were used in the raw fabric, dyeing 1, dyeing 2, finishing 1, finishing 2, and bagging areas. To ensure the boards were properly understood, operators were trained in their use and maintenance.

As final implementation artwork, Poka-Yoke sheets were created, showing the correct steps for starting and using the dyeing machines, with the goal of making the adaptation process for new personnel faster and more efficient.

## 5. Results and Discussion

This thesis contributes by presenting a structured and practical approach to identifying inefficiencies within the textile industry through the application of Lean Manufacturing tools. The implementation of Lean principles—focused on waste reduction and process optimization—allowed for measurable improvements in a short period. Although applied to a specific case, the methodology developed can be replicated and adapted by other organizations in the sector. The results demonstrate the potential of Lean Manufacturing to enhance operational efficiency and provide a valuable contribution to both academic research and industrial practices.

## 5.1 Numerical Results

As part of the impact evaluation of the implementation of Lean Manufacturing techniques, a satisfaction survey was conducted among the workers of the textile SME. The results showed a predominantly positive perception: 85% of respondents reported feeling satisfied with the changes introduced, highlighting improvements in workspace organization, greater clarity in processes, and a significant reduction in idle times. Additionally, 78% stated that the tools applied made their daily tasks easier and contributed to a more organized and less stressful environment. On the other hand, 12% expressed neutrality and 3% reported some initial resistance, mainly related to adapting to new routines. Overall, the data reflect a high level of acceptance and satisfaction among the staff, supporting the effectiveness of the applied Lean approach.

The tools were physically implemented in the company, and administrative and operational employees were trained in their use. After three weeks, we returned to the company to evaluate the performance and use of the implemented improvements, which gave us the following results (Table 2).

Table 2. Final results

| Indicator | Real | As is | Goal | Achieved |
|---|---|---|---|---|
| Quality | 75% | 80% | 85% | 94% |
| Customer Satisfaction | 70% | 80% | 95% | 84% |
| Productivity | 68% | 70% | 75% | 75% |

It is observed that after the trial period there was a notable increase in the indicators, quality increased from 75% to 94%, customer satisfaction from 70% to 84% and productivity from 68% to 75%, demonstrating the effectiveness of the engineering tools and the proper training of personnel.

## 5.2 Graphical Results

Evidence is presented concerning the implementation of engineering tools in the company and how staff have been using them to improve their performance in their work activities. During the 5S implementation, laboratory staff were guided to identify material layouts and designated areas, followed by classifying spaces and supplies. Special tapes and laminated labels were used to mark and name areas, machines, and instruments. Next, customized Kanban boards were created for each production area—raw fabric, dyeing 1, dyeing 2, finishing 1, finishing 2, and bagging—and installed in accessible locations. Staff received training on their use, and evidence of usage was documented. Finally, Poka-Yoke worksheets were developed for the startup, use, and shutdown of dyeing machines (Fong 1, Fong 2, and Sclavo), including photo guides. These laminated sheets were placed in the machines' central power boxes for visibility, as the company cuts power via these boxes to reduce costs (Figure 12- Figure 15).

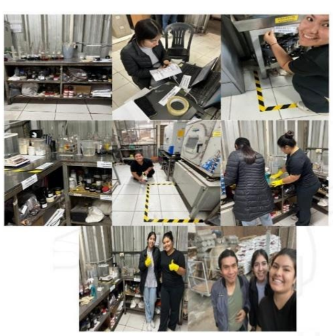

Figure 12. 5S's implementation in the laboratory

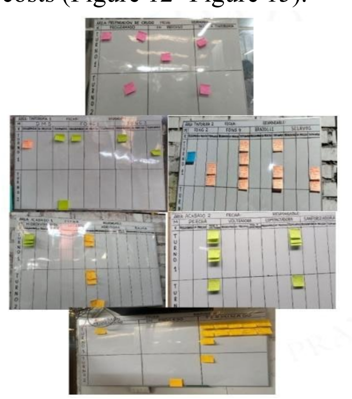

Figure 13. Kanban boards completed

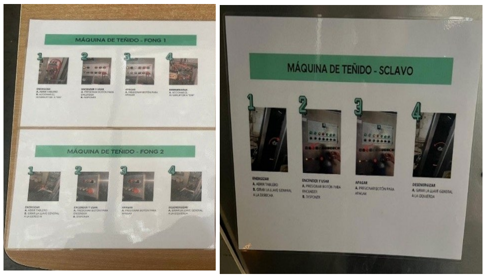


Figure 14. Creating POKA-YOKE tokens

Figure 15. Placing tokens into the machines

### 5.3 Proposed Improvements

I. Implementation of Real-Time Indicator Dashboards
Proposal: Install TVs that display a digital dashboard on the production floor to show real-time KPIs such as batch quality, downtime, and shift performance.
Justification: Immediate visibility improves decision-making and allows dynamic adjustments to production.
Expected hypothetical results (Table 3):

- 25% reduction in downtime.
- 10% increase in shift efficiency.

Table 3. Shift Efficiency Before and After Dashboard Implementation

| Shift | Before | After |
|---|---|---|
| Morning | 72% | 80% |
| Afternoon | 70% | 78% |
| Night | 68% | 76% |

II. Warehouse Redesign Using Systematic Layout Planning (SLP)

Proposal: Apply the SLP methodology to reorganize the raw material and finished goods warehouse.
Justification: Reducing search and handling times improves logistical efficiency.
Expected hypothetical results:

- 30% reduction in picking time.
- 12% savings in physical space utilization (Table 4).

Table 4. Average Picking Time Before and After Redesign

| Period | Picking Time (minutes) |
|---|---|
| Before | 18.5 |
| After | 13.0 |

III. Implementation of SMED to Reduce Changeover Times

**Proposal:** Apply the Single Minute Exchange of Die (SMED) technique to the dyeing machines to reduce batch changeover times.
**Justification:** Increases equipment availability and reduces non-productive time between orders (Table 5).
**Expected hypothetical results:**

- 40% reduction in setup time.
- 8% increase in Overall Equipment Effectiveness (OEE).

Table 5. Setup Time per Machine Type

| Maquine | Before | After |
|---|---|---|
| Jet Dye | 22 min | 13 min |
| Overflow | 18 min | 10 min |
| Soft Flow | 25 min | 14 min |

### 5.4 Validation

The planning, execution, and monitoring of continuous improvement were carried out in an orderly manner, allowing not only for the achievement of quantifiable results but also for the generation of a replicable model for other organizations in the sector. However, it is important to note that this implementation was carried out over a three-week period due to the specific characteristics of the case studied. For broader and more sustainable applications, a longer implementation period is recommended to ensure deeper analysis, adaptation, and consolidation of improvements.

I. Relevance of the Initial Diagnosis
The situational diagnosis was adequately supported by data obtained from the company's actual records and by analytical tools such as the Ishikawa diagram. The sample of 152 orders (23.4% of the annual total) was statistically significant with a margin of error of 5% and a confidence level of 95%. This analysis revealed that 40% of the problems were related to poor planning, 30% to operator errors, and another 30% to material losses, the latter being responsible for 12% of rework.
II. Effectiveness of Implementation

Lean tools (5S, Poka-Yoke, and Kanban) were strategically selected based on the specific weaknesses identified. Training was provided to 100% of operational and administrative staff (approximately 30 employees), achieving 75% effective attendance and 87% understanding according to post-training surveys.

III. Sustainability of Change
A survey conducted three weeks after implementation showed that 90% of employees perceived an improvement in the organization of their department and workflow. Furthermore, 82% stated that the implemented tools allowed them to perform their work with fewer errors and greater efficiency. A 15% reduction in average order response time and a 22% improvement in effective machine utilization were identified.

## 6. Conclusion

This study aimed to demonstrate how the implementation of lean manufacturing tools can significantly improve key performance indicators (KPIs) in a Peruvian textile dyeing company, and how these tools can be practically implemented in small businesses, which is beneficial for small businesses in emerging economies and countries. Based on the results obtained, the following conclusions are drawn:

- Identification of relevant KPIs: The team successfully identified the core KPIs—quality, customer satisfaction, and productivity—which revealed significant deficiencies in the company's production process prior to intervention. Establishing this baseline was essential for measuring the impact of the implementation.
- Implementation of Lean-manufacturing tools: Introducing 5S, Poka-Yoke, and Kanban directly addressed the company's specific problems. These tools reduced physical disorder, variability in process execution, and the lack of control over production scheduling. Complementing them with Total Quality Management (TQM) helped standardize procedures and produce visual guides that improved quality control and operator training.
- Evaluation of post-implementation results: Quantitative results showed substantial improvements in all three KPIs. Quality rose from 75 % to 94 %, customer satisfaction from 70 % to 84 %, and productivity from 68 % to 75 %. These figures demonstrate that, with proper implementation and effective staff training, significant impact can be achieved in a short period. They also reinforce the need to apply engineering tools to optimize processes in small and medium-sized enterprises.

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## Biographies

**Alisson Daiana Altamirano Ayala** is an Industrial Engineering graduate from the University of Lima, with professional experience in the commercial and insurance sectors. She currently works at Pacífico Seguros as part of the Product Management and Pricing team, where she continues to strengthen her analytical and strategic skills in product development and market analysis. Her role has enhanced her competencies in data analysis, process optimization, and pricing strategies, contributing directly to the company's commercial goals. In addition to her professional experience, her academic background has provided her with a strong foundation in operational efficiency and continuous improvement methodologies.Her research focused on the implementation of Lean Manufacturing techniques to improve productivity and quality in the textile industry. With a results-driven mindset and strong adaptability, she aims to continue growing professionally in the industrial and financial sectors, applying innovative solutions to optimize processes and drive sustainable business growth.

**Brenda Stephanie Dávila Segura** is a graduate of the University of Lima, Peru. She is part of the process simulation study group and has experience planning and controlling maintenance activities at Qroma, where she completed her pre-professional internship for one year. She also led meetings between the maintenance and production areas, managed daily and weekly performance indicators, and supported the supervision of the monthly budget. She is currently pursuing a PMO specialization to complement her knowledge and achieve her certification.

**Richard Nicholas Meza-Ortiz** is the Demand, Distribution and New Business Planning Lead of Ajeper, and additionally serves at the University of Lima as a Professor. Mr Meza is a qualified Industrial Engineer (University of Lima), and holds a Masters in Strategic Business Administration from Pontification Universidad Catolica Peru (PUCP). He has led multiple supply chain networks in multiple locations, both domestically and internationally for large bulk consumers, retailers, automotive industries and agricultural clients. He has been responsible for managing processes covering S&Op, Operations, Planning, Warehousing, Distribution planning, Procurement, Comex, Digital transformation and Reverse logistics.