

Increasing the Rate of Orders Delivered on Time by Applying Work Standardization and 5s In a Metalworking Company

**Jhon Hayro Condor-Ponce, Sebastián Matías Gutiérrez-Rabanal, Marcos Fernando Ruiz-
Ruiz and Juan Carlos Quiroz-Flores**

Carrera de Ingeniería Industrial
Universidad de Lima, Lima, Perú

20172023@aloe.ulima.edu.pe, 20211229@aloe.ulima.edu.pe, mruiz@ulima.edu.pe,
jcquiroz@ulima.edu.pe

Abstract

The on-time delivery rate in a metalworking company is a key indicator because it reflects operational efficiency, productivity, and customer satisfaction in an environment that requires strict adherence to manufacturing deadlines. In this type of company, delayed orders generate cost overruns, contractual penalties, and a gradual loss of competitiveness. The objective of this research was to increase the on-time delivery rate through the DMAIC methodology, implementing two industrial engineering tools: work standardization and the 5S methodology. To achieve this, an applied improvement design was developed, incorporating a computer simulation using Arena software and a controlled pilot test. The results showed that the on-time delivery rate increased from 36.7% to 73.3%, closing 62.8% of the technical gap relative to the sector. This improvement generated key benefits, such as reduced cycle time and rework, lower operating costs, better work organization, and enhanced process sustainability. The contribution of this research lies in providing a low-cost and highly applicable improvement model for small companies in the sector. Future research may replicate the model in other areas of the production process, assess the consolidation of the results, and further analyze the interaction among standardization, workplace organization, and operational performance in metalworking workshops with similar characteristics.

Keywords

On-time delivery, DMAIC methodology, Work standardization, 5s methodology, metalworking.

1. Introduction

The case study focuses on a Peruvian metalworking workshop dedicated to the fabrication of heavy-duty truck bodies and customized metal structures, which operates within the manufacturing sector under a make-to-order production strategy. This type of company plays an important role in the national economy; however, micro and small metalworking enterprises commonly exhibit operational informality, limited process control and high variability in production times, which negatively affect their productivity and delivery performance (Jara et al. 2023). Furthermore, on-time delivery is considered one of the most critical indicators in make-to-order environments, since customers expect strict compliance with promised dates to avoid operational disruptions and financial penalties (Rossini et al. 2019).

At the level of the sector, metalworking companies face recurring challenges related to material shortages, rework, low standardization and deficiencies in production planning. These issues generate delays, cost overruns and variability in operational results. While companies with established production systems achieve on-time delivery rates close to 95%, many small workshops struggle to maintain consistent performance due to the absence of standardized

work methods and limited workplace organization. These difficulties are aligned with findings in the literature, which highlight that small metalworking firms often lack continuous improvement practices and structured management tools that guarantee stable operational results (Qureshi and Mewada 2025).

Within this context, the company analyzed in this study experiences similar challenges. The workshop presents an average cycle time of 41 days, an on-time delivery rate of only 41.38%, and long search time for work tools. The economic impact of these delays is substantial. In 2024, the company incurred US\$ 10,413.96 in overtime payments, US\$ 233,500 in lost business opportunities mainly associated with the cancellation of a contract for six truck bodies, and US\$ 32,427.20 in penalties for late deliveries. These results demonstrate that delivery delays not only reduce profitability but also weaken the company's competitiveness and limit its ability to secure recurring contracts.

To better understand the causes of the problem, a diagnostic analysis was conducted. A Pareto chart revealed that the main contributors to the delays were the variability in processing times during the lower-body assembly stage, a high rework rate of 34.48 percent in the painting area, and excessive time spent searching for tools due to the lack of workplace organization. Complementary tools, such as the Ishikawa diagram and the problem tree, showed that these issues originate from the absence of standardized procedures, insufficient visual controls and limited order and cleanliness in the work environment. These findings correspond with previous studies indicating that metalworking workshops require structured methods to reduce variability and improve production reliability.

Based on the identified issues, this article seeks to analyze whether Work Standardization and 5S can improve the operational performance of the company by reducing cycle time, rework and delays. The study follows DMAIC methodology to ensure a systematic approach to problem identification, solution design and validation. The results obtained provide evidence of the relevance of standardized work and workplace organization for improving delivery performance in make-to-order environments. The following section presents the general objective and specific objectives that guide this research.

1.1 Objectives

- Diagnose the current situation of the metalworking sector and the operational problems affecting delivery performance in the case study.
- Design an improvement proposal based on Work Standardization and 5S to reduce delays, variability and rework in the production system.
- Validate the proposed solution and its sustainability through simulation and a pilot test, ensuring improvements in on-time delivery, cycle time and operational performance.

1.2 Literature Review

Several studies indicate that the metalworking sector in Latin America is characterized by operational informality, limited production planning and insufficient process control. These conditions generate delays, rework and low productivity (Jara et al. 2023). These problems are more frequent in micro and small enterprises, where the lack of standardized methods increases process variability and makes it difficult to meet delivery dates promised to customers (Mendoza-Galvis et al. 2024).

In make-to-order environments, the on-time delivery indicator is considered a critical factor for competitiveness, since customers depend on strict delivery dates to avoid operational disruptions and financial losses (Rossini et al. 2019). Recent research shows that on-time delivery levels below 80 percent affect commercial continuity and lead to frequent penalties, especially in metalworking workshops with variable production processes (Pianto-Hora et al. 2023). Other studies report that a significant part of total lead time is associated with non-productive activities such as waiting for materials, unnecessary movements and long tool search times. These inefficiencies are mainly linked to the lack of workplace organization and basic control mechanisms (Ingar Medina 2023).

Recent empirical studies highlight that work standardization plays a key role in reducing operational variability and strengthening process reliability in small and medium-sized manufacturing firms. Standardized methods improve repeatability, facilitate operator training, and reduce rework by establishing clear sequences and defined task parameters (Santos et al. 2021). In metalworking environments, evidence shows that implementing method and time standards in critical processes, such as assembly and painting, leads to reductions in cycle time and improvements in process stability, particularly in workshops with limited technological resources (Mendoza-Galvis et al. 2024).

Complementary literature also emphasizes the advantages of combining workplace organization tools such as 5S with process validation mechanisms like simulation. Studies demonstrate that 5S significantly reduces search time, eliminates unnecessary movements, and improves resource availability by establishing orderly and visually controlled work environments (Fitri and Putra 2024; Oleksiak et al. 2025). Likewise, discrete-event simulation has proven effective for evaluating improvement scenarios before implementation, allowing companies to estimate impacts on cycle time, bottlenecks and on-time delivery without interrupting production (Dias et al. 2022; Gunreddy et al. 2022). In addition, investigations highlight that SMEs often face barriers such as resistance to change and limited training, making pilot tests essential for validating feasibility and ensuring sustainability of the improvements (Maware and Parsley 2022).

2. Methods

The present research was categorized as an applied improvement case study, with a pre-test and post-test design, whose methodological sequence was structured in five phases. It is important to highlight that the methodological sequence is based on the DMAIC philosophy, which is a continuous improvement approach within the Lean Six Sigma methodology. This philosophy is defined by five stages: Define, Measure, Analyze, Improve, and Control, which allow the identified problems to be addressed in an orderly and systematic manner, ensuring the implementation of solutions that can be sustained over time (Daniyan et al. 2022). In this regard, each phase proposed in the present research was aligned with the principles of the DMAIC cycle, enabling an organized and structured intervention aimed at achieving concrete and measurable results

Additionally, it is worth mentioning that the conceptual model of the proposed solution is specifically located in the Improve phase of the DMAIC methodology. It is composed of two main components: standardized work and 5S, which not only address specific operational problems but also generate operational synergy when applied together, reinforcing the objectives of the proposed conceptual model. Furthermore, this study adopted an applied experimental and quantitative approach, as the improvement model based on standardized work and 5S was implemented directly in the operational environment of a metalworking workshop, and its effects were measured through performance indicators such as on-time delivery rate and cycle time. The following section details the phases corresponding to the methodological design.

2.1 Phase 1: System Characterization and Problem Definition

The first phase involved characterizing the operational system of the metalworking workshop through document review, field observation, and structured interviews with personnel involved in production activities. This information enabled the identification of recurrent operational issues, such as reprocessing, delays, disorganization, and lack of standardized methods. Based on this analysis, the main performance indicator of interest was defined as the on-time delivery rate. This KPI was compared with the sector benchmark, which indicates that metalworking companies typically achieve on-time delivery rates above 80 percent, whereas the studied workshop reported only 36.7 percent. This gap served as the central justification for designing and implementing the improvement model.

2.2 Phase 2: Measurement and Diagnostic Analysis

In this phase, quantitative data were collected to characterize the operational baseline. The primary data sources included production records, delivery logs, and direct time measurements. A Pareto analysis was carried out to identify the most relevant causes contributing to delays. The analysis revealed that more than 70 percent of late deliveries were associated with the absence of standardized procedures, disorder in work areas, and unplanned rework. The diagnostic process also included the construction of the problem tree to identify root causes and visualize their impact on the performance indicator (see Figure 1). This diagnostic served as the basis for selecting the improvement tools to be implemented during the experimental intervention.

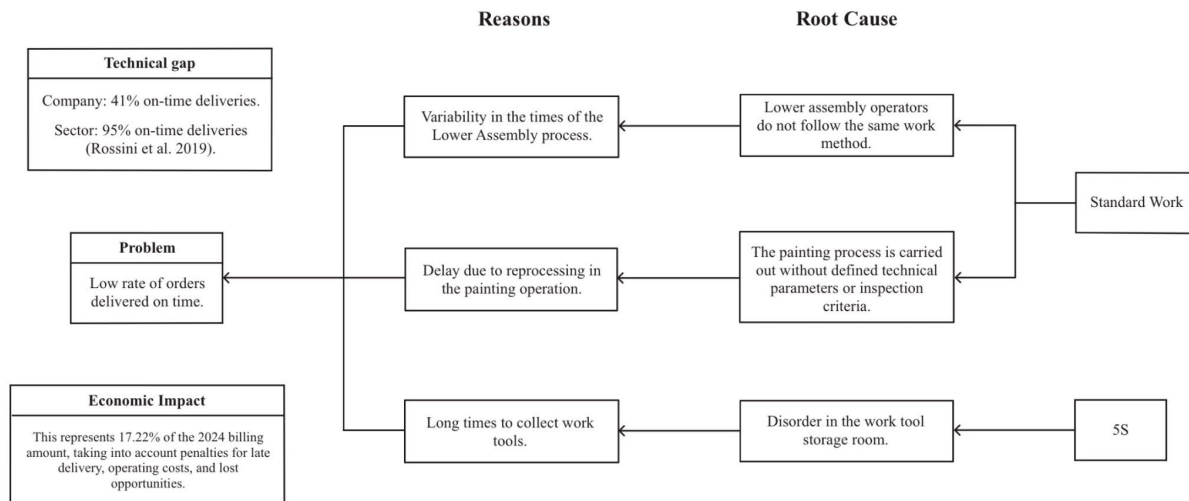


Figure 1. Root Cause Tree

2.3 Phase 3: Design of the Improvement Model

Following the diagnostic analysis, an improvement model was designed comprising two complementary industrial engineering tools: standardized work and the 5S methodology. The model was defined conceptually by detailing its components, expected interactions, and operational implications (see Figure 2). Standardized work focused on defining work sequences, establishing operational parameters, and eliminating variability in the execution of tasks. The 5S methodology focused on restoring order, cleanliness, and visual control to work areas, reducing waste and facilitating workflow stability. This phase also included the design of operational formats, procedures, and visual aids necessary for the implementation, ensuring the model's compatibility with the workshop's characteristics.

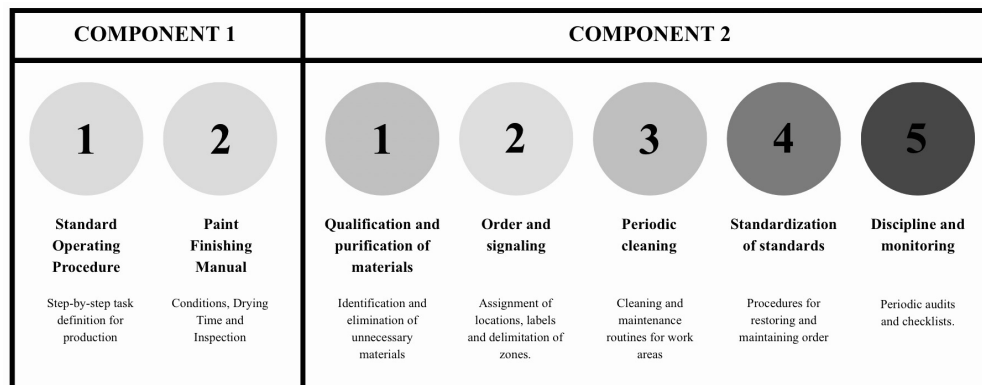


Figure 2. Simulated Model

2.4 Phase 4: Implementation and Validation Strategy

A controlled experimental implementation was conducted using a pre-test and post-test structure. The improvement model was installed in the operational environment of the company, and compliance with the new procedures and 5S practices was monitored throughout the intervention period. A discrete-event simulation in Arena was developed to validate the improvement model before its physical implementation. The simulation reproduced the workshop's production dynamics, allowing the evaluation of scenario performance and confirming the expected impact of the intervention on cycle time and the on-time delivery rate. The experimental process allowed the comparison of performance indicators before and after applying the model, ensuring methodological rigor in the validation of the proposal.

3. Results

3.1 Data Collection and Model Preparation

Data collection was carried out using structured procedures adapted to the validation needs of each component. For the Standardized Work intervention, operational times were recorded in the lower-frame assembly and painting processes (see Table 1). These areas were selected because they showed the highest levels of variability and had a direct impact on delivery performance. A stratified convenience sampling method was applied across multiple workdays, shifts, and operators. The collected times were consolidated in Excel and analyzed in the Input Analyzer module of Arena 16.1, where representative probabilistic distributions were identified. Outliers were reviewed and removed, and the distributions were compared with historical records and operator experience to ensure the reliability of the model parameters.

Table 1. Data collected from the lower assembly process times.

Nº	AS IS	TO BE	Units
1	10.39	6.61	min
2	10.74	6.30	min
3	11.34	8.19	min
4	11.60	7.44	min
5	10.55	7.09	min
6	11.43	7.13	min
7	11.29	6.67	min
8	9.81	6.03	min
9	9.92	6.69	min
10	10.11	7.47	min
11	11.74	6.82	min
12	12.14	7.29	min
13	8.58	6.96	min
14	9.32	6.18	min
15	11.53	6.79	min
16	9.92	7.65	min
17	10.92	6.54	min
18	11.69	7.21	min
19	9.90	6.34	min
20	9.99	7.77	min

For the 5S pilot, data collection was performed through direct observation in the tool storage area. The time required for each operator to locate and retrieve tools at the beginning of the workday was measured before and after the intervention (see Table 2). Normality tests were performed in Minitab, confirming that the AS-IS and TO-BE datasets followed a normal distribution, which allowed the use of parametric statistical tests in the analysis. This approach ensured that both the simulation model and the 5S pilot evaluation were based on reliable and consistent data.

Table 2. Data of tool collection times at the start of the workday

Nº	AS IS	TO BE	Units
1	6.91	2.32	min
2	8.35	2.98	min
3	8.77	3.32	min
4	9.14	2.25	min
5	8.09	3.59	min
6	8.86	3.07	min
7	8.73	2.77	min
8	7.54	3.24	min
9	7.67	3.74	min
10	7.89	3.77	min
11	9.33	4.12	min
12	9.77	3.30	min
13	6.18	3.15	min
14	7.14	2.27	min
15	9.53	3.47	min
16	7.68	3.14	min
17	8.50	3.56	min
18	9.64	3.06	min
19	7.65	2.84	min
20	7.73	3.71	min
21	7.94	3.03	min
22	9.70	3.96	min
23	7.42	3.48	min

3.2 Validated Results of the Standardized Work Component (Arena Simulation)

The Standardized Work component was validated through a discrete-event simulation built in Arena 16.1 (see Figure 3). The model represented the complete production flow of a furgón-type truck body, including material cutting, lower-frame assembly, suspension installation, upper-frame assembly, accessory installation, electrical and brake systems, and painting. A total of 30 replications were executed for both the AS-IS and TO-BE scenarios using different random seeds. The Output Analyzer module was used to compare indicators with 95 percent confidence intervals and paired differences analysis.

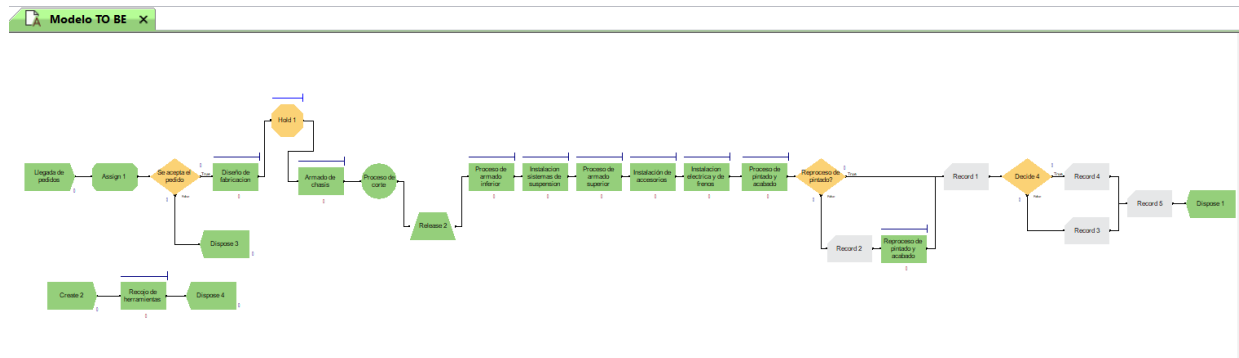


Figure 3. Simulated Model

The results confirmed the effectiveness of the Standardized Work intervention. The average cycle time decreased from 41.1 days in the AS-IS model to 38.0 days in the TO-BE model. The confidence intervals did not overlap, which confirmed statistical significance (see Figure 4). The on-time delivery rate improved from 36.7 percent to 73.3 percent. This increase reflected the stabilizing effect of standardized sequences on operational flow (see Figure 5). The reprocessing rate in the painting process decreased from 30.0 percent to 26.7 percent. Although the initial comparison showed overlapping intervals (see Figure 6), the paired differences test demonstrated a significant improvement in favor of the TO-BE model (see Figure 7). These results validate that the Standardized Work component effectively reduced variability and improved delivery reliability in the workshop.

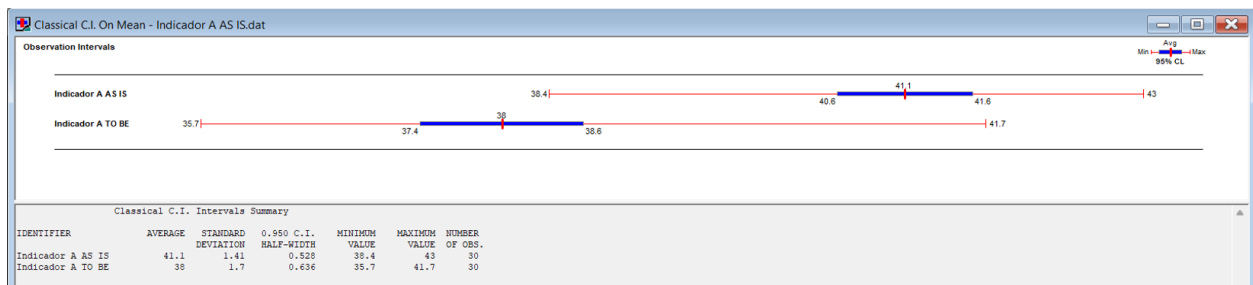


Figure 4. Comparison of average cycle time confidence intervals

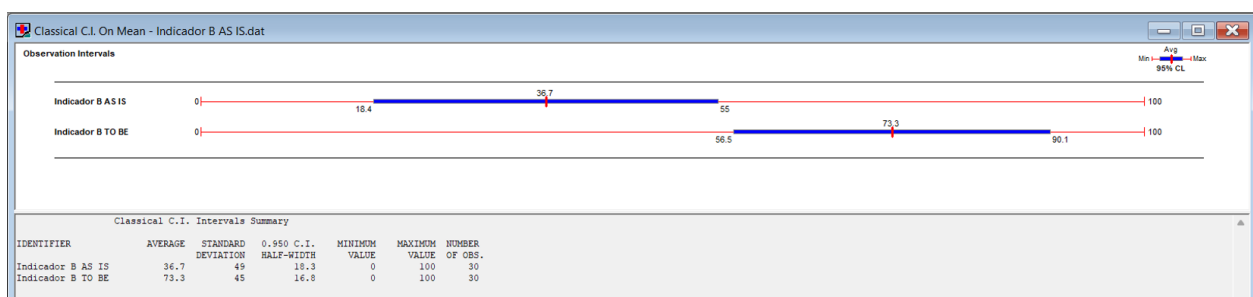


Figure 5. Comparison of on-time delivery rate confidence intervals

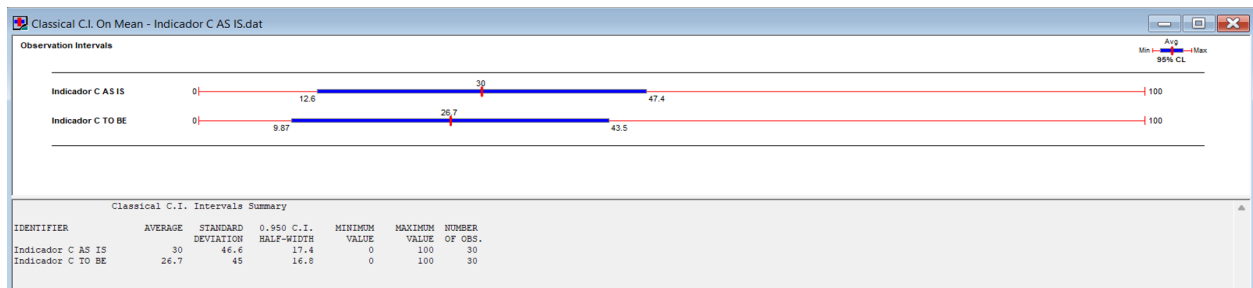


Figure 6. Comparison of reprocessing rate confidence intervals

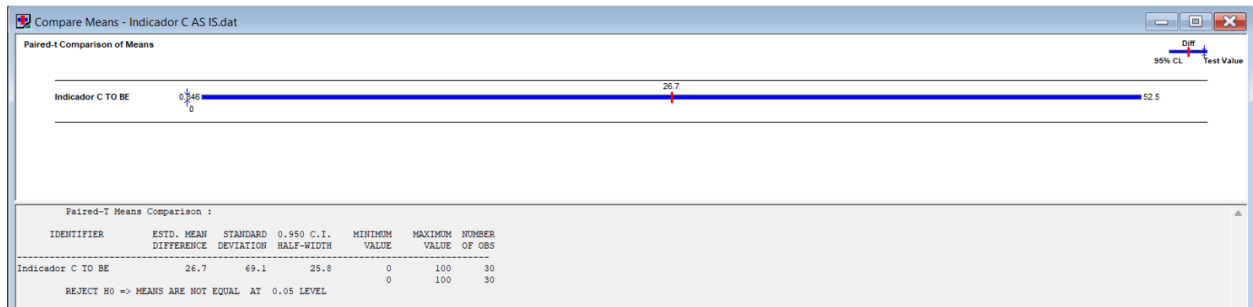


Figure 7. Paired differences test for reprocessing rate confidence intervals

3.3 Validated Results of the 5S Pilot Implementation

The 5S methodology was validated through a controlled pilot conducted in the tool storage area (see Figure 8 and Figure 9). This space was selected because tool search time represented one of the main sources of non-productive activity. The pilot implemented the full sequence of the 5S method, including sorting, order, cleaning, standardization, and discipline. Visual controls, fixed locations, checklists, and internal audits were incorporated as part of the intervention.



Figure 8. Tool storage before intervention

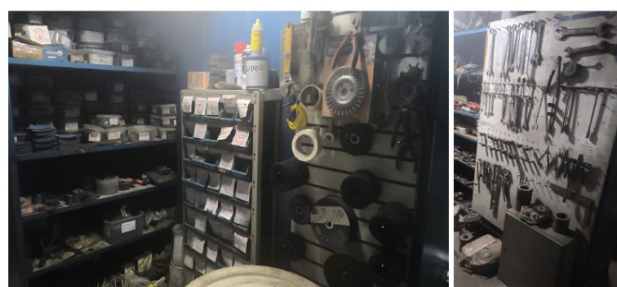


Figure 9. Tool storage after intervention

Statistical validation was performed using a two-sample t-test with 95 percent confidence. Prior normality tests demonstrated that both datasets were suitable for parametric analysis. The results showed a reduction in tool search time from 8.159 minutes in the AS-IS state to 3.191 minutes in the TO-BE state. The difference of 4.967 minutes was statistically significant, as indicated by a p-value of 0.000 (see Table 3). This confirmed that the 5S implementation reduced unnecessary movements, improved workspace organization, and strengthened operational discipline among workers. The validated results demonstrate that the pilot produced measurable and sustained improvements, supporting the future expansion of the 5S methodology to other areas of the workshop.

Table 3. Statistical validation of the 5s intervention

Sample	N	Average	Standard deviation	Standard error of the mean	Difference	95% CI for the difference	T value	GL	P-value
AS IS	60	8.159	0.951	0.12	4.967	(4.698, 5.237)	36.60	83	0.0000
TO BE	60	3.191	0.447	0.058					

3.4 Integrated Validation Summary

This section concludes the validation stage of the improvement model. The results obtained through the Arena simulation for the Standardized Work component and the pilot test for the 5S methodology provided consistent and reliable evidence of their functional effectiveness (see Table 4). Each validation method generated measurable improvements aligned with the operational issues identified in the diagnostic phase, ensuring that both components are feasible and applicable within the workshop's real conditions. These validated findings establish a robust foundation for the subsequent discussion of benefits, implications, and the extent to which the proposed model contributes to reducing the performance gap.

Table 4. Table of Indicators and Validation of the Improvement Proposal.

Indicator	Target	AS-IS	TO-BE
OTD (Orders Delivered on Time)	Increase compliance in on-time deliveries to the customer.	36.7%	73.3%
Average Cycle Time	Standardize processes to reduce variability and improve operational efficiency.	41.1 días	38 días
% of reprocessing in painting	Reduce the amount of rework generated in the painting area.	34.48%	26.7%
Average tool search time	Reduce the time spent searching for tools.	8.159 min	3.191 min

4. Discussion

The results obtained in this study confirm that work standardization and the 5S methodology had a positive impact on the operation of the metalworking shop, although the magnitude of the effects was conditioned by the company's specific characteristics. The increase in the On-Time Delivery indicator (from 36.7% to 73.3%) and the reduction in cycle time (from 41.1 to 38 days) demonstrate that the reduction in operational variability was a decisive factor in

improving performance, mainly in the bottom assembly and painting processes, where the lack of formal procedures generated inconsistencies. This behavior coincides with the trend noted by Heinzova et al. (2024), who demonstrated that companies with documented processes register higher levels of on-time delivery. Similarly, the reduction in the percentage of rework in the painting operation observed in the simulation supports the claim of Santos et al. (2021), who identified that standardized routines allow for the elimination of non-value-added tasks and a more balanced workload among operators. In this sense, the proposal implemented in the case study largely coincides with the findings in the literature and reaffirms the relevance of standardization in highly variable environments.

Regarding the 5S component, the pilot results, with a reduction in tool search time from 8,159 to 3,191 minutes, show a clear convergence with findings reported in studies such as those by Fitri and Putra (2024) and Oleksiak et al. (2025), who highlight this methodology's ability to reduce waste and operating time. However, some differences were also identified: the magnitude of the improvement observed in this study was less than in plants with more mature lean practices, which may be due to the structural limitations of a small metalworking company operating with limited resources and a predominantly experienced workforce.

Additionally, the resistance to change detected during the diagnostic phase aligns with the literature of Maware and Parsley (2022) and Habek et al. (2023), who emphasize that a lack of effective communication and a poor understanding of the benefits create barriers to adoption. In the case analyzed, while training and staff participation reduced these barriers, the sustainability of the results continues to depend on the organization's cultural maturity. Overall, the discussion shows that the results are consistent with previous studies, but also demonstrates that the impact of the tools is conditioned by the level of operational structure and the company's organizational culture.

5. Conclusion

The initial situation analysis revealed that the metalworking company in the case study exhibited problems similar to those reported in the sector, including low productivity, high operational variability, a high rework rate, and poor on-time delivery performance. The production process showed significant delays and a lack of standardization, resulting in a reduced On-Time Delivery (OTD) of 36.7% and an average cycle time of 41.1 days. These findings highlighted the need for intervention through the use of engineering tools to control variability, reduce downtime, and improve the reliability of the production system.

Based on the analysis, an improvement proposal was designed focusing on standardizing work processes for the bottom assembly and painting, complemented by the implementation of the 5S methodology in the tool room. Both solutions were validated through simulation and pilot testing, demonstrating significant improvements in operational performance. The OTD increased to 73.3%, the cycle time was reduced to 38 days, rework in the painting operation decreased significantly, and tool search times dropped from 8,159 minutes to 3,191 minutes.

To ensure the long-term sustainability of the proposal, it is recommended to strengthen ongoing operator training, periodically update standardized procedures, and appoint leaders who promote operational discipline and full compliance with the 5S methodology. Additionally, it would be beneficial to progressively extend the implementation of these tools to other areas of the metalworking shop and evaluate the use of real-time monitoring technology to reduce variability and consolidate a culture of continuous improvement.

References

- Daniyan, I., Adeodu, A., Mpofu, K., Maladzhi, R. and Kana-Kana Katumba, M. G., Application of lean Six Sigma methodology using DMAIC approach for the improvement of bogie assembly process in the railcar industry, *Heliyon*, vol. 8, no. e09043, 2022.
- Dias, A. S. M. E., Antunes, R. M. G., Abreu, A., Anes, V., Navas, H. V. G., Morgado, T., and Calado, J. M. F., Utilization of the Arena simulation software and Lean improvements in the management of metal surface treatment processes, *Procedia Computer Science*, pp. 140-147, Oporto, Portugal, March 9-11, 2022.
- Fitri, T. Z. and Putra, R. D. E., Implementation of 5S in the Manufacturing Industry, *Journal of Engineering Science and Technology Management*, vol. 4, no. 2, pp. 76–82, 2024.
- Gunreddy, N., Gupta, I., Poddar, I., Menon, A. P., Srivastava, R. and Saxena, A. K., Bottleneck analysis for gear manufacturing unit by using discrete event simulation using ARENA, *Proceedings of the International Conference*

- on Product Design, Development, and Deployment (PDCUBE-2021), pp. 020003-1–020003-12, Vellore, India, September 10–12, 2021.
- Habek, P., Lavios, J. J. and Grzywa, A., Lean manufacturing practices assessment: Case study of automotive company, *Production Engineering Archives*, vol. 29, no. 3, pp. 311–318, 2023.
- Heinzova, R., Hoke, E. and Janova, N., Lean management methods: Evidence from the manufacturing industry in the Czech Republic, *Problems and Perspectives in Management*, vol. 22, no. 3, pp. 517–527, 2024.
- Ingar Medina, C. A., Lean Six Sigma y mejora de la productividad en el servicio de reparación de equipos de minería en una empresa metalmeccánica, *Industrial Data*, vol. 26, no. 2, pp. 239–265, 2023.
- Jara, B., Calderon, S. and Avalos-Ortecho, E., Application of lean manufacturing to increase productivity of a company in the metalworking sector, *Industrial Engineering and Applications*, vol. 35, pp. 740–753, 2023.
- Maware, C. and Parsley, D., The challenges of lean transformation and implementation in the manufacturing sector, *Sustainability*, vol. 14, no. 6287, pp. xx–xx, 2022.
- Mendoza-Galvis, D. J., Vega-Molina, A. L., Pumarejo-Sanchez, J., and Zambrano, C. M., Sector metalmeccánico: una propuesta de diseño de estándares de métodos y tiempos, *Aibi revista de investigación, administración e ingeniería*, vol. 12, no. 1, pp. 99-108, 2024.
- Oleksiak, B., Żyszczyński, M., and Micor, K., 5S method usage for the improvement of production process in the manufacturing company, *Management Systems in Production Engineering*, vol. 33, no. 3, pp. 354-361, 2025.
- Pianto-Hora, G., Trevejo-Torres, A. and Quiroz-Flores, J., Improvement model to reduce defective parts in the hinge line of a Peruvian metalworking SME using lean manufacturing tools, *Proceedings of the 21st LACCEI International Multi-Conference for Engineering, Education, and Technology*, pp. xx–xx, Buenos Aires, Argentina, July 17–21, 2023.
- Qureshi, K. M. R. and Mewada, B. G., Assessing Lean barriers for Lean 4.0 implementing in small and medium-sized enterprises (SMEs): a combinatorial approach of CoCoSo and fuzzy DEMATEL, *Frontiers in Engineering and Built Environment*, vol. 5, no. 3, pp. 227-248, 2025.
- Rossini, M., Audino, F., Costa, F., Cifone, F. D., Kundu, K., and Portioli-Staudacher, A., Extending lean frontiers: a kaizen case study in an Italian MTO manufacturing company, *International Journal of Advanced Manufacturing Technology*, vol. 104, pp. 1869-1888, 2019.
- Santos, D. M. C., Santos, B. K. and Santos, C. G., Implementation of a standard work routine using Lean Manufacturing tools: A case study, *Gestão & Produção*, vol. 28, no. 1, e4823, 2021.

Biographies

Jhon Hayro Condor-Ponce holds a Bachelor's Degree in Industrial Engineering from the Universidad de Lima (UL). He has experience in supply chain and operational processes, focusing on inventory management, demand analysis, procurement coordination, and logistics optimization. He has a strong interest in supply chain management and continuous improvement, with competencies in data analysis, KPI monitoring, process mapping, and the identification of efficiency opportunities that support strategic decision-making in planning, procurement, and distribution activities.

Sebastián Matías Gutiérrez-Rabanal holds a Bachelor's Degree in Industrial Engineering from the Universidad de Lima (UL). He has experience in the commercial area, focusing on sales analysis, data collection at points of sale, coordination of commercial events, and stock management. He has a strong interest in commercial and marketing fields, with competencies in data analysis, performance indicator monitoring, and the identification of improvement opportunities that support strategic decision-making. Additionally, he has experience working with data analysis tools to transform commercial information into actionable insights. He is motivated by continuous learning and by contributing to data-driven strategies that enhance business performance and customer value.

Marcos Fernando Ruiz-Ruiz holds a Degree in Industrial Engineering and a PhD in Education Sciences from Pontificia Universidad Católica del Perú (PUCP). He is currently Associate Professor of the Research Methodology Projects Area of the Faculty of Engineering at Universidad de Lima (UL). He holds a Postgraduate Certificate (Expert Diploma) in Future Studies from UNED (Spain). He is a Renacyt researcher accredited by the National Council of Science and Technology of Peru (Concytec). Additionally, he is a member of several professional organizations,

including the Ibero-American Chapter of the World Futures Studies Federation (WFSF), the Peruvian Society for Educational Research (SIEP), the College of Teachers of Peru (CPP) and the College of Engineers of Peru (CIP).

Juan Carlos Quiroz-Flores holds a PhD in Business Management from UNMSM, an MBA from ESAN, and a Degree in Industrial Engineering from Universidad de Lima. He completed postgraduate studies in Operations Management at ESADE Business School (Barcelona, Spain). He is a Renacyt-accredited researcher by the National Council of Science and Technology of Peru (Concytec) and a lifetime member of Beta Gamma Sigma as well as a full elected member of Sigma Xi. He is currently a professor and researcher in Lean Supply Chain, Operations Management, and Process Improvement, with more than 25 years of professional experience, and has published in Scopus and Web of Science-indexed journals while serving on editorial boards of international scientific publications. Additionally, he is a Certified Lean Six Sigma Black Belt and a member of several professional organizations, including IEOM, IISE, ASQ, IEEE, ACM, and the College of Engineers of Peru (CIP).