ISBN: 978-628-95207-8-1. ISSN: 2414-6390. Digital Object Identifier: 10.18687/LACCEI2024.1.1.453

Application of 5S and standardized work to improve labor productivity: Case of textile SME

Johan Raul Romero-Parra, Bach.[1], Felipe Gastón Tataje-Sanchez, Bach.[2], and Richard Nicholas Meza-Ortiz, MBA[3]

[1,2,3] *Facultad de Ingeniería Industrial, Universidad de Lima, Av. Javier Prado Este 4600-Santiago de Surco, 15023, Lima, Perú,*
20191762@aloe.ulima.edu.pe, 20191979@aloe.ulima.edu.pe, *rnmeza@ulima.edu.pe*

Abstract– Textile sector in Peru is composed mostly by SMEs and 76% of these enterprises are informal businesses, whose main characteristic is low labor productivity that affects competitivity and profitability. With this in mind, the aim of this study was to increase the labor productivity in a Peruvian textile SME using a Lean Manufacturing methodology through 5S and Standardized Work in four processes: classification, ironing, finishing and packaging. Validation methodology consist in simulation trough Arena software using data which was collected by pilot testing. The results showed an increase in productivity of 5% (from 8.05 to 8.45 blazers/man-hour), an improvement in time efficiency of up to 96%, a reduction of the delay time for unnecessary transport and movements in 62.95% using 5 S, as well as a reduction in the standard time of 9.57% with Standardized Work.

Keywords—Labor productivity, SME, textile sector, 5S, standardized work, value stream mapping, process improvement, simulation, pilot testing

I. INTRODUCTION

Textile sector in Peru is composed by 95% of small and medium-sized enterprises (SMEs), and only 24% of these enterprises are correctly registered [1]. Also, during 2016 to 2020, textile sector contributed 6.3% to PBI of manufacturing sector, proving to be an important element in Peruvian economy.

Following fashion trends, respond to orders quickly, pricing and order fulfillment is fundamental to be competitive in dynamic textile industry [2, 3]. However, it is difficult to achieve these standards being a SME that uses traditional production methods [4], makes decisions with minimal investment in research [5], does not carry out planning, is disorganized in the processes or procedures [6], and suffers from a lack of quality culture among collaborators [7].

Labor productivity, according to Peruvian Ministry of Production [1], is the relation between total production and number of workers. Furthermore, if we compare the productivity of the sector, it is found that SMEs have a productivity equivalent to almost 23% of the productivity of large companies. Given the enormous technical gap between organizations, the application of a project to improve productivity in SMEs is appropriate considering their role in the national economy and their ability to generate employment.

Digital Object Identifier: (only for full papers, inserted by LACCEI).
ISSN, ISBN: (to be inserted by LACCEI).
DO NOT REMOVE

Two famous Lean Manufacturing tools to solve this gap are 5S and Standardized Work. The first methodology obtains cleaned and organized spaces, and allows to maintain it in that way with a sustained, functional, pleasant and safe manner only in 5 steps: Seri, Seiton, Seiso, Seiketsu and Shitsuke [8]. On the other hand, Standardized work aims to define and organize a set of activities of a process. As a result, it is obtained a more effective and efficient procedure which reduces variability and defects in the processes, and provides flexibility by having an orders visual scheme of the process.

The goal of this research aims to increase labor productivity in a SME textile trough an improvement proposal composed by 5S, Value Stream Mapping and Standardized work.

This document is divided into four sections. The first section will present a literature review, it consists of searching and collecting previous cases in the textile sector that serves as inspiration for the proposed model. The second section will detail the methodology and tools used to solve the main problem. The third section will focus on the validation of the model proposed using a simulation and the discuss of results through key performance indicators. Finally, the last section presents conclusions which are the most important findings respect to the objectives stated.

II. STATE OF ART

Many authors agree on the favorable productivity effects from different perspectives. High productivity levels provide good results for organizations [9, 2], impact on profitability (internal level) and competitive advantage (external level) [10]. Therefore, this concept plays an important role in the strategic planning of the organization. In addition, earnings are considered an important indicator to measure the growth and development of an organization. Therefore, it is clear that output will give small businesses the edge they need to move into competitive areas with better results. The authors also found a strong relationship between productivity and lean manufacturing.

Reduction waste is a key objective for building Lean [11] and for that reason, organizations use different technologies, methods and resources to increase productivity levels in different processes. Lean manufacturing methods have proven to be very effective in reducing production cycle times. A variety of lean tools are used when applying a lean manufacturing model. Before designing, many authors agree that value stream mapping should be used to examine the current state of the organization, and its future after the implementation of the improvement model [12, 13,14, 15]. The authors explain that this tool allows you to visualize process flows and identify possible activities that do not add value. Ukey et al. [16] proposed a lean manufacturing model using Kanban, 5S, and Kaizen and the result was an 8% increase in productivity within 30 days of implementation at Textile SME.

To reduce the time, SMED technology was introduced into the improvement model. Mejia-Carrera and Rau-Álvarez [17] show how the preparation time of the rubber machine was implemented in a textile SME in Lima, Peru. Also, 5S is the first tool that small and medium-sized companies prefer to use for lean manufacturing implementation throughout their production system, because it is easy to work in an organized and clean environment [18]. It should be noted that factory layout planned with 5S reduces travel distances and ensures the availability of materials and tools [18, 19]. As a result, efficient plant layout can also save time and reduce costs [19].

In summary, productivity affects the level of financial development, competition and management. Increase the productivity is achieved by reducing all activities that do not create value, and LEAN techniques are one of the best ways to increase productivity.

III. Methods

This is quantitative applicative research. The methodology is developed in the proposed model, which is depicted in Figure 1, and consists in four phases: diagnosis, implementation of standardized work, implementation of 5S, and evaluation of results. This methodology follows the Deming Cycle of continuous improvement and the philosophy of Lean Manufacturing.

Phase 1 Diagnosis

The textile SME company fabricates batches of garments each month because it adopts a business-to-business approach, offering an extensive range of blazer models, colors, and sizes to other companies in the Gamarra Commercial District. It is noteworthy that the garment production is outsourced, a strategic decision aimed at cost optimization and efficient utilization of workshop. We collected a sample from production data in the period from February to June of 2022, data of work shifts and number of workers. As a result of that, we can visualize the evolution of labor productivity (blazers over man-hours) in Figure 2, which shows that average productivity has a value of 9.10% lower than the maximum historical.

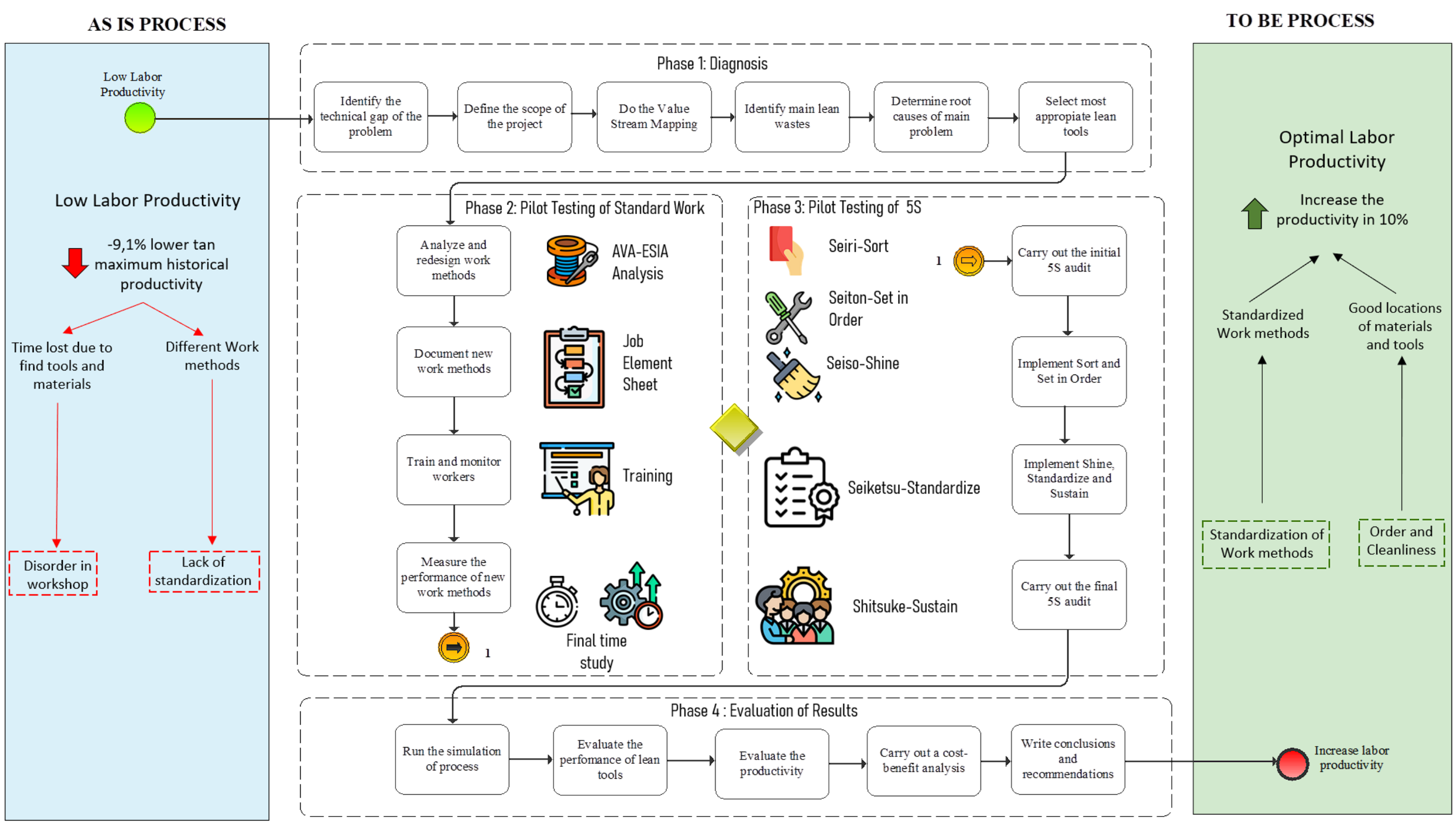

Fig. 1 Macro Design of improvement proposal

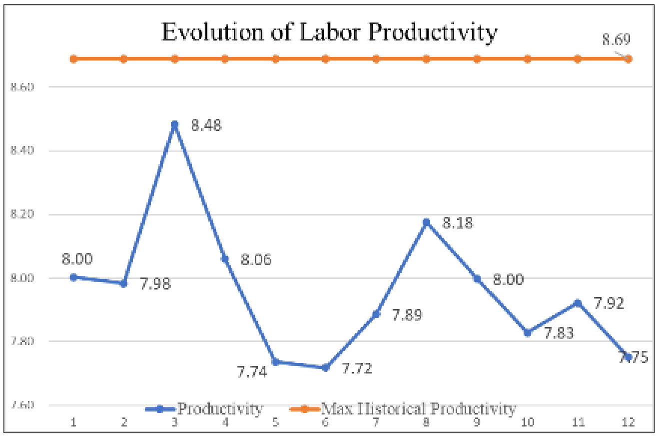

Fig. 2 Evolution of Labor Productivity

Step 1: Selection of principal product family

The proposed lean manufacturing model will apply to the main product family. Pareto diagram allowed us to select the principal product family: female blazers. In Figure 3, we can see the process diagram of fabrication; so, we focused on the following set of activities: classification, finishing, ironing, and packaging (subprocess 2).

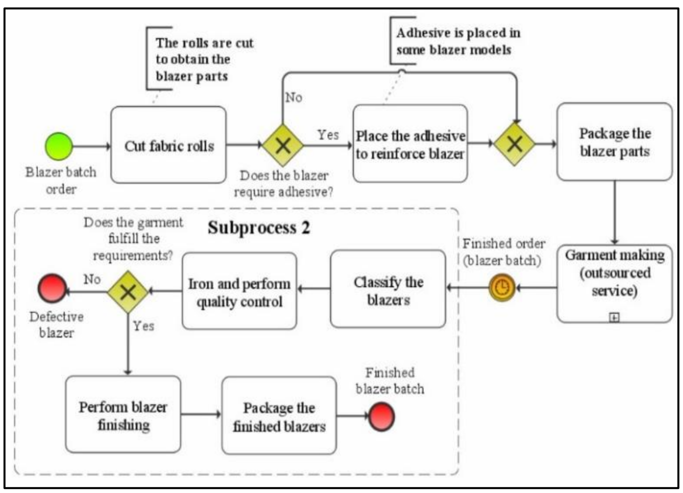

Fig. 3 Flow Chart of the Garment Process

Step 2: Current VSM

Value Stream Mapping was the diagnosis tool. Eight different lean wastes were identified with red circles (as shown in Figure 4), all of which affect productivity just as explained in the state of the art. Those wastes were grouped by similarity in Figure 5. Using the data from time study, we associated each group with non-added value time: the first group (blue) of "non-standardized work" represents 7% of total time, and the second group (green) of "disorder of workplace" represents 6%.

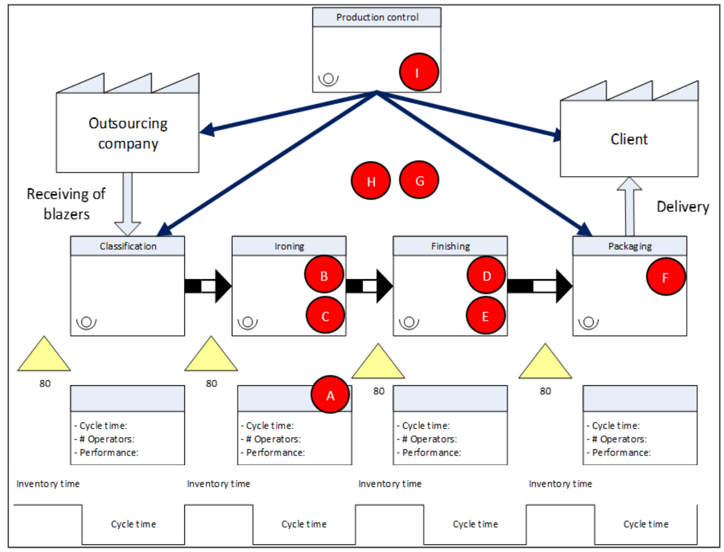

Fig. 4 Current Value Stream Mapping

Item	Identified Lean waste	Classification
A	Inefficient work methods	Waiting
B	The hanger furniture is located away from the workstati	Motion
C	Workers move clothes hangers to workstation	Transport
D	Many finished products in work table	Inventory
E	Defective blazer	Defects
F	Other materials area placer in the work table	Motion
G	Disorder in textile workshop	Motion / Transport
H	Lack of training in work methods	Wasted Human Resources
I	Inefficient production control	Waiting

Fig. 5 Lean Waste Identified

Step 3: Determination of root causes

We utilized the tree problem, that we developed in Figure 5, and the 5 Whys to determine the root causes of these two main subproblems that impact in productivity. Figure 6 illustrates that two root causes were found: lack of guidelines for order and cleanliness, and the lack of documentation and training of work methods.

When the root causes were identified, we can select the most appropriate tools to address them.

Step 4: Selection of tools

We worked with the results of tree problems and the state of the art to determine the most appropriate lean tools. According to state of art, we implemented 5S for the first cause [11, 20]. Also, standardized work is identified as the lean tool to solve the second root cause [9, 21]. In addition, we include a "Visual Control" as part of 5s to support the task of production supervision [16].

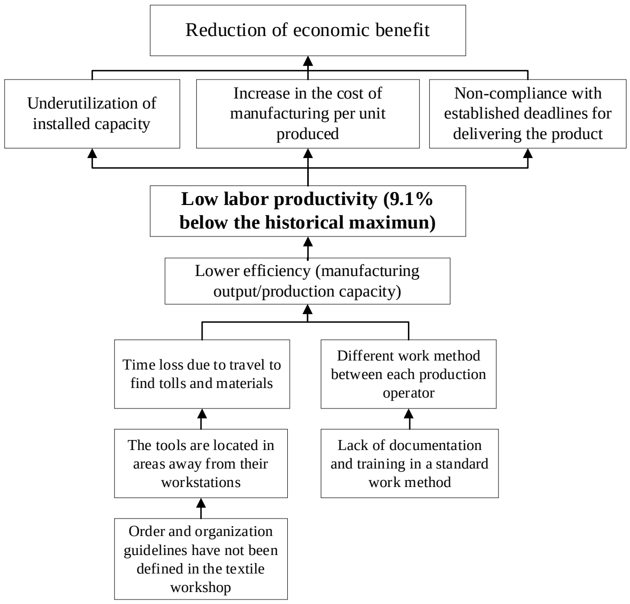

Fig. 6 Tree Problems Diagram

Step 5: Lean Key Performance Indicators

We need indicators to measure the impact of the improvement proposal. We calculated indicators of the current process and the future process, which will be improved through lean tools. In table I, we defined the following indicators.

TABLE I
LEAN KEY PERFORMANCE INDICATORS

Lean Tool	Metrics	Unit
Standardized Work	Standard Time and standard deviation	Minutes
Five S	Wasted time for unnecessary transport and movements	Minutes
Proposed Model	Labor Productivity	Blazers / HH

The indicators are expected to achieve the following results: reduction of wasted time in 45%, reduction of standard time of each activity in 20%, reduction of standard deviation, and increase the labor productivity in 10%.

Phase 2: Implementation of Standardized Work

Step 1: Time Study

Time study is a tool that can determine the performance of worker activities, also it helps to determine how much time is dedicated for non-added value activities. This information is the base for the improvement of working methods; so, we measure times from the subprocess 2.

First, we defined the working methods and started to measure times, this data was processed to determine standard times for each activity. After that, we determined the statistical sample size for the study. Finally, we collected enough samples to have a representative study. As a result, we got standard times (table II) and standard deviation from each activity of subprocess 2.

TABLE II
STANDARD TIMES OF ACTIVITY IRONING

Activity	Tasks of activity	Standard Time (min)
Ironing	1. Iron the collar of the garment	0.54
	2. Iron the front section of the garment	1.5
	3. Iron the back section of the garment	1.2
	4. Iron the sleeves of the garment	0.6
	5. Place the garment on clothes hangers	0.3
	Waiting Time	**1.1**

Step 2: Added-value Analysis

In this step, we did the added value analysis. We classified the tasks from each activity in 3 types of activities: valued-added activities (VA), value-added for enterprise activities (VAE), and non-value-added activities (NVA). One key indicator is the added value ratio which is described in the following formula: Added value ratio = Added value Time / Total Process Time

If the ratio is greater than 79%, it means that the activity has a good performance. The objective is the implementation of actions according to the kind of activity.

Step 3: Redesign of work methods

In this step, we utilized the methodology ESIA, which allowed us to select the following corrective action for each task: eliminate, simplify, integrate, or automate.

For example, in table III, we used the AVA-ESIA methodology for activity “Ironing blazer”. So, we proposed the following possible corrective actions:

a) Eliminate waiting time: lean wasted generated by interruptions.
b) Simplify the procedure of “Iron the front and back section” because the task had the longest time duration.

TABLE III
AVA-ESIA ANALYSIS

Activity: Ironing					
Tasks	**Standard Time (min)**	**Classification**	**Eliminate**	**Simplify**	**Integrate**
Iron the collar of the garment	0.54	VA			
Iron the front section of the garment	1.5	VA		X	
Iron the back section of the garment	1.2	VA		X	
Iron the sleeves the garment	0.6	VA			
Place the garment on clothes hangers	0.3	VAE			
Waiting Time	**1.1**	**NVA**	X		

Step 4: Documentation

Organization must identify and document knowledge which includes the best textile practices for the execution process [22].

As a result of previous activities, we could define a work method which is composed by basic, sequential and added-value activities. We decided to document methods using a simple and didactic format “Job Elements Sheet”.

Job Elemenet Sheet - 001		
Activity: Ironing	Area: Ironing Work Station	Approval date: 30/08/2023
Process Goal: Iron the blazer for packaging.		Author: Thesis student
Graphical Representation of Task	Procedure (list of tasks)	Observations
	1. Iron the collar of the garment	- Key Points - Key Safety Points - Tools
	2. Iron the front section of the garment	- Key Points - Key Safety Points - Tools
	3. Iron the back section of the garment	- Key Points - Key Safety Points - Tools
	4. Iron the sleeves of the garment	- Key Points - Key Safety Points - Tools
	5. Place the garment on the clothes hangers	- Key Points - Key Safety Points - Tools

Fig. 7 Job Elements Sheet of Ironing

Figure 7 illustrates the format for the activity Ironing. The document divided “Ironing” into five tasks. Each task has a description, a graphic (using tools or equipment) and an observation section for key points and safety recommendations.

Step 5: Validation and Implementation of redesigned methods

We validated the redesigned methods using a checklist, depicted in Figure 8. The validation must ensure that those procedures are aligned with quality product requirements and are an understandable tool.

Checklist to validate the Job Element Sheet	YES	NO
1. Does the document compliance requeriments?		
It contributes to achieve a quality product	X	
It considers best textile practices or techniques	X	
The document contains process controls	X	
2. Can workers understand the document?	X	
The instructions are understandable for workers	X	
The graphics are understanble for workers	X	
3. Does the document have an appropiate structure?		
The sequence of tasks is well defined	X	

Fig. 8 Checklist of Job Elements Sheet

To implement the new methods, it`s necessary to do training and support for workers. The improvement model proposes training including the following topics: presentation of the improvement project, presentation of operation and quality standards, structure Job Element Sheet, improved methods, practical demonstration of each method, and a question round.

It should be noted that standardization requires that workers develop and reinforce competencies, so we will carry out accompaniment to support them. Furthermore, it was proposed to carry out weekly practical evaluations.

Step 6: Measurement and Evaluation

When operators have acquired enough experience, the impact of the lean tool should be measured. Then, a second Time Study will be carried out to determine the standard time of the four activities, those times will be compared with their initial values. Moreover, it will be measured the standard deviation and added value rate.

This last step functions as feedback, so it can identify the impact of redesigned work methods.

Phase 3: Implementation of 5S

To begin, a first audit was carried out in the current process. We made a checklist according to the physical conditions of the textile workshop, including questions to evaluate 5S. A radar diagram is used to visualize the results of initial audit; this diagram help us to identify specific actions for each S.

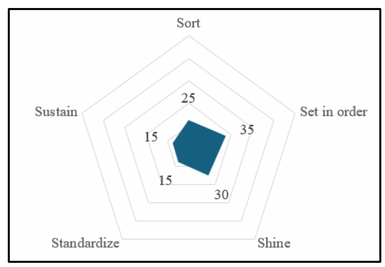

Fig. 9 Radar Diagram of initial audit

Step 1: Sort

Beginning with Sort, we identified items from each area using red cards. After that, we decided to take actions according to necessity: eliminate, replace, repair, keep.

Red card			
Area:			
Date:		Work shift:	
Responsable:			
Material:			
Quantity:			
Action Plan			
Discard			
Move		to	
Repair			
Recycle			
Other			

Fig. 10 Example of Red Card

Step 2: Set in Order

Figure 11 showcases an example where designated locations were determined for each sorted item. Also, signs and labels were designed with a double mission: guiding users to specific items and defining spaces.

Fig. 11 Organization of thread material

Step 3: Shine

A shining program was designed including the tasks for each operator and shifts. The program looked to do a general cleaning. For machines, we identified dirty spots and hard-to-reach places. The idea was creating cleaning procedures that can be used by operators to clean the machines.

Step 4: Standardize

The plan was to make a poster to delimit the different areas of the textile workshop. In addition, visual controls were designed for materials, so operators could control stock. As a part of "Standardization", we proposed to implement a Kanban board in a whiteboard; this tool can help the manager to control the production of blazers.

Step 5: Sustain

For the last step, it was proposed to do training to reinforce the good practices for 5S and monthly meetings will be held to evaluate the performance. This stage is crucial to guarantee the application of 5S for the next years. It´s important to emphasize the benefits of workers training.

At last, it was scheduled a second audit with the same methodology to evaluate 5S after the implementation. Results will be evaluated, and feedback will be given to the workers.

IV. Validation and Discussion

Methodology of Validation

In this chapter, we explain the detail of proposed improvement execution and the impact measurement. The chosen methodology to validate the proposed model is a simulation using the software *Arena Simulator*, which allowed us to validate the current process and determine the results and effectiveness from the future process [18].

We designed the current process flow chart (Figure 12), this process focuses on the best-selling blazer model.

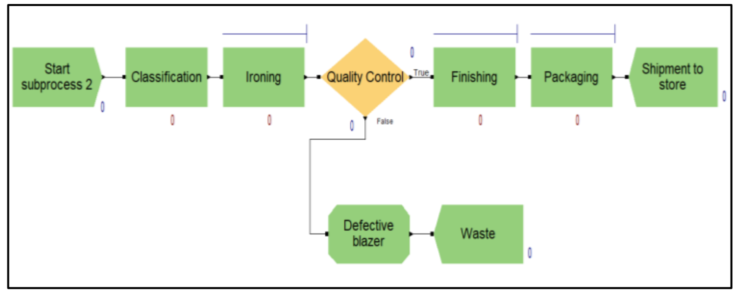

Fig. 12 Simulation Diagram of AS IS Process

In the current diagram, we identified that quality control is executed after ironing of blazers and this control should be done in the first activity "Classification of Blazers" to prevent processing defective blazers.

In Figure 13, the proposed flow chart is presented including the changed identified. Furthermore, we could reduce the cycle time by eliminating activities that do not generated added value (AVA-ESIA analysis). The implementation of 5S allowed the reduction of times dues to unnecessary transport or movements.

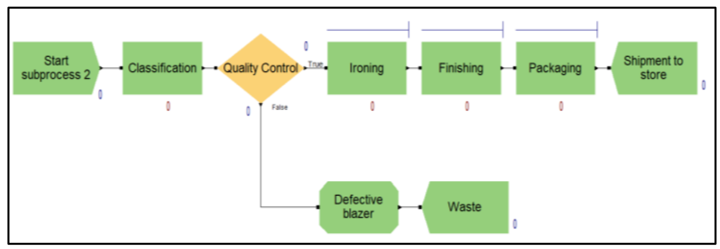

Fig. 13 Simulation Diagram of TO BE Process

In the simulation, we developed two scenarios: current "As Is" and proposal "To Be". We used data of standard times from the first Time Study (part of diagnosis). For the second scenery, we worked with the most real data possible. We implemented a small pilot testing which consists in organization of the workstation and location of tools and material, training in more efficient work methods without non added value tasks.

Consequently, we collected samples, and we could calculate standard times and waiting times. This data was supplied to Arena with the aim of simulating the execution of optimized productive process with lean tools.

In table IV, we can check main indicators for the scenarios:

TABLE IV
RESULTS OF SIMULATION

Value	AS IS Scenery	To Be Scenery
Cycle Time	7.51 minutes /blazer	6.79 minutes / blazer
Production	620 blazers	651 blazers

Discussion

In this section, we are going to discuss the results of simulation including the evaluation of indicators, which measure the impact of the improvement proposal.

Evaluation of 5S results

The tool 5S was implemented focus in reducing delay time dues to unnecessary transports and movements; delay time reduces the production time of workers. The results are presented in table V.

TABLE V
RESULTS OF 5S IMPLEMENTATION

Delay time due to unnecessary transport and movements					
Activity	**Unit**	**AS IS**	**TO BE**	**Real Variation**	**Expected Variation**
Classification	Minutes	11.04	3.28	-70.33%	-45.00%
Finishing	Minutes	22.27	7.53	-66.21%	-45.00%
Ironing	Minutes	12.39	7.22	-41.74%	-45.00%
Packaging	Minutes	20.53	6.5	-68.33%	-45.00%
Total Time	Minutes	66.23	24.52	-62.97%	-45.00%

The table VI shows the reduction of delay time for a workday of 11 hours. All the delay time per activity were reducing by percentages greater than 45%, except for ironing whose reduction approached the goal. So, the indicator goal was exceeded. In addition, we identified that reduction of delay times had a positive effect in time efficiency.

Available time = Total time - Delay time
Time Efficiency = Available Time / Total Time

TABLE VI
EFFICIENCY TIME

Indicator	AS IS	TO BE
Total Time (hours)	11.00	11.00
Delay Time (horas)	1.10	0.41
Available Time (horas)	9.90	10.59
Time Efficiency (%)	89.97%	96.28%

The research background indicates the following findings: reduction of non-added value time of 32% using 5S [23], a reduction of material search times in 65% and tool search time in 59% using 5S and manufacturing cells [21]. We conclude that implementation of 5S managed to exceed the established goals, results are similar to the research background and the time efficiency improved.

Evaluation of Standardized Work

The tool Standardized Work was implemented with the goal of execution an order flow of tasks which added value to process. Results are presented in table VII and VIII.

TABLE VII
RESULTS OF STANDARDIZED WORK IMPLEMENTATION

Variation of Standard Time and Standard Deviation per activity					
Indicator	**Unit**	**Classification**	**Finishing**	**Ironing**	**Packaging**
Standard Time AS IS	min / blazer	0.72	1.72	3.53	1.54
Deviation AS IS	min / blazer	0.05	0.04	0.09	0.10
Standard Time TO BE	min / blazer	0.64	1.61	3.24	1.29
Deviation TO BE	min / blazer	0.02	0.02	0.03	0.04

Total Standard Time was reduced in 9.57%, in table 3 we visualize the results of variation per activity. All standard time were reduced, but the objective of 20% was not achieved. In addition, the coefficient of variation (deviation/standard time) was reduced significantly for all activities, achieving greater values than the initial goals. This means the reduction of process variability, in another words, the standard time were stabilized.

TABLE VIII
STANDARDIZED WORK INDICATORS

Indicator	Classification	Finishing	Ironing	Packaging
Real Variation of Standard Time	-10.99%	-6.02%	-8.04%	-16.35%
Expected Variation of Standard Time	-20.00%	-20.00%	-20.00%	-20.00%
Real Change of Coefficient of Variation	-58.96%	-48.88%	-63.14%	-65.35%
Expected Change of Coefficient of Variation	-15%	-15%	-15%	-15%

The research background indicates the following findings: reduction of standard times in 18% using Kanban and Jit [9]; another improvement proposal used Poka Yoke and Andon [16]; reduction of 45% of cycle time using standardization in manufacturing cells [21]. We conclude that implementation of standard work did not achieve the goal, and the results are less or similar, for specific activities, than research background.

Evaluation of Productivity

Evaluation of productivity is shown in table IX. The productivity increased in +4.97%, but it did not achieve the goal of 10%. It means that the technical gap of productivity, the main indicator of this research, could not be overcome.

TABLE IX
PRODUCTIVITY VARIATION

Indicator	AS IS	TO BE	Real Variation	Expected Variation
Production (blazers)	620.00	651.00		
Man-Hours	77.00	77.00		
Labor Productivity	8.05	8.45	+4.97%	+10%

The research background indicates the following findings: productivity increase of 8% [16]; 24% [11]; increase of 14% using SMED and TPM [17]; duplication of productivity through Kanban, JIT and SW [9]. It´s important to mention that the project only focus on labor productivity with a narrower objective and scope. In addition, most of previous research proposed improvement proposals which included more leans tools with a complete implementation. Due to constraints, we could perform a small pilot testing.

The above findings illustrate that project objective was not achieved and there are improvement opportunities. Productivity can be increased with full implementation, and more lean tools to solver other critic factors which affects the productivity.

Evaluation of Feasibility

The company currently has no debts or shareholders, so the use of internal capital is chosen, as the investment represents less than 5% of its average monthly net profit. An economic flow analysis is carried out to identify the exclusive cost-benefit of the investment. This means that only the projected additional revenues resulting from increased productivity and maintenance costs related to the improvement project are considered.

To model the projected additional revenues, the simulation (see Table IX) indicates that the improvement project allows to produce an additional of 31 blazers per scheduled workday. Activities for the chosen subprocess are schedules for 8 days per month, we achieved an additional production capacity of 2976 blazers annually with a net profit of S/8.47 per each one. However, as shown in Table X, demand will be considered based on three scenarios (reflecting historical small, medium and large orders) since income is directly tied to market demand-driven sales.

TABLE X
PROJECT BENEFIT PROJECTION MODEL

Scenario	Number of blazers sold	Additional Revenues (Benefits)
Pessimistic	80	S/ 678
Realistic	666	S/ 5,641
Optimistic	1047	S/ 8,868

On the other hand, cost modeling aligns with the pilot testing conducted in select areas of the company, calculating total costs for implementing 5S and Standardized Work throughout the entire workshop (Workstations for subprocess 1 and subprocess 2). In summary, Table XI outlines the factors for economic flow analysis and their respective scenarios for a thorough sensitivity analysis. It is noteworthy that associated costs exhibit higher variability due to potential future price inflation.

TABLE XI
MODEL ACTORS AND SCENARIOS

Factor	Scenario			Variation
	Pessimist	Realist	Optimist	
Additional revenues	S/ 678	S/ 5,641	S/ 8,868	Due historical orders
Total implementation ´s cost	S/ 3,805	S/ 3,459	S/ 3,113	10%
Maintenance cost	S/ 4,083	S/ 3,550	S/ 3,018	15%

Utilizing the gathered information, we model the economic flow for a 5-year horizon to calculate economic indicators and determine whether assuming the total project cost is justified. Employing the @Risk software for sensitivity analysis yields acceptable expected values (see Table XII): an average NPV of S/ 2,286.33 (see Figure 14), an average IRR of 51.89% (see Figure 15).

TABLE XII
CASH FLOW

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Investment	**-S/ 3,459**					
Incomes		S/ 5,065	S/ 5,065	S/ 5,065	S/ 5,065	S/ 5,065
Costs		-S/ 3,550	-S/ 3,550	-S/ 3,550	-S/ 3,550	-S/ 3,550
Cash flow	**-S/ 3,459**	**S/ 1,515**	**S/ 1,515**	**S/ 1,515**	**S/ 1,515**	**S/ 1,515**

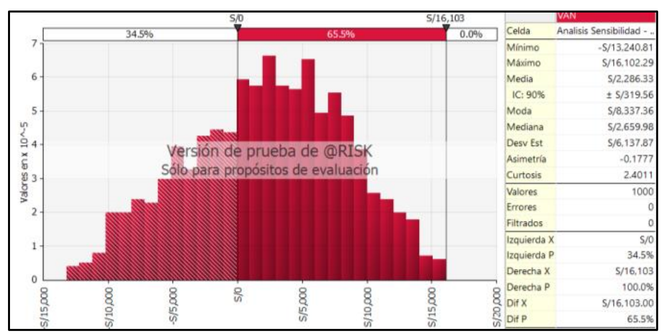

Fig. 14 Sensitivity analysis - NPV

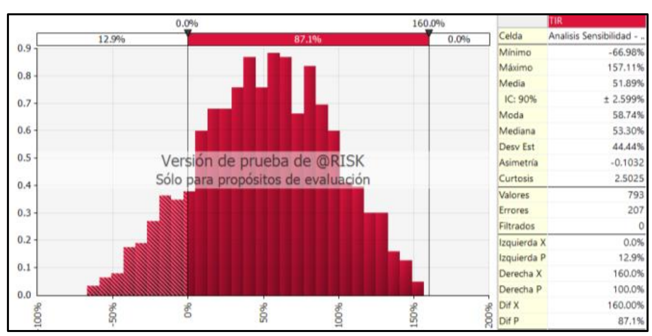

Fig. 15 Sensitivity analysis - IRR

In summary, the comprehensive implementation of the improvement project is deemed viable, as it generates an acceptable level of benefits, and the probability of loss is less than 34.5% for NPV and less than 12.9% for IRR.

V. Conclusions

SMEs constitute an important pillar of the national economy and job creation; but they have low level of productivity. Therefore, the SME sector is at a disadvantaged compared to more competitive industries. The hypothesis of this research was that the implementation of a lean manufacturing could improve the productivity. As a result of this research, we conclude that the hypothesis is true.

We could demonstrate that an improvement proposal based in lean manufacturing fulfilled the function of increasing the productivity of a textile SME. First of all, considering that SME could have many lean wastes, the proposal model was designed focus on solving the most important problems, identified as the "root causes". Second one, the solution prioritizes the goal of "Standardize Everything" through the basic lean tools: 5S for physical environment and Standardized Work for working methods. It is aligned with Lean Manufacturing theory, whose first step is achieving a well-defined, executed under optimal conditions, and controlled process. Third one, the components of improvement model optimize the textile process. The productivity increased in 5%, but it did not reach the goal of 10%. The 5s could reduce the delay time for unnecessary transport and movements in 62.95%, surpassing the goal and 10%, and improving the time efficiency from 89% to 96%. Standardized Work could decrease total standard time in 9.57%. Although it did not reach the goal of 20%, standard times of all activities were stabilized.

The proposal model is economically viable considering a good level of benefit/cost, low probability of loss in NPV and IRR.

It is recognized that the proposal does not have the expected results dues to the following factors: limitations for a complete implementation, the use of only two basic lean tools. Background research can get better results with different kind of tools.

Finally, we determine that the present research will be an "basic improvement model" to implement lean manufacturing in SMEs regardless of the textile sector. This model gives the solid base of lean manufacturing and allows the possibility to implement other lean tools such as Jidoka or Just in Time more effectively.

Acknowledgment

We would like to thanks to the following people who support us during all the development of this research: Cardenas Vilma, Lizarraga Carlos, Chirinos Carlos, Bonilla Elsie, Bedoya Luis and Cornejo Martin. Additionally, we would like to thanks to our families, University of Lima and his Engineering Faculty.

References

[1] Ministerio de la Producción PRODUCE. (2022). Estudio de Investigación Sectorial, Textiles y Confecciones 2020. https://ogeiee.produce.gob.pe/index.php/en/shortcode/oee-documentos-publicaciones/publicaciones-anuales/item/1065-estudio-de-investigacion-sectorial-sector-textil-y-confecciones-2020

[2] Ramasubramaniam, P. (2020). Productivity improvement by reducing waiting time and over-production using lean manufacturing technique. International Journal of Recent Engineering Science (IJRES), 7(4),20-26. Doi: 10.1445/23497157/IJRES-V7I4P104

[3] Quiroz-Flores, J. C., & Vega-Alvites, M. L. (2022). Review lean manufacturing model of production management under the preventive maintenance approach to improve efficiency in plastics industry SMES: A case study. South African Journal of Industrial Engineering, 33(2), 143-156. doi:10.7166/33-2-2711

[4] Cáceres-Gelveza, S., Arango-Serna, M. D., & Zapata-Cortés, J. A. (2022). Evaluating the performance of a cellular manufacturing system proposal for the sewing department of a sportswear manufacturing company: A simulation approach. Journal of Applied Research and Technology, 20(1), 68-83. doi:10.22201/icat.24486736e.2022.20.1.1335

[5] Aguilar, O., Posada, R., Peña, N., Patiño, J. (2019). Impacto de la aplicación de estrategias de mercadotecnia en la productividad de las micro y pequeñas empresas. Espacios. https://revistaespacios.com/a19v40n06/a19v40n06p09.pdf

[6] Ortiz, V., Primo, P., Yomona, M., Orihuela, M., Sotelo, F., Raymundo, C. (2019). Propuesta de un modelo de nivel de madurez adaptado a la realidad de las MYPES del Perú. Proceedings of the LACCEI international Multi-conference for Engineering, Education and Technology. http://dx.doi.org/10.18687/LACCEI2019.1.1.95

[7] Flores-Andrade, K., Guardia-Miranda, R., Castro-Rangel, PM, Raymundo-Ibañez, C., & Perez, M. (2020). Production management model through MPS and line balancing to reduce the non-fulfillment of orders in lingerie clothing MSEs in Peru. Paper presented at the IOP Conference Series: Materials Science and Engineering. DOI 10.1088/1757-899X/796/1/012018

[8] Rey, S. F. (2005). Las 5S: orden y limpieza en el puesto de trabajo. Madrid: FC Editorial.

[9] Canales-Jeri, L., Rondinel-Oviedo, V., Flores-Perez, A., & Collao-Diaz, M. (2022). Lean model applying JIT, kanban, and standardized work to increase the productivity and management in a textile SME. ACM International Conference Proceeding Series, 79-84. doi:10.1145/3524338.3524351

[10] Alanya, B., Dextre, K., Nuñez, V., Marcelo, G., &Álvarez, J. (2022). Improving the Cutting Process Through Lean Manufacturing in a Peruvian Textile SME. Paper presents at 2020 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM), doi: 10.1109/IEEM45057.2020.9309992.

[11] Flores-Meza, S., Limaymanta-Perales, J., Eyzaquirre-Munarriz, J., Raymundo-Ibañez, C., & Perez, M. (2020). Lean manufacturing model for production management to increase SME productivity in the non-primary manufacturing sector. Paper presented at the IOP Conference Series: Materials Science and Engineering, 796(1). Doi:10.1088/1757-899X/796/1/012019

[12] Manickam, B. K., & Rathinasamy, P. (2022). A FUZZY GRA-BASED DECISION-MAKING APPROACH ON THE SELECTION OF LEAN TOOLS: A CASE STUDY OF INDIAN APPAREL INDUSTRY. International Journal of Industrial Engineering: Theory Applications and Practice, 29(1), 1-20. doi:10.23055/ijietap.2022.29.1.6777

[13] Cristobal, J., Quispe, G., Dominguez, F., Zapata, G., & Raymundo, C. (2020). Waste reduction with lean manufacturing model in an alpaca wool workshop. Paper presented at the IOP Conference Series: Materials Science and Engineering, , 999(1). Doi:10.1088/1757-899X/999/1/012014

[14] Sosa-Perez, V., Palomino-Moya, J., Leon-Chavarri, C., Raymundo-Ibañez, C., & Dominguez, F. (2020). Lean manufacturing production management model focused on worker empowerment aimed at increasing production efficiency in the textile sector. Paper presented at the IOP Conference Series: Materials Science and Engineering, , 796(1) doi:10.1088/1757-899X/796/1/012024

[15]Tanasic, Z., Janjic, G., Sokovic, M., & Kusar, J. (2022). IMPLEMENTATION OF THE LEAN CONCEPT AND SIMULATIONS IN SMES – A CASE STUDY. International Journal of Simulation Modelling, 21(1), 77-88. doi:10.2507/IJSIMM21-1-589

[16]Ukey, P., Deshmukh, A., & Arora, A. (2021). Implementation of lean tools in apparel industry for improving productivity. Proceedings on Engineering Sciences, 3(2), 241-246. doi:10.24874/PES03.02.012

[17]Mejia Carrera, S., & Rau Alvarez, J. (2019). Analysis of improvement for the implementation of lean manufacturing tools in the clothing line of a textile company in lima. Paper presented at the Proceedings of the LACCEI International Multi-Conference for Engineering, Education and Technology, , 2019-July doi:10.18687/LACCEI2019.1.1.236

[18]Ruiz, S., Simón, A., Sotelo, F., & Raymundo, C. (2019). Optimized plant distribution and 5S model that allows SMEs to increase productivity in textiles. Paper presented at the Proceedings of the LACCEI International Multi-Conference for Engineering, Education and Technology, 2019-July doi:10.18687/LACCEI2019.1.1.59

[19]Lista, A. P., Tortorella, G. L., Bouzona, M., Mostafad, S., & Romeroe, D. (2021). Lean layout design: A case study applied to the textile industry. Production, 31 doi:10.1590/0103-6513.20210090

[20]Leyva, L. L. L., Perugachi, E. P. C., Piarpuezan, R. V. S., Orges, C. A. M., Montenegro, E. P. O., & Burgos, G. (2018). Lean manufacturing application in textile industry. Paper presented at the Proceedings of the International Conference on Industrial Engineering and Operations Management, 2018 (JUL) 808-820. http://www.ieomsociety.org/paris2018/papers/155.pdf

[21]Barrientos-Ramos, N., Tapia-Cayetano, L., Maradiegue-Tuesta, F., & Raymundo, C. (2020). Lean manufacturing model of waste reduction using standardized work to reduce the defect rate in textile MSEs. Paper presented at the Proceedings of the LACCEI International Multi-Conference for Engineering, Education and Technology, doi:10.18687/LACCEI2020.1.1.356

[22]International Organization for Standardization. (2015). ISO 9001:2015 Quality management systems – Requirements. ISO.

[23]Kumar, D. V., Mohan, G. M., & Mohanasundaram, K. M. (2019). Lean tool implementation in the garment industry. Fibres and Textiles in Eastern Europe, 27(2), 19-23. doi:10.5604/01.3001.0012.9982