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Time study and systematic questioning techniques to enhance production in a textile company

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***Abstract*– The primary challenge faced by the textile company Textile Industry R10 E.I.R.L. is low productivity in its sewing operations, a factor that compromises its competitiveness in the market. This issue is associated with inefficient time management and work methods, highlighting the need for industrial engineering tools to enhance process efficiency. This study aimed to reduce task durations through the implementation of time study and questioning techniques, with the objective of increasing daily production output. A quantitative methodology was employed, comparing observed time data from pre-test and post-test phases and assessing tasks within the sewing operations. The results demonstrated a 22% reduction in standard time, a 7% decrease in tasks within the garment manufacturing process, and, consequently, a 21% improvement in daily production. This methodology could be successfully replicated in other textile companies facing similar operational challenges.**

***Keywords*- Textile industry, Time study, Production, Questioning techniques, Standardization**

I. Introduction

On a global scale, the textile industry is among the top five industries in economic activity, experiencing a 3% annual growth rate and generating over $66.06 billion in global revenue in 2020 [1]. This sector ranks third in contribution to the Gross Domestic Product (GDP), surpassed only by the non-metallic materials industry and petroleum refining, and employs more than 75 million people worldwide [2-3].

The textile and apparel industry, which encompasses manufacturing processes that convert fibers into yarns, fabrics, and finished products, plays a pivotal role in the global economy, influencing both industrialized and developing nations [3-4]. Within the global trade landscape, China leads textile exports, followed by the European Union, India, Turkey, and the United States. Meanwhile, the Asia-Pacific region has solidified its position as the dominant hub for textile production and consumption, driven by strategic factors such as high population density, particularly within the middle socioeconomic class, which fosters cost-effective labor [5-6].

The textile sector operates within a multinational framework, where various companies oversee the simultaneous production and manufacturing of apparel across multiple countries [7]. It is distinguished by a complex organizational structure that integrates strategic activities, ranging from conventional processes to advanced techniques [8]. Over time, the industry has undergone continuous transformations in its industrial processes and marketing strategies,

establishing itself as a cornerstone of global production and trade [9]. Consequently, it has become a key driver of economic development in numerous countries [10], with a predominant concentration in regions characterized by lower labor costs, often associated with a low-skilled and undereducated workforce [11].

In Peru, textile and apparel companies serve as key drivers of national economic growth, recognized for the high quality of their cotton products in Latin America [12]. These companies have experienced an average annual growth rate of 4.3% [13]. Moreover, the sector is one of the primary sources of employment and income for Peruvians, generating approximately 422,000 jobs annually and making a significant contribution to the manufacturing sector's GDP [13-14]. However, the majority of companies in this sector are Micro and Small Enterprises (MSEs), characterized by low productivity and inefficiency in production. This is largely due to the lack of prioritization in machinery maintenance, leading to rapid wear and frequent failures in the production process, as well as the absence of effective activity control, which negatively impacts production efficiency [12-15].

Textile Industry R10 E.I.R.L., a textile MSE based in Lima, Peru, specializes in the production and commercialization of women's apparel. The company currently faces significant challenges in its sewing department, particularly in the production of blouses, its main product line. The core issue lies in the reliance on empirical work processes, which result in considerable idle time and low production efficiency. This is primarily due to the lack of standardized processes and insufficiently trained personnel, leading to recurring delivery delays that affect the company's reputation and operational efficiency.

In response to this issue, time study and questioning techniques emerge as viable strategies for improving the economic performance of textile companies by enhancing profitability. Consequently, a review of the scientific literature was conducted to identify preliminary research in this area. However, few studies have focused on a precise methodology for time study alone, although several have explored its integration with other improvement tools. For instance, [16] combined the DMAIC methodology with time study to enhance productivity in the production area of a chocolate manufacturing company. Their results demonstrated an increase in chocolate productivity from 92.32% to 94.07%, an improvement in efficiency from 93.47% to 94.36%, and a rise in effectiveness from 98.77% to 99.70%.

In another study, [17] aimed to optimize the productivity of the assembly process in an Ethiopian garment industry by integrating various lean techniques and work-study methods, including line balancing, work standardization, time and method study, total work method, and improvement processes such as Kaizen and 5S. As a result, non-value-added activities were reduced from 43% to 5%, bottlenecks decreased from three to none, and production increased from 470 to 800 pieces per shift. Meanwhile, [18] investigated the implementation of time and motion studies to standardize the production process in a small and medium-sized publishing company, focusing on the box assembly area. Their findings showed a 66% reduction in inefficient operator movements, an 18.4% decrease in the standard time of a workstation, a 63.2% increase in production rate, and the complete elimination of overtime. Additionally, [19] proposed the implementation of lean manufacturing techniques through time study in a textile company, achieving a reduction in cycle time from 472 seconds to 438 seconds, as well as a decrease in operator movement from 153 feet to 117 feet. Consequently, these tools contributed to a 4.84% increase in productivity.

Besides, [20] demonstrated the efficacy of the ECRS framework (Eliminate, Combine, Rearrange, Simplify) in reducing waste within Indonesia's furniture manufacturing sector. Through its systematic implementation, the study achieved a delivery time reduction of approximately 4.79%, while concurrently ensuring a balanced distribution of workloads among operators. Adopting a comparable methodological approach in a distinct industrial setting, [21] employed systematic questioning techniques within a refrigerated meat production line. These were integrated with the Theory of Constraints (TOC) and principles of line balancing. The resulting comprehensive strategy led to a marked improvement in production line efficiency, increasing from 46.21% to 79.71%, thereby underscoring the adaptability and effectiveness of these tools across diverse manufacturing environments.

Within this context, the present study aimed to implement time study techniques complemented by the questioning method, focusing on the highest-demand product, the "Floreado Pretel" blouse, with the objective of improving production times, increasing production capacity, and ultimately enhancing the organization's profitability.

II. METHODOLOGY

The present research is applied in nature, explanatory in scope, quantitative in approach, and follows an experimental design. This classification is based on the implementation of time study and questioning techniques to enhance production at the textile company Textile Industry R10 E.I.R.L., focusing on practical solutions to improve manufacturing processes and reduce operational times. Additionally, the causes of inefficiencies in the Pretel blouse manufacturing process were analyzed, and numerical data were collected at each stage of the production process. The observed times from the pre-test and post-test phases were then compared [22-23].

A. Steps in the Time Study Procedure and Questioning Technique

The following section details the six stages involved in the application of the time study and questioning technique conducted at Textile Industry R10 E.I.R.L .

The systematic questioning technique constitutes a methodological framework developed by the International Labour Organization (ILO) for the critical evaluation of work methods [24]. This approach employs a structured sequence of interrogative phases. The initial phase comprises preliminary questions addressing current practices—what (activity identification), why (justification), where (location), when (timing/sequence), who (responsibility), and how (current methods). The subsequent phase involves more exhaustive inquiries, targeting improvement opportunities using the same interrogative structure but oriented toward future process optimization. This methodology aligns with the ECRS framework (Eliminate, Combine, Rearrange, Simplify), offering industrial engineers a rigorous tool for diagnosing inefficiencies and identifying potential enhancements.

In the present study, the systematic questioning technique was integrated with time study analysis to develop a comprehensive strategy for process enhancement in the manufacturing of the Pretel blouse. This integration combines quantitative time measurement with qualitative method evaluation, thereby facilitating more effective productivity improvements.

Stage 1: Selection of the Most Prominent Product and Its Activities Within the Production Process

In this stage, the highest-demand product within the production process was selected for evaluation in the time study. Direct observation was employed, and a structured observation guide was used to record standard time, production capacity, and labor productivity. Data collection took place in the sewing production area, where process data were documented using an operation diagram (Figure 1). This approach facilitated a clear identification of sequential activities, and the time required for each stage in the product's manufacturing process.

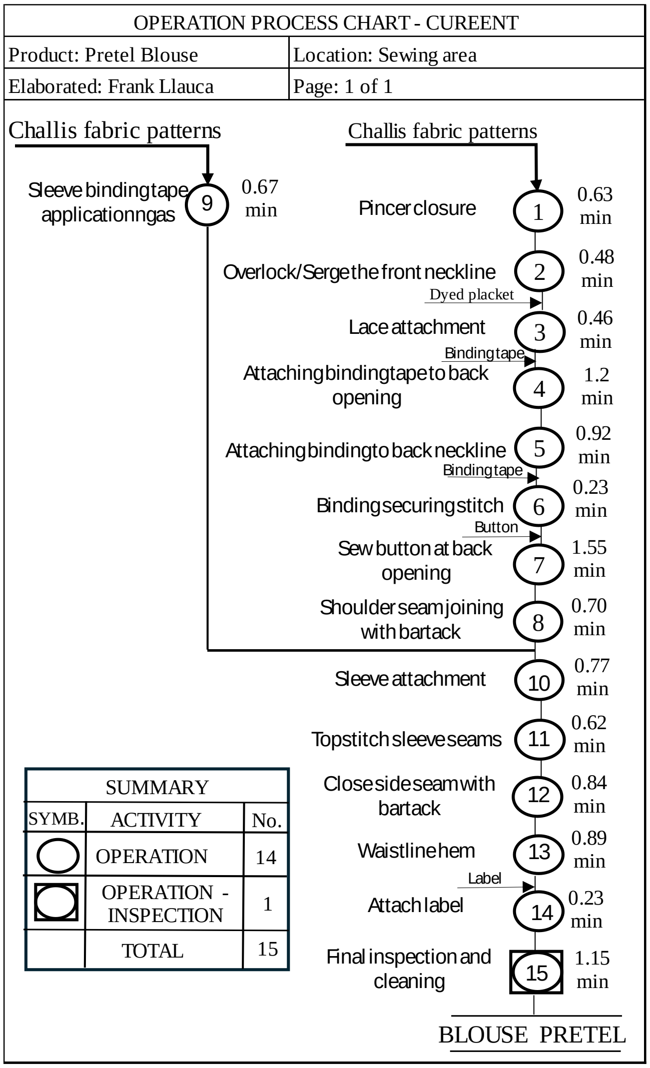

Fig. 1 Operational process diagram for the Pretel blouse depicting sequential activities and corresponding processing times.

Stage 2: Analysis of Tools for Activity Evaluation

At this stage, a time study template was developed using an MS Excel spreadsheet. The data were collected through direct observation, and the recorded times for each cycle were documented in the observation guide (Figure 2).

TIME STUDY SHEET																											
OPERATION:		STUDY No.:																									
MODEL:		SHEET No.:																									
TOOLS:	STOPWATCH	OBSERVED BY:																									
PROCESS TYPE:	-																										
OPERATION:	TYPE	CYCLES																					P	FA	TN	S	TS
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21					
TOTAL SEWING TIME (MIN):																											

Fig. 2 Standardized data collection instrument for time study.

Stage 3: Determining the Required Number of Observations for Activity Assessment

At this stage, Equation (1) for determining the number of observations, as proposed by Mequanent and Yewondwosen [17], was applied to conduct the time study. This was based on an initial set of 10 measurements for both the pre-test and post-test (Figure 3), serving as a reference point. Prior to this, the average time (2) and standard deviation (3) for each activity were calculated. To ensure consistency and fairness in the sample, 21 observations were used for all activities, with the highest value corresponding to the binding securing stitch process process.

TIME STUDY BASELINE READING											
OPERATION:	SEWING PROCESS	STUDY No.:	001 - 2025								
MODEL:	BLOUSE FLOREADO PRETEL	SHEET No.:	1								
TOOLS:	STOPWATCH	OBSERVED BY:	FRANK LLAUCA								
OPERATION:	TYPE	CYCLES									
		1	2	3	4	5	6	7	8	9	10
Pincer closure	Mach.	0.59	0.63	0.55	0.65	0.58	0.56	0.64	0.57	0.65	0.61
Overlock/Serge the front neckline	Mach.	0.51	0.46	0.57	0.45	0.55	0.46	0.49	0.51	0.47	0.50
Lace attachment	Mach.	0.42	0.42	0.44	0.36	0.42	0.39	0.45	0.41	0.41	0.39
Attaching binding tape to back opening	Mach.	1.22	1.17	1.18	1.23	1.24	1.22	1.18	1.17	1.20	1.17
Attaching binding to back neckline	Mach.	0.95	0.94	0.94	0.93	0.94	0.94	0.96	0.95	0.96	0.92
Binding securing stitch (Attach elastic)	Mach.	0.21	0.28	0.22	0.23	0.22	0.18	0.25	0.27	0.19	0.18
Sew button at back opening	Man.	1.58	1.54	1.55	1.56	1.59	1.55	1.55	1.59	1.59	1.57
Shoulder seam joining with bartack	Mach.	0.67	0.63	0.72	0.64	0.64	0.74	0.66	0.67	0.69	0.74
Sleeve binding tape applicationngas	Mach.	0.69	0.74	0.70	0.71	0.72	0.66	0.74	0.62	0.67	0.63
Sleeve attachment (Armhole and sleeve cap)	Mach.	0.79	0.73	0.78	0.81	0.82	0.72	0.85	0.81	0.85	0.75
Topstitch sleeve seams at 3 millimeters	Mach.	0.58	0.54	0.66	0.63	0.62	0.57	0.55	0.56	0.63	0.58
Close side seam with bartack	Mach.	0.86	0.84	0.92	0.93	0.90	0.88	0.83	0.90	0.84	0.89
Waistline hem	Mach.	0.87	0.93	0.80	0.91	0.92	0.89	0.83	0.86	0.83	0.89
Attach label	Mach.	0.17	0.13	0.18	0.11	0.16	0.24	0.12	0.12	0.11	0.19
Final inspection and cleaning	Man.	1.11	1.17	1.13	1.14	1.11	1.16	1.16	1.16	1.15	1.13
TOTAL SEWING TIME (MIN):		**11.23**	**11.15**	**11.34**	**11.29**	**11.41**	**11.17**	**11.26**	**11.17**	**11.26**	**11.14**

Fig. 3 Standardized baseline data sheet for time study including initial measurements.

Number of Observations

The number of observations is determined by the product of the error risk and the standard deviation, divided by the product of the absolute error and the average observation time.

$$\# \, Observations = \left(\frac{k \, . \, \sigma}{\varepsilon \, . \, x}\right)^2 + 1 \qquad (1)$$

Where:

Observations: Number of observations in units
K: 2 - 5% error risk
σ: Standard deviation in minutes/units
ε: 5% decimal error
X: Average observation time in minutes

Average Time: This is the result of summing all observed times recorded during the study and dividing by the total number of observations.

$$Tp = \frac{\sum_{i=1}^{n} TO}{n} \qquad (2)$$

Where:

Tp: Average time (minutes/units)
TO: Observed time (minutes)
N: Number of observations (units)

Standard Deviation: It is defined as the square root of the sum of the squared differences between each observed time and the average time, divided by the total number of observations.

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n} f(X_i - X)^2}{n}} \qquad (3)$$

Where:

σ: Standard deviation (minutes/units)
X: Average observed time (minutes)
Xi: Observed time (minutes)
n: Number of observations (units)

Stage 4: Data Collection for Activity Analysis

In this stage, data on the product manufacturing process were collected. The work pace was evaluated using the Westinghouse system, which assesses four factors: skill, effort, working conditions, and consistency. The assigned rating factor was 18% (Table 1).

Equation (4) represents the calculation of normal time as the product of the observed time and the pace rating factor. Subsequently, allowances were determined in accordance with the guidelines of the International Labour Organization (ILO) (Table 2) to compute the standard time for each activity (Equation 5). The results from the pre-test time study are summarized in Table 3.

TABLE I. Westinghouse rating system for work performance evaluation with a detailed breakdown of contributing factors

Westinghouse				
Skill Effort Conditions Consistency Rating	Skill Effort Conditions Consistency Rating	Skill Effort Conditions Consistency Rating	Skill Effort Conditions Consistency Rating	Skill Effort Conditions Consistency Rating
8 %	10 %	2 %	-2 %	18 %

TABLE II. Assessment of work allowances in accordance with ILO guidelines, with percentage allocation by category.

Supplements	
Personal needs	5%
Fatigue supplement	4%
Abnormal posture supplement	2%
Poor lighting	2%
Concentration	2%
Noise	2%
Monotony	4%
Tedium	2%
Total	23%

Normal Time Calculation

$$TN = TO * (1 + FA) \qquad (4)$$

Where:

TN: Normal time (minutes)
TO: Observed time (minutes)
FA: Activity factor (18%)

Calculation of Standard Time

$$TS = TN * (1 + S) \qquad (5)$$

Where:

TS: Standard Time (minutes)
TN: Normal Time (minutes)
S: Allowance (23%)

Activity Time Measurement

All the previously described information on the time study for the Pretel blouse manufacturing process is presented in Table 3.

TABLE III. Comprehensive pre-test time study results for the Pretel blouse manufacturing process.
FA: 18 % S: 23 %

ACTIVITIES	TP	TS
Pincer closure	0.60	0.88
Overlock front neckline	0.50	0.73
Lace attachment	0.30	0.44

Attaching binding tape to back opening	1.19	1.73
Attaching binding to back neckline	0.93	1.36
Binding securing stitch (Attach elastic)	0.22	0.32
Sew button at back opening	1.57	2.28
Shoulder seam joining with bartack	0.67	0.98
Sleeve binding tape applicationngas	0.70	1.01
Sleeve attachment (Armhole and sleeve cap)	0.78	1.14
Topstitch sleeve seams at 3 millimeters	0.59	0.86
Close side seam with bartack	0.88	1.27
Waistline hem	0.88	1.27
Attach label	0.20	0.29
Final inspection and cleaning	1.15	1.67
TOTAL SEWING TIME (MIN)		**16.21**

*FA:Perfomance factor, S:Supplements

Stage 5: Reviewing the Activity Study Data

At this stage, the information obtained from the current standard time was reviewed. To achieve this, an analytical process diagram (DAP) was developed, providing a summarized representation of the results from the initial time measurement (Figure 4). Furthermore, production capacity indicators (Equation 6) and labor productivity (Equation 7) were calculated.

ANALYTICAL PROCESS DIAGRAM - PRE-TEST							
Product: Blouse Pretel		Location:	Sewing Area				
Prepared by: Frank Llauca		Page:	1 of 1				
N°	**DESCRIPTION**	**QUANTITY (units)**	**TIME (min)**	**ACTIVITY** ●	■	➡	◙
1	Pincer closure	1	0.88				
2	Overlock front neckline	1	0.73				
3	Lace attachment	1	0.44				
4	Attaching binding tape to back opening	1	1.73				
5	Attaching binding to back neckline	1	1.36				
6	Binding securing stitch (Attach elastic)	1	0.32				
7	Sew button at back opening	1	2.28				
8	Shoulder seam joining with bartack	1	0.98				
9	Sleeve binding tape applicationngas	1	1.01				
10	Sleeve attachment (Armhole and sleeve cap)	1	1.14				
11	Topstitch sleeve seams at 3 millimeters	1	0.86				
12	Close side seam with bartack	1	1.27				
13	Waistline hem	1	1.27				
14	Attach label	1	0.29				
15	Final inspection and cleaning	1	1.67				
	TOTAL	15	16.21	**14**	**-**	**-**	**1**

Fig. 4 Pre-Test analytical process chart (APC) displaying activity classification and associated time values

Next, production capacity is calculated using Equation (6), and labor productivity is determined using Equation (7). A summary of these two indicators, representing the company's current state, is presented in Table 4.

Production Capacity: It is defined as the total work shift duration divided by the standard time per unit.

$$CP = \frac{TD}{TE} \tag{6}$$

Where:

CP: Production capacity (units/day)
TD: Available work shift time (minutes/day)
TE: Standard time (minutes/unit)

Labor Productivity: It is defined as the total production achieved during a work shift divided by the total hours worked.

$$P = \frac{PO}{RU} \tag{7}$$

Where:

P: Labor productivity (units/hour)
PO: Output produced (units/day)
RU: Resources utilized (hours/day)

The pre-test indicators were calculated and presented in Table 3.

TABLE IV. Pre-Test performance metrics: production capacity and workforce productivity.

Summary of indicators – Pre-test		
Description	Quantity	Measured
Production capacity	34	Units/day
Labor productivity	3.8	Units/Hr

Stage 6: Evaluating the Work Method for Activities

At this stage, the collected information was meticulously analyzed using diagnostic tools such as the Ishikawa diagram, which grouped the potential causes of the "low production" issue, as illustrated in Figure 5. Additionally, the Pareto diagram was employed to identify and prioritize the most critical causes, facilitating a more efficient allocation of resources (Figure 6).

The analysis indicated that the primary cause was the absence of a standardized procedure, followed by excessive overtime in activities, delays in delivery schedules, and inadequate planning, these being the most frequently identified factors. Consequently, improvement strategies were

proposed to implement a new work method based on the questioning technique (Table 5), aiming to enhance production efficient.

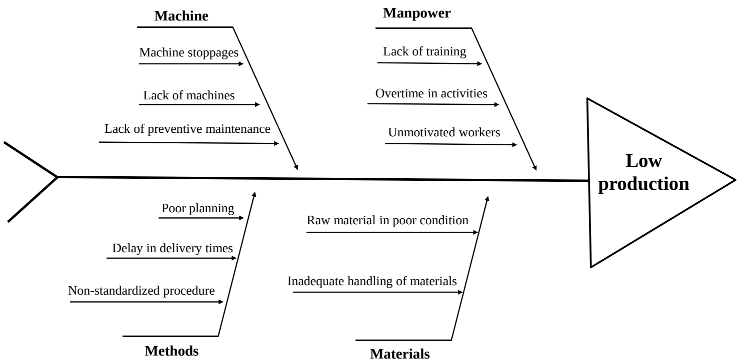

Fig. 5 Ishikawa (Cause-and-Effect) diagram categorizing root causes of reduced production efficiency

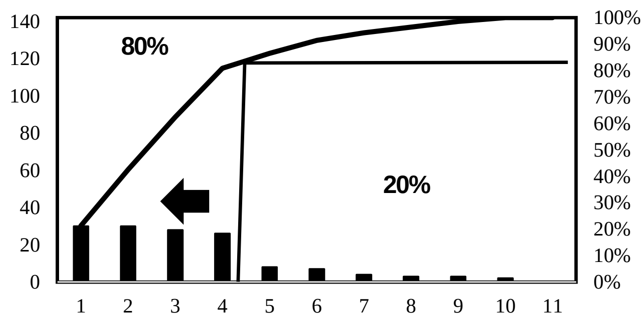

Fig. 6 Pareto Chart highlighting critical inefficiency causes with corresponding cumulative percentages.

Improvement Strategy

To resolve the most critical causes, an improvement strategy was implemented using the questioning technique. This approach involves systematically formulating questions to analyze and enhance the work process. Its objective is to justify and critically assess each aspect of the current process to introduce improvements in every activity—whether by eliminating, combining, reorganizing, or simplifying operations—to enhance overall process efficiency. As a result, the production process for the 'Floreado Pretel' blouse was optimized (Figure 7).

Fig. 7 Front and rear views of the Floreado Pretel Blouse: Target product for process improvement

Table 5 outlines the work method employed in the manufacturing company, along with the proposed improvement strategy.

TABLE V. Implementation of the systematic questioning technique: preliminary and analytical phases with corresponding proposed solutions.

Preliminary Questions	**How are activities carried out?**	**Why is it done that way?**
	In parallel	This is how it was originally established
Background Questions	**How could it be improved?**	**How could this be done?**
	Grouping activities 4 and 5 and implementing an industrial button machine in activity 7	Performing the back opening and neckline activities jointly, along with the semi-automation of the button sewing process at the back opening.

Proposal Development

In this study, two key activities in the production of the standard product were merged, and one of them was partially automated as an improvement (Figure 8). This outcome was derived from the responses collected through the questioning technique applied to the 12 operators. The primary objective was to enhance the work sequence and significantly reduce production times in the sewing area.

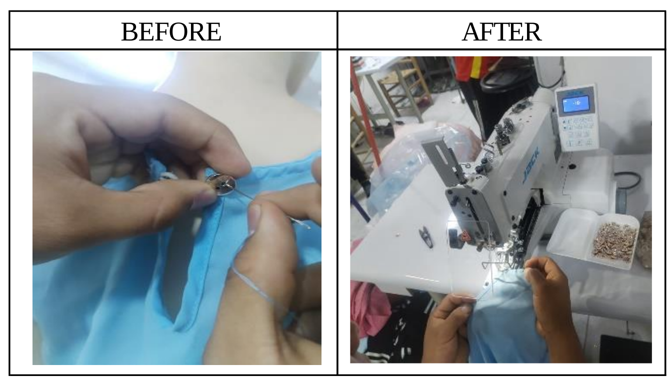

Fig. 8 Before-and-After analysis of semi-automation implementation in the button sewing process.

III. RESULTS

As a result, the workflow was improved by analyzing the root causes (Figures 5 and 6) and implementing the questioning technique (Table 5) to establish a new work method aimed at enhancing efficiency and productivity in the manufacturing area. Accordingly, Table 6 presents the revised production times in detail, Figure 9 illustrates the updated activity sequence, and Table 7 displays the improved production indicators.

Table 6 presents the proposed set of activities and their corresponding standard time.

TABLE VI. Post-Improvement analysis of standard time (ST) and average time (AT) for each activity.

FA: 18 % S:23 %

ACTIVITIES	AT	ST
Pincer closure	0.58	0.78
Overlock front neckline	0.52	0.75
Lace attachment	0.39	0.57
Attach binding tape to back opening and neckline	1.44	2.09
Binding securing stitch (Attach elastic)	0.18	0.26
Sew button at back opening	0.14	0.20
Shoulder seam joining with bartack	0.71	1.02
Sleeve binding tape applicationngas	0.68	0.99
Sleeve attachment (Armhole and sleeve cap)	0.76	1.10
Topstitch sleeve seams at 3 millimeters	0.64	0.93
Close side seam with bartack	0.88	1.27
Waistline hem	0.92	1.34
Attach label	0.21	0.31
Final inspection and cleaning	1.12	1.63
TOTAL SEWING TIME (MIN)		**13.24**

*FA:Perfomance factor, S:Supplements

Based on Table 6, a new activity diagram was developed to document the revised standard times for each activity following the implemented improvement

ANALYTICAL PROCESS DIAGRAM - POST-TEST							
Product: Blouse Pretel		Location:	Sewing Area				
Prepared by: Frank Llauca		Page:	1 of 1				
N°	DESCRIPTION	QUANTITY (units)	TIME (min)	ACTIVITY ●	■	➡	◙
1	Pincer closure	1	0.78				
2	Overlock front neckline	1	0.75				
3	Lace attachment	1	0.57				
4	Attach binding tape to back opening and neckline	1	2.09				
5	Binding securing stitch (Attach elastic)	1	0.26				
6	Sew button at back opening	1	0.20				
7	Shoulder seam joining with bartack	2	1.02				
8	Sleeve binding tape applicationngas	2	0.99				
9	Sleeve attachment (Armhole and sleeve cap)	2	1.10				
10	Topstitch sleeve seams at 3 millimeters	2	0.93				
11	Close side seam with bartack	1	1.27				
12	Waistline hem	1	1.34				
13	Attach label	1	0.31				
14	Final inspection and cleaning	1	1.63				
	TOTAL	18	13.24	13	-	-	1

Fig. 9 Post-Test analytical process chart featuring enhanced activities and shortened execution times.

TABLE VII. Post-Test Performance Metrics: Enhanced production capacity and workforce productivity.

Summary of indicators – Post-test		
Description	Quantity	Measurement
Production capacity	41	Units/day
Labor productivity	4.6	Units/Hr

Subsequently, improvements in activities and time measurements were observed, based on 21 observations (Equations 1, 2, and 3) for both the pre-test and post-test. These improvements resulted in reduced variability, optimized standard time, increased production capacity, and enhanced labor productivity, as illustrated in Figures 10, 11, 12, 13, and 14. Furthermore, an inferential analysis was performed, as shown in Table 8.

Figure 10 illustrates the time recordings for the pre-test and post-test. Figure 11 illustrates the improvement in recorded times expressed as percentages. Figure 12 illustrates the standard time for the work methods established in this study. Figure 13 illustrates the production capacity over a 9-hour work shift. Figure 14 illustrates labor productivity in the manufacturing of the Pretel blouse.

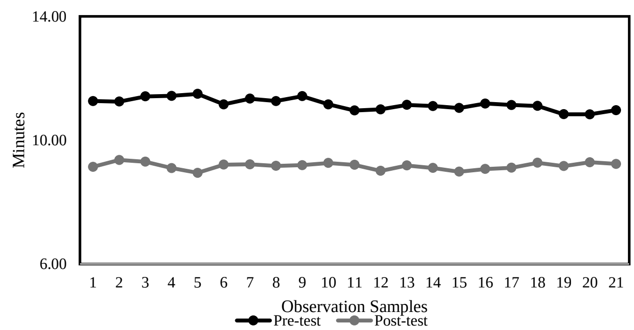

Fig. 10 Comparative analysis of 21-time observations across pre-test and post-test measurement phases

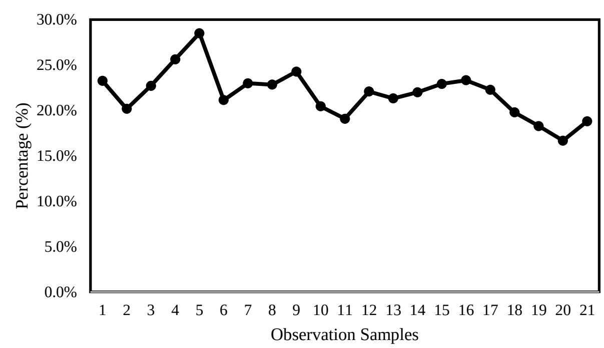

Fig. 11 Percentage improvement in processing time based on observational sample data.

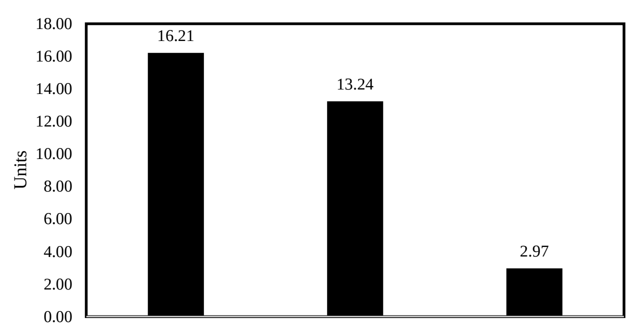

Fig. 12 Comparison of standard time measurements: pre-test, post-test, and resulting time reduction.

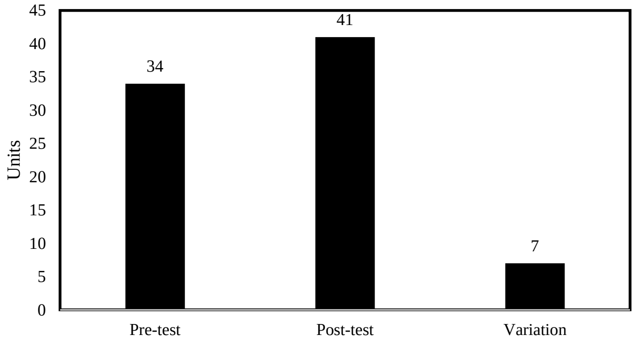

Fig. 13 Analysis of production capacity enhancement: pre-test and post-test comparison with garment output increase.

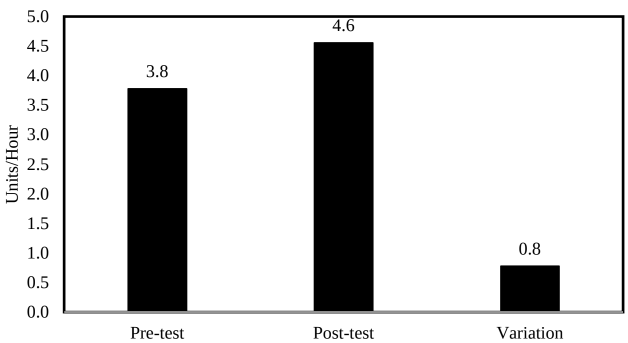

Fig. 14 Labor Productivity Enhancement: Comparative Analysis of Pre-Test and Post-Test Results with Per-Worker Output Increase.

Inferential Statistical Analysis

Hypothesis for Decision-Making

H_0: The application of time study and the questioning technique does not lead to a significant improvement in production within a textile company.

H_1: The application of time study and the questioning technique leads to a significant improvement in production within a textile company.

To support decision-making, the parametric paired t-test was conducted, considering the pre-test and post-test results from the study (Table 8). The obtained significance value (0.00 < 0.05) indicates the rejection of the null hypothesis and the acceptance of the alternative hypothesis. This finding confirms that the implementation of the time study and the questioning technique leads to a significant improvement in production within a textile company.

TABLE VIII. Statistical validation: Paired T-Test results comparing pre-test and post-test measurements.

	Average	Standard Deviation	Standard Error of the Mean	95% interval of Confidence in the difference		t	gl	p-value (two-tailed)
				Low	High			
PreT-PosT	2.00	,22627	,04938	189891.00	210490.00	40545.00	20.00	,000

IV. DISCUSSION

This study focused on applying time measurement and the questioning technique to enhance production in the sewing area through a detailed analysis of activity times and structured questioning of workers to identify bottlenecks and propose improvements. The methodology in this study was structured into six stages, systematically demonstrating the application of various industrial engineering techniques and tools to optimize production. This approach aligns with the work of [18], who developed their method into four phases: data collection and analysis, time and motion study, visual standardization design, and implementation, with the goal of standardizing production processes in an SME, ultimately increasing its production rate by 63.2%. The findings indicate a reduction in standard times from 16.21 to 13.24 minutes, representing a 2.97-minute decrease (22.43%). Similarly, production capacity increased by 20.58%, rising from 34 to 41 units per workday, reflecting a positive variation of 7 units. Labor productivity also improved, increasing from 3.8 to 4.6 units per worker per day, equating to a 21.05% growth. Additionally, the DAP analysis showed a decrease in the number of activities from 15 to 14, demonstrating a 7.1% improvement.

These results suggest that the implementation of the time study, combined with the questioning technique, is strongly associated with performance improvement. The methodology facilitates activity standardization and the reduction of nonproductive time, ultimately enhancing production efficiency.

When comparing these findings with previous research, similar trends are observed with different levels of impact. The results of the present study demonstrate a 22.43% reduction in standard time and a 20.58% increase in production, figures that significantly surpass the findings reported by [20] in the Indonesian furniture industry, where the application of the ECRS principle achieved a reduction in delivery time of just 4.79%. This suggests that the integrated methodology of time study with systematic questioning techniques is particularly effective in the context of the textile industry. This difference could be attributed to the sequential and repetitive nature of textile manufacturing processes, where the combination of similar activities and semi-automation offers greater optimization potential.

Similarly, [17] achieved a 5% reduction in activities by eliminating non-value-added tasks and bottlenecks, increasing production to 800 pieces per work shift in an Ethiopian garment industry, while [19] reported a reduction in production time from 472 to 438 seconds, resulting in a productivity improvement of 4.84% in a textile company. These cases confirm the general effectiveness of time studies and manufacturing improvement tools, albeit with more modest results than those obtained in the present research.

A distinctive aspect of this study compared to previous research is methodological integration. While [20] focused primarily on applying the ECRS framework as an isolated tool, and [16] exclusively used the DMAIC methodology to improve productivity by 1.75%, this research combined time study with systematic questioning techniques and root cause analysis tools (Ishikawa and Pareto). This holistic integration allowed not only the identification of improvement opportunities but also the effective prioritization of interventions according to their potential impact. Similarly, [21] demonstrated the benefits of an integrated approach by combining the Theory of Constraints with systematic questioning principles, reinforcing the idea that complementary methodologies produce superior results to individual applications of improvement tools.

Additionally, [16] documented an increase in productivity from 92.32% to 94.07%, reflecting a variation of 1.75%, as well as an efficiency boost from 93.47% to 94.36%, with an increase of 0.89%, following the application of time studies, method studies, and the DMAIC methodology. Moreover, [25] used method engineering to achieve a 41% reduction in downtime, successfully eliminating non-productive time and improving manufacturing methods. These cases, together with the results of the present study, confirm that complementary methodologies produce superior results to isolated applications of improvement tools, regardless of the specific industrial sector.

V. CONCLUSION

A key component of this study was the evaluation of the pre-test standard time for the sewing activities of the Pretel blouse, selected as the reference product, to compare it with the post-test standard time. By applying the time study alongside the questioning technique, a pre-test standard time of 16.21 minutes was identified, prompting further investigation into potential improvements. The use of the Ishikawa and Pareto diagrams facilitated the identification of the most frequent causes of low production. As a result of the implementation and prior analysis, a new work procedure was established, enhancing the process by consolidating activities that could be performed simultaneously.

Consequently, the standard time was reduced from 16.21 to 13.24 minutes, leading to an increase in production from 34 to 41 units in the post-test. This represents a 2.97-minute reduction in processing time and a 7-unit increase in output.

Within this framework, considering the findings and their implications, it can be inferred that the structured and effective implementation of the time study and the questioning technique contribute significantly to improving efficiency and production within a textile company.

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