

Standardization of a furniture manufacturing process

Estandarización de un proceso de fabricación de muebles

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Abstract

The company where the project was carried out is Muebles Quiché, located at Av. José María Chávez 1317 interior D. The project was carried out in the “Unique Designs” process, to optimize workstations, through the implementation of methodologies and solutions for the company. Through the study of times and movements, each of the operations that make up the process were analyzed, as well as identifying the operator's movements and subsequently generating a proposal that improves the efficiency of the line. The manufacturing process has evolved empirically, the first area of opportunity was to put order in the process and based on the observation of the operation, and the continuous improvement methodology (Prioritization matrix, Pareto diagram, Kaizen newspaper among others), starting with the clarification the path of operations, also gave order to the materials, and to the standardization of operations; These activities generated savings in costs, distances, times.

Kaizen, 5's, Unnecessary movements, spaghetti diagram,

Resumen

La empresa donde se realizó el proyecto fue Muebles Quiché, ubicada en Av. José María Chávez 1317 interior D. El proyecto fue realizado en el proceso llamado “Diseños Únicos”, para optimizar las estaciones de trabajo, mediante la implementación de metodologías y soluciones para la empresa. Mediante el estudio de tiempos y movimientos se analizaron cada una de las operaciones que compone el proceso, así como identificar los movimientos del operador y posteriormente generar una propuesta que mejore la eficiencia de la línea. El proceso de fabricación, ha evolucionado de manera empírica, se encontró como primera área de oportunidad poner orden al proceso y con base a la observación de la operación y a la metodología de mejora continua (Matriz de priorización, diagrama de Pareto, periódico Kaizen entre otros), iniciando con clarificar el recorrido de las operaciones, además se dio orden a los materiales, y a la estandarización de operaciones; estas actividades generaron ahorros en los costos, distancias, tiempos.

Kaizen, 5's, Movimientos innecesarios, diagrama, espagueti

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Introduction

Companies are currently facing a strong competence that requires the identification of opportunities in the outputs of their processes and changes in the way they operate, delivery time and costs (Hernández-Pitalua, Sánchez-Gómez, & Hernández Orduña, 2020), That is why organizations are beginning to apply lean manufacturing tools to improve their processes and be more competitiveness.

One of the tools used in production processes is continuous improvement (Kaizen), it is a tool that is part of the Lean Manufacturing methodology, it allows to have results such as reduction of waste and delays in each of the processes (Martínez Saavedra & Arboleada Zuñiga, 2021).

In 2017, Alvarado Ramírez & Pumisacho Álvaro conducted an evaluation of practices on continuous improvement in large and medium-sized companies, related to manufacturing and services in the Metropolitan District of Quito (DMQ), which required the involvement of directors, managers and workers in continuous improvement, solving problems to meet the organizational objectives of the company. The use of techniques has had an essential part of the business administration system where it is applied and which is to keep and improve the standards that are in place.

The spaghetti tool allows to observe the physical routes and to identify unproductive times and unnecessary movements, in order to satisfy the customer's requirement (L. Bermudez, 2009).

According to Campos Quispe, & Robles Poemape, (2020), they used the spaghetti diagram tool, within the warehouses, in order to indicate the quantity and the allocate of the products into the warehouse, since they did not have control, thus generating delays in the operations.

Regarding the time and movement study, it is used to determine the standard time of the operations of a process, the objective is to reduce costs and resources, eliminate unnecessary movements (Tejada-Díaz, Gisbert-Soler, & Pérez-Molina, 2017).

Angulo Noel & Carretero Landauro (2021), their project objective was to identify improvements that can be implemented in the warehouse area to reduce operating costs, supported by the time and motion analysis, the Deming cycle (PDCA). Also, the identification and characterization of waste from the process (Mudas) in the transportation and process, unnecessary movements and waiting times.

Particularly a fundamental tool of the Lean Manufacturing methodology, the 5's, which means: Selection, Order, Cleanliness, Standardization and Discipline (Chilón Aguilar, Esquivel Paredes, & Estela Tamay, 2017).

The company where the project was carried out is Quiché furniture, located in the State of Aguascalientes, Mexico, in order to cover the demand of customers established in Jalisco and San Luis Potosí; the location is advantageous due to the competitive cost of product transfer, even in small volumes (Martínez González, 2019).

The goal in this company was to optimize the most profitable product process, through the times and movements methodology; standardization and continuous improvement.

The work contents: Analysis of the original situation of the process, identification of opportunity areas in order to optimize operations for contributing to the reduction of idle times (Martínez Saavedra & Arboleada Zuñiga, 2021), and the establishment of a standard in order to keep the improvements.

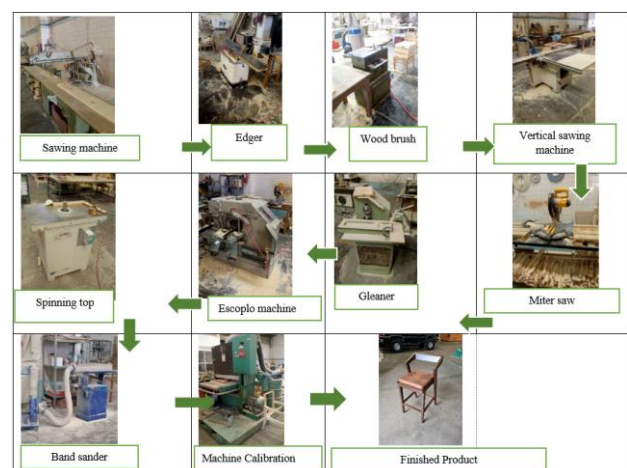


Figure 1 Standard model process

Source: Own elaboration with information from the company Muebles Quiché

Unique Design model elaboration process

The Unique Design model, is the product, defined for analysis of its processes steps: Cutting, Sanding, pre-assembly and fixed.

No.	Descripción	Operación	Inspección	Transporte	Descartar	Tiempo (Seg)	Observations
1	Bring wood to the cutter	●		→		15	
2	To cut wood	●				15	
3	Transfer to brush			→			
4	Transfer of cutter wood to sander	●		→		8	
5	Wood sanding	●				30	
6	Chop the wood into sections	●				30	
7	Moving wood			→		10	
8	Remove the excess left by the cutter	●				45	
9	Moving the wood			→		6	
10	Smooth wood	●				60	
11	Transfer the raw material			→		8	
12	The wood is cut crosswise	●				60	
13	Transfer the raw material			→		8	
14	The parts coupling is done (male)	●				75	
15	Transfer the raw material to turning			→		6	
16	Parts coupling is performed (female)	●				12	
17	Transfer the raw material			→		3	
18	The wood is leveled	●				12	
19	Transfer the raw material to contouring machine			→		6	
20	The contour is made to the piece of wood	●				30	
21	The wood is sanded	●				30	
22	Transfer the raw material to the assembly area			→		3	
23	Assemble	●				60	
24	Transfer the raw material to the warehouse			→		20	

Figure 2 Flow diagram of a standard chair model (Design Area)

Source: Own elaboration with information from the company Muebles Quiché

The first operation passes the wood to the cutting area, then it goes to Sanding where an edging machine is used, and a calibrating machine that helps correct irregularities, so that all its sides are the same size and thickness; when the wood is ready, it is sent to the process where the vertical sawing machine, band saw, miter saw, tenoning machine and spinning top are located.

These machines shape the wood and make the corresponding holes for the assembly; when the wood is ready it is moved to the assembly area where different materials are used, in this case pneumatic guns are used, one for staples and another for nails, these use air compressors, industrial glue is also used to join the pieces with the nails or staples; once the final product is ready it is sent to the finished product storage area (Figure 1).

The model with the highest demand is called Unique Design, identifying areas of opportunity (Figure 2), which are described below.

After having made a referenced analysis on the manufacture of the Unique Design, and considering process sheets or operation standards, the information was organized in a prioritization matrix, taking as reference the “7 wastes” of lean manufacturing practices, as can be seen in Figure 3 (prioritization matrix) the one with the highest relevance was the unnecessary movement and lost time.

3 point

2 points

1 point

Problems	Ponderation					Sum
	Importancy	Prioridad	Department policies	Impact	Difficulty	
Unecessary movements						13
Product in process inventory						9
Machinery inventory						7
Lost time						13
No signalization						7

Figure 3 Problem prioritization matrix

Source: Own elaboration with information from the company Muebles Quiché

Problem Statement

The main problem detected in the operator performs was, unnecessary movements, affecting whit this, costs and timely deliver of customer orders.

General objective

Currently there is a capacity of 44 chairs per day, so it is wanted to increase by 20%, with the improvement proposal.

Justification

The Unique Design model represents 10% of total production, however, it is a product that presents a high profit margin for the company. By intervening in this project, the company incorporates production management techniques that could be replicated in other models of higher production volume.

Development

The “Muebles Quiché” company has 11 workstations with a different cycle time, due to the range of designs they have.

The manufacture of a chair consists of six parts: Seat, shipowner, chair lap, hind legs, front and back legs.

Seat

For the elaboration of the seat, unnecessary journeys were identified with a total time of 2.64 minutes (Table 1).

In the study of movements, it can be observed that there is no standard, due the operator goes slower depending on the weight of the raw material that he transfers (Figure 4).

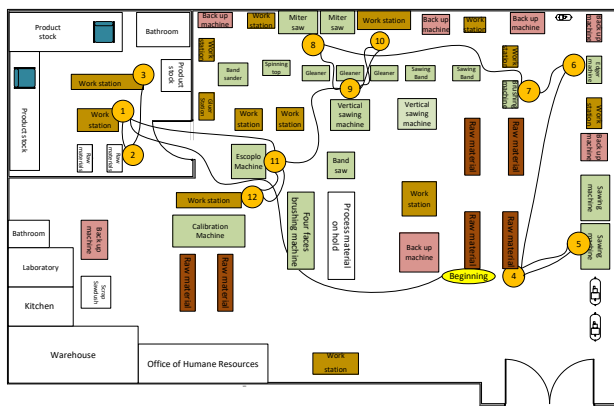


Figure 4 Spaghetti Diagram for Seat Assembly
Source: Own elaboration with information from the company Muebles Quiché

Point	Distance (Meter)	Time (sec)
Beginnig-1	30	35
1-2	1.20	2
2-3	3.20	4
3-4	36	24
4-5	2.80	8
5-4	2.80	8
4-6	12	18
6-7	10	8
7-8	20	14
8-9	3.80	7
9-10	3.30	2
10-9	3.30	3
9-11	4.70	5
11-12	7.5	6
12-11	7.5	6
11-1	13.5	9
Total of the operation	161.6	158.95 sec 2.64 min

Table 1 Data concentration (Distance and time) of the Seat assembly
Source: Own elaboration with information from the company Muebles Quiché

Shipowner

For the owner's elaboration, unnecessary routes were identified with a total time of 2.98 minutes (Table 2 and 5), it can be observed that out of 18 movements only two are not irregular, due to the transferred load carried by the operator.

Point	Distance (Meter)	Time (sec)
1-2	6.20	6
2-3	7.80	9
3-4	20	21
4-5	2.80	6
5-4	2.80	6
4-6	12	10
6-7	10	6
7-8	5	4
8-9	7	9
9-8	7	11
8-1	5	6
1-10	3.80	7
10-1	3.80	7
1-2	3.20	5
2-3	12.70	24
3-11	10	11
11-1	10	12
1-12	10	12
Total of the operation	139	178.93 sec 2.98 min

Table 2 Concentrated data (Distance and time) of the Shipowner's product.
Source: Own elaboration with information from the company Muebles Quiché

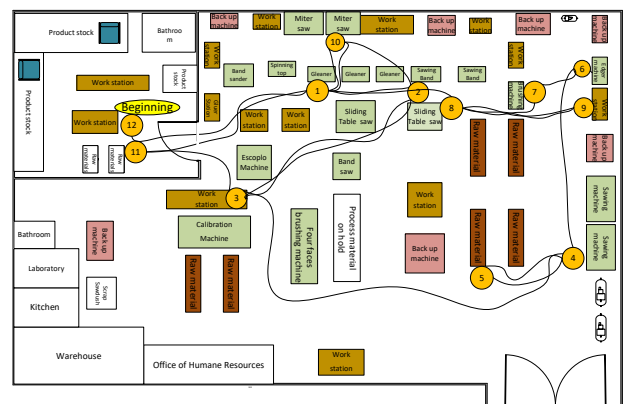


Figure 5 Spaghetti Diagram for Assembling the Lap
Source: Own elaboration with information from the company Muebles Quiché

Chair lap

For the elaboration of the lap, the incensorial paths were identified with a total time of 2.12 minutes; the longest time was 36 seconds which is at the beginning (Table 3 and Figure 6).

Point	Distance (Meter)	Time (sec)
1- Beginning	38	36
Beginning - 2	36	34
2-3	12	15
3-4	6	9
4-5	7.5	7
5-6	3	3
6-5	3	4
5-7	1.20	1
7- Beginning	13.5	16
Total operation	120	127.23 sec. 2.12 min.

Table 3 Data Concentration (Distance and Time) of the Lap Assembly

Source: Own elaboration with information from the company Muebles Quiché

In elaboration of the lap assembly, the first operation is located in the warehouse area, and in the process area are located machines out of operation; therefore it will be an area of opportunity for improvement the plant distribution (Figure 6).

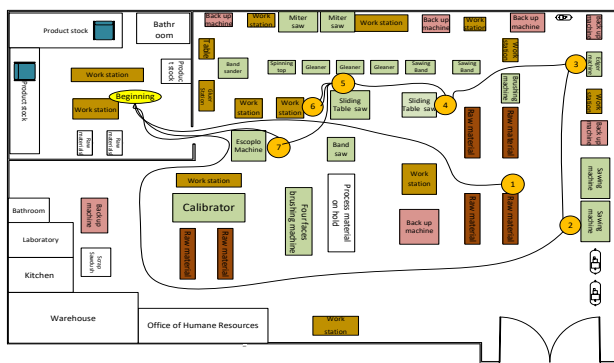


Figure 6 Spaghetti Diagram for Assembling the Lap
Source: Own elaboration with information from the company Muebles Quiché

Chair back

Elaboration of the backrest, the total journeys requires a whole time of 1.74 minutes (Table 4 and Figure 7).

Point	Distance (meter)	Time (sec)
1-2	38	28
2-3	2.80	2
3-4	12	17
4-5	1.20	5
5-6	7.25	9
6-7	6	5
7-8	20	14
8-9	3.80	6
9-10	1.20	2
10-11	1.15	1
11-12	14	11
12-1	2.37	2
Total operation	109.77	104.88 seg 1.74 min

Table 4 Data Concentration (Distance and Time) of Backup Arming

Source: Own elaboration with information from the company Muebles Quiché

In operations one and twelve, they also use the tables as a work area and see the possibility of improving their distribution (Figure 7).

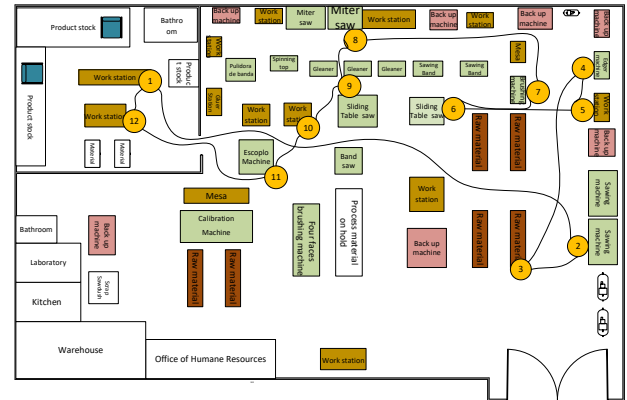


Figure 7 Spaghetti diagram for backrest assembly
Source: Own elaboration with information from the company Muebles Quiché

Hind legs

For the elaboration of the hind legs, the routes with a total time of 1.76 minutes were identified, in which it was identified that there are three long distances, the first with a route of 36mts., the other of 15 and the third of 14.8mts., it can be observed that the times vary due to the number of pieces that the operator loads from one work area to another, for this reason, sometimes the route is long or slow (Table 5 and Figure 8).

Point	Distance (Meter)	Time (sec)
Beginning-1	2.37	2
1-Beginning	2.37	2
Beginning-2	36	24
2-3	2.80	3
3-4	12	16
4-2	14.8	21
2-5	15	12
5-6	5	4
6-7	7.5	7
7-8	3.30	5
8-1	11	10
Total of the operation	112.14	105.65 Sec 1.76 min

Table 5 Data concentration (Distance and time) of the assembly of the hind legs

Source: Own elaboration with information from the company Muebles Quiché

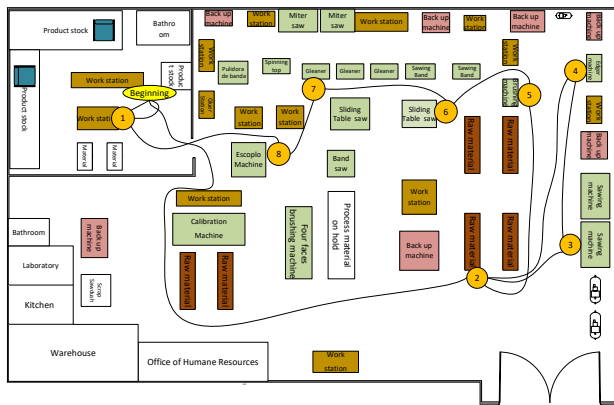


Figure 8 Spaghetti diagram for the assembly of the hind legs

Source: Own elaboration with information from the company Muebles Quiché

Front legs

For the elaboration of the lap, the incensorial movements were identified with a total time of 1.52 minutes. The first movement is the longest at 36 meters, with a time of 25 seconds (Table 6 and Figure 9).

Point	Distance (Meter)	Time (sec)
1-2	36	25
2-3	2.80	5
3-4	12	11
4-3	12	10
3-5	2.80	8
5-6	12	10
6-7	10	8
7-8	3.30	5
8-1	11	10
Total of the operation	101	91.64 seg. 1.52 min.

Table 6 Data concentration (Distance and time) of the front leg assembly

Source: Own elaboration with information from the company Muebles Quiché

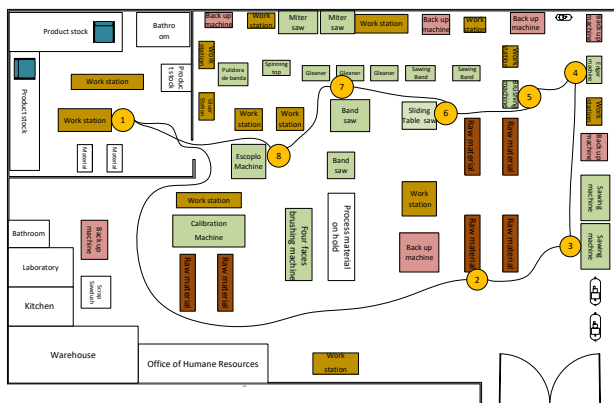


Figure 9 Spaghetti diagram for front leg assembly

Source: Own elaboration with information from the company Muebles Quiché

It can be concluded that with the spaghetti diagrams of each of these parts, the times and their respective distances are obtained as a result with a total of 12.76 minutes, since it is only performed by a single operator (Table 7).

Chair part	Distance (Meter)	Time (minutes)
Seat	161	2.64
Shipowner	139	2.98
Chair lap	120	2.12
Chair back	110	1.74
Front legs	101	1.52
Hind legs	112	1.76
Total of the operation	743	12.76 minutes

Table 7 Result of the movements of each part of the product

Source: Own elaboration with information from the company Muebles Quiché

Methodology

To achieve the main objective of increasing the production capacity of the chairs, the following Lean manufacturing management tools were used: Observation of the operation, process mapping, prioritization matrix, spaghetti diagram and the 5's methodology.

(1) Selecting, which involves separating what is necessary and identifying what is not useful in the work areas; (2) ordering, which consists of organizing everything in its place, so that it is easy to locate it considering labels, place to store, depending on the product; (3) cleaning, involves cleaning the work area before and after the shift (4) standardize, means to apply the first three "S" permanently, with the support of some photographs, statistics, procedures; (5) discipline, in this last one visits are made to the areas to verify compliance with the standardization that was proposed (Chilón Aguilar, Esquivel Paredes, & Estela Tamay, 2017).

At the beginning of this document, the company lacks a production management culture, because that, this project and some tools were implemented to generate better work practices such as: Cleaning, standardization, Kaizen. In order to adapt this work culture, the worker must be involved in training, starting with the training of the 5's and locking generate a mentality about the benefits that can be reached.

Results

The following diagram shows the route that the operator will take to make the six parts of the chair, obtaining a distance of 55.32 meters, consuming 0.95 minutes. It was decided to place the workstation in this location since it is located in a centralized place in the plant, with the purpose of obtaining that the operator has the machines closer and thus be able to reduce unnecessary movements (Table 8 and Figure 10)

Point	Distance (Meter)	Time (sec)
1-2	3.48	4
2-3	2.60	2
3-4	14.40	12
4-5	3.30	3
5-6	6.45	7
6-7	3.57	4
7-8	3.35	4
8-9	5.55	6
9-10	2.50	2
10-1	10.12	13
Total of the operation	55.32 meter	57 sec. 0.95 min.

Table 8 Improvement Spaghetti diagram improvement
Source: Own elaboration with information from the company Muebles Quiché

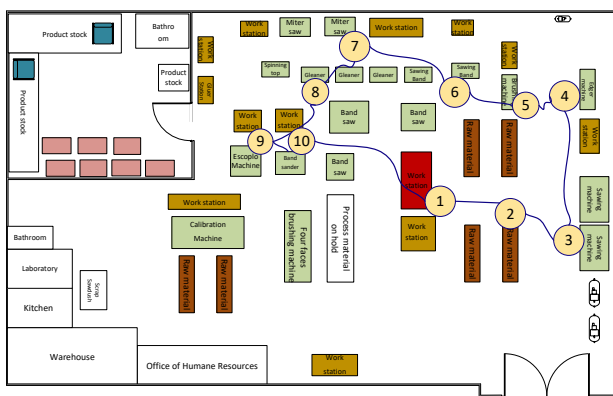
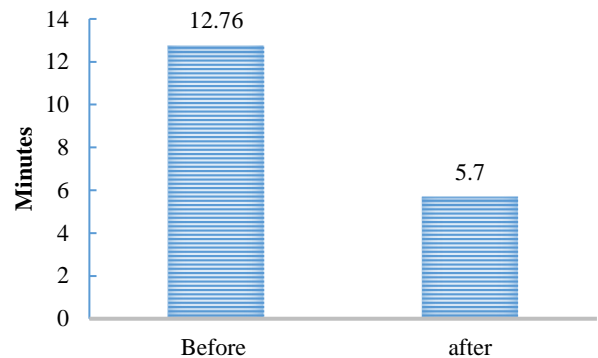


Figure 10 Spaghetti diagram improvement
Source: Own elaboration with information from the company Muebles Quiché

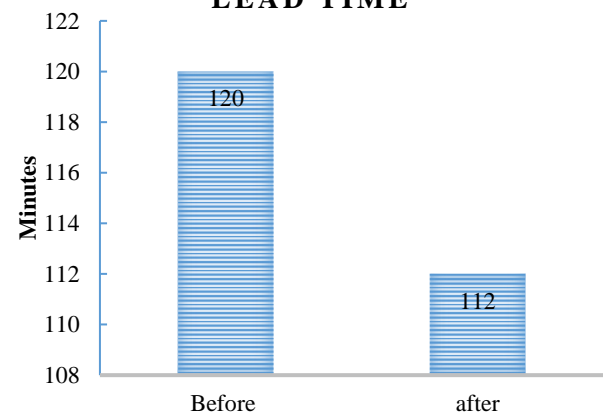
The total time of transfers before the intervention was 12.76 min., after the changes made it was 5.38 min., therefore the manufacturing time of 120 min. was reduced to 112 min., therefore it was reduced by 6.3% vs. 20% targeted (Graphic 1 and 2).

OPERATOR MOVEMENTS RESULT



Graphic 1 Result of operator movements
Source: Own elaboration with information from the company Muebles Quiché

LEAD TIME



Graphic 2 Lead time before and after improvement
Source: Own elaboration with information from the company Muebles Quiché

The improvement points are follows:

- (1) Machinery that was not being used was removed.
- (2) Worktables were relocated between operations.

From 56 chairs that were produced with the improvement, now will be produced 60 chairs per day, with a difference of seven pieces, which impacts the utility of the company.

The methodology of 5S was implemented, which is a lean manufacturing in order to improve production processes considering the steps: Classification, cleaning, standardization and discipline (Seiri, seiton, seiso, seiketsu and shitsuke) (Martínez Saavedra & Arboleda Zuñiga, 2021); starting with the training in order to make the operators aware of their scope of work since their commitment is required.



Figure 11 Before and after in the Warehouse Area
 Source: Own elaboration with information from the company Muebles Quiché

Obtaining as a result the elimination of unnecessary movements since these were caused by the lack of a tool near your workstation (Figure 11).



Figure 12 Evidence of the training for the implementation of the 5's

Source: Own elaboration with information from the company Muebles Quiché

After the training, with the support of the staff, the cleaning caused by sawdust was carried out, the location of the tools through standardization (Figure 12).

Conclusion

We thank the company Quiché for having trusted the staff of the Technologic University of Aguascalientes and students who participated in field work, López Valdez Luis Eduardo, Villarreal González Margarita, Atilano Gutiérrez Ignacio Antonio, Díaz Sara Eli, and Suarez Hernández María Guadalupe.

For the moment it is recommended that the 5's practices be maintained, for a more organized production, the standardization (Chilón Aguilar, Esquivel Paredes, & Estela Tamay, 2017).

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