Workflow Analysis of a Lumber and Furniture Microenterprise: Basis for Improvement

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Abstract

The furniture sector of the Philippines presently accommodates approximately 15,000 manufacturers. Employment is envisioned at approximately 800,000 people inclusive of manufacturers, subcontractors, and suppliers. The furniture market is a flexible industry that continuously strives to adapt to current trends and provide products that would be of interest to a broad range of people and lifestyles on a global scale. The micro-company is offering different furniture sets made with Mahogany and Gmelina, the enterprise also offers building materials. As a Company that produces products like furniture to a wide area, proper operations management should be practiced in order to achieve better customer service and reduce the cost in each process while increasing the profit, efficiency, and productivity. The study was conducted to evaluate the area for improvement in the operations management of the company in terms of Facilities Planning and Design using Lean Six Sigma Techniques, in particular Value Stream Mapping and 5S System. The researchers made use of desktop research, document analysis, distribution of the questionnaire, and virtual interview to collect necessary data for the study. With the information above, the company can address the identified research problem by relay-outing and rearranging the processes in manufacturing the furniture single bed. It increases the workflow efficiency by 19% in site 1 and 62% in site 2 and reduces the time spent in nonvalue-adding activity by 9.92%.

Keywords
Workflow, Furniture, Lean, Six Sigma, Lean System

1. Introduction
The furniture sector of the Philippines presently accommodates approximately 15,000 manufacturers. Employment is envisioned at approximately 800,000 people inclusive of manufacturers, subcontractors, and suppliers.[1] The segment utilizes 2.1 million roundabout laborers across the nation and serves 5.4 million individuals through its supply chain. The furniture market is a flexible industry that continuously strives to adapt to current trends and provide products that would be of interest to a broad range of people and lifestyles on a global scale. Consumer income, shifting lifestyles, and developing urban landscapes are just a few of the issues that should be considered by people in the sector.

Lean manufacturing and Six Sigma have been successfully used in manufacturing and service fields to optimize various performance indicators. In the past two decades, both lean manufacturing and Six Sigma have proven that by focusing on process performance, cost, quality, and production time can be significantly improved.[3] In this study, the researchers investigated the possible links between some optimization techniques used in operations management and the performance of small and medium-sized enterprises in manufacturing operations. Operational management activities should be primarily related to companies that belong to the industrial rather than non-industrial sector.[4] Workflow analysis has frequently been utilized with the objective of improving efficiency. It can be used to redesign existing processes. [5] Workflow design has been applied to improve the productivity of work processes or empower parallelization of work.

The company is a micro-company located at Victoria Village, Tabunok, Talisay City. The company offers different furniture sets made with Mahogany and Gmelina, the enterprise also offers building materials. Their target customers are locals in the Visayas area. As a Company that produces products like furniture to a wide area, proper operations management should be practiced in order to achieve better customer service and reduce the cost in each process while increasing the profit, efficiency, and productivity. The researchers' goal of this study was to propose recommendations to the management in order to improve the current problem area/s in terms of Lean Systems, specifically the Facilities Planning and Design. The proposed recommendations/process will be simplified and will be beneficial to the company.

1.1 Objectives

This study is conducted to evaluate the area for improvement in the Operations Management of Jimmy's Lumber and Furniture Enterprises in terms of Facilities Layout and Design using Lean Six Sigma Techniques, in particular Value Stream Mapping and 5S System. In line with that, this study aims to know the following:

- What is the existing production process and layout of the production area of the company?
- What are the current problems encountered by the company and production workers? What are the root causes and its effect on the company?
- What are the possible solutions and recommendations to improve the current problem area in the operations management practices in terms of Facilities Layout and Design using Lean Six Sigma Techniques, in particular Value Stream Mapping and 5S System?

2. Literature Review

In improving the efficiency of a production system, the most frequently used methods include Lean Principles and Facilities Layout and Design,[8] the other being Simulation. This study intends to incorporate Lean Principles into Facilities Layout and Design techniques to provide better solutions and recommendations for improvement to the Operations Management of the business as opposed to only using one method for improvement.

Lean Manufacturing / Production

The American Society for Quality (ASQ) defines lean as a "set of management practices to improve efficiency and effectiveness by eliminating waste." Whereas the system for running a manufacturing or service operation, whose practices have the commonality of eliminating most, if not all, of the waste in the system is called Lean Production.[9] This study intends to use lean manufacturing principles to reduce the amount of different waste/s created in the production process (Kosky et al. 2020).

On The Philippines' Economy and Lean Systems

A case study from India has found that Lean principles can be used by industries when the economy is in recession to survive by following lean techniques, in particular, Value Stream Mapping (Sing et al. 2009). To wit, The Office of the National Statistician of the Philippines had said the 9.5% drop in GDP during 2020 was the biggest since the government started recording annual output in 1946. Prior to this, the worst recession was in 1984, burdened with a debt crisis (de Vera 2021). As of the first quarter of 2021 the Philippines was still in recession, suffering its fifth consecutive quarter of economic contraction. Economic recovery remains to be delayed but the country seeks to move up to a higher income status in 2022 but the decrease in GNI shows it may be difficult to achieve this (Biswas, 2021).

Visual Workplace

Lean Manufacturing often overlaps with Visual Workplace as its main principle rests on the definition that a visual workplace is a self-ordering, self-explaining, self-regulating, and self-improving work environment—where what is

supposed to happen does happen, on time, every time—because of visual devices (Galsworth 2005). Introducing the 5S and kaizen rules to an organization can bring significant and noticeable changes e.g., increased process effectiveness and efficiency; improved visibility of the process; improved morale and safety of the employees; and reduced delays, searching time, and dangerous conditions (Galsworth 2011). It has also been stated that the more the process becomes visual; the more production velocity increases (Gupta & Jain 2014). One of the key principles of 5S is to not distract the eye with cluttered, damaged, and/or dirty so the eye can focus on gathering useful information (Ward et al., 2014). As such, images are used in a visual workplace to convey messages to be known to the workers (Wilson 2016).

Lean's Effect and Implementation Problems

When deciding Lean Strategy, it's necessary to keep in mind what would yield the most benefit to the company thus the focus on what to integrate into the study should be that which has the stronger significance on operational performance while still being feasible. Previous evidence shows Just-in-Time and automation as having the strongest while Kaizen, Total Productive Maintenance and Value-Stream Mapping have a lesser or negative effect (Belekoukias et al. 2014). It's important to ensure the success of the implementation of Lean concepts in manufacturing systems. This can be done by (1) having a training program that focuses on how to eliminate waste; (2) having the training include participants from the top, middle, low-level management, staff function personnel, process engineers and the affected workers; and (3) having reliability in the manufacturing process as well as equipment (Hancock et al. 1998).

Facilities Layout Design

The main objective of facility layout design is to design smooth workflow and improve worker and equipment productivity in operations. An efficient layout can reduce total operating costs and total manufacturing costs by as much as 50% and 75% respectively by minimizing the total distance travelled of goods, the material handling cost, and the time spent in the manufacturing system (Bozer et al. 2010). Multiple similar studies on Facilities Layout Design with Lean Methods have been conducted (Balachandar & Reddy 2020; Kovács & Kot 2017; Kovács 2020) that, in all cases, the combination of both yields more Key Performance Indicators (KPIs) for the study to measure. Among these are Material Handling Costs, Distance of Material Flow, Cycle Time, and Workplace Ergonomics.

Flow Analysis and Techniques

A part's flow is the path that it takes while moving through the facility. Flow analysis not only considers the path of each part, but it also tries to minimize the: 1. distance travelled, 2. backtracking, 3. cross traffic, and 4 cost of production. In establishing the best arrangement of equipment, four techniques can be used (Stephens, 2013):

- String Diagram
- Multicolumn Process Chart
- From-to Chart
- Process Chart

Studies have shown that redesigning a product's workflow can be used as a technique to decrease cycle time and lower production cost (Keil et al. 2014).

Flow efficiency is the proportion of distance travelled by the parts of a product when moving between workstations.

$$Workflow\ Efficiency = \frac{Total\ Distance\ Travelled}{Total\ Penalty\ Points} \times 100\%$$

or

$$\%\ Distance = \frac{Distance_{ideal} - Distance_{actual}}{Distance_{actual}} \times 100\%$$

Work Measurement

Manufacturing Cycle Efficiency is defined by Chegg as the "proportion of time that is to be spent on manufacturing by value-added activities."

$$MCE = \frac{value - added\ time}{manufacturing\ cycle\ time}$$

$$Manufacturing\ Cycle\ Time = process\ time + queue\ time + moving\ time + inspection\ time$$

Production waste can come in the form of idle time. This waste can cause problems down the line such as underproduction and lowering the Manufacturing Cycle Efficiency. A study on a steel-processing industry has shown that Manufacturing Cycle Efficiency can be improved with a lean approach (Andrawati et al. 2019).Value-stream mapping has proved to be an effective approach by differentiating between non-value-adding and value-adding activities streamlining the process (Seth et al. 2017). In shared worker environments, such as the subject of this study, machine idle time will certainly occur due to the lack of available workers. Thus, efficient utilization of labor is also a method to lessen downtime (Hn et al. 2013). Several techniques from the Maynard's Industrial Engineering Handbook by Maynard and Zandin are used in this research to compute for standardized time with certain aspects considered such as the allowance factor and performance rating (Maynard & Zandin 2001).

3. Methods

Subject Delimitation

Through thorough deliberation with the management of the company, the researchers and the management decided to focus on the production layout of making the furniture. The product lines, process time, move time, queue time, raw materials, machines, and equipment used were also considered. Thus, the study only focused on identifying the problem and analyzing possible layout design in reducing the wastes on the production layout of the product focus. Lean Six Sigma (LSS) techniques were used to analyze the manufacturing company's existing setup. The principle of identifying the value stream and eliminating waste. It means knowing the process's flow and eliminating the barriers that slow down or impede the flow, and those barriers were waste. The company also adopted the principle of continuously improving in pursuit of perfection, gathering data, and sharing learning after improving, building quality, and mistake-proofing into the process. To achieve the goal of the study, researchers applied the techniques of lean systems to reduce wastes in the production area. Waste is defined as any action or process that does not add value to the product or benefit the customer. The following are the wastes that were being addressed in the study:

Move or motion waste - Any movement or motion that the worker performed but does not add value to the product, resulting in capital depreciation and opportunity loss.

Transportation - Transportation waste involves moving inventory, people, or tools more often or further than necessary. Excessive movement can result in product damage, unnecessary work, and opportunity losses.

Inventory waste - This waste refers to the waste produced by unprocessed inventory. It includes the waste of storage or space and the waste of capital tied up in the unprocessed inventory. It has an environmental impact like deterioration or damage in work-in-process additional materials to replace damaged or obsolete areas and the energy to light.

Place Delimitation

This study was conducted in the company. It is a wood or furniture manufacturing sector that is located at Victoria Village, Tabunok, Talisay City, Cebu. The proposed layout was only intended for two (2) of the three (3) locations of production area of the company. Consequently, the proposed solution did not involve the 3rd location — Site 3 Mohon, Talisay City, Cebu, because the management did not provide the researchers with the necessary data from this location.

Time Delimitation

The study was conducted this academic year 2021-2022, within the first and second cluster of the first semester. The study was expected to finish this December 2021.

Research Environment

The researchers conducted the study at The company, which is located at Victoria Village, Tabunok, Talisay City. The company operates in the Wood or Furniture Manufacturing sector. There are no studies conducted related to this topic, so this study is considered as the first study in the place where it was conducted.

Research Respondents

In gathering the needed data respondents represent, the entire population of the target users, and their number was enough from which to adequately gather data, the researchers interviewed the business owner and the production workers of the company. The business owner is the one who is responsible in establishing the rules and policies within

the company, implementing strategies for the development of the company, and preparing the business plan of the company. The production workers, on the other hand, are the ones who showed the step-by-step process in making the products being produced and the list of raw materials and equipment being used.

Research Procedures

Figure 1 below shows the inputs that were needed for the focus of this study being Facilities Layout and Planning, Workflow Analysis in particular, and integrating Lean Principles and Techniques. After the researchers have gathered the needed data using research instruments, it was treated with data analysis tools to come up with proposals for improvements in the Operations Management of the company, and its Facilities Layout and Design.

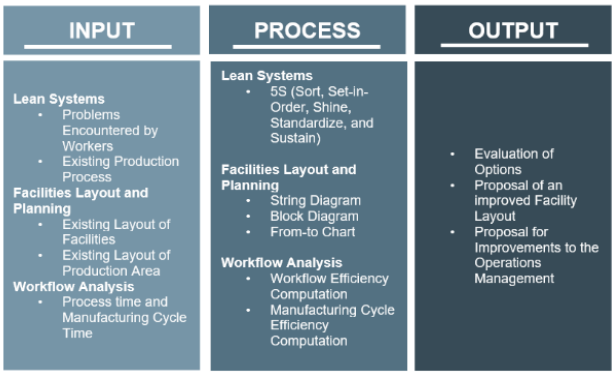


Figure 1. Research Procedure

4. Data Collection

The methods of data collection needed to be used for the complete fulfillment of this research study were the interview, the document analysis/desktop research, the questionnaire, and the focus group discussion through virtual or online means. Through this, the researchers obtained information needed that would be subject to analysis in order to provide solutions and to propose recommendations to improve the Operations Management practices in terms of Facilities Layout and Design using Lean Six Sigma Techniques.

5. Results and Discussion

A. Facility Planning (Manufacturing Cycle Efficiency)

Manufacturing Cycle Efficiency (MCE) is a tool used in measuring the proportion of production time spent on value-added activities. This can be used in any business to get rid of the non-value-added in order to shorten the time in manufacturing a product thereby reducing costs. The Value-added activities include all the activities in processing a product while non-value added activities include the queuing, moving and inspecting the products.

Table 1 shows the existing process in the making of a single bed had 186.37 and 114.44 minutes for value-adding and non-value-adding activities, respectively.

Table 1. Summary of Value Adding Analysis (Existing Process)

Process	**Value-added time (minutes)**	**Non value-added time (minutes)**
Cutting Process of Single Bed in Cutting Area	33.32	13.48
Planing and Drilling Process of Single Bed	53.93	9.29
Cutting Process of Single Bed in Workstation	24.73	13.16
Assembly of Single Bed	26.55	35.3
Transporting of Assembled Single Bed	0	26.83

Sanding and Body Filling Process	34.15	3.72
Varnishing/ Painting and Drying Process	13.69	12.66
TOTAL	**186.37**	**114.44**

Table 2 shows the summary the proposed process brought the non-value-adding activities down to 68.684 minutes which ultimately led to the increase of Manufacturing Cycle Efficiency.

Table 2. Summary of Value-added Time Analysis (Proposed Process)

Process	**Value-added time (minutes)**	**Non value-added time (minutes)**
Cutting Process of Single Bed in Cutting Area	47.43	12.96
Planing Process	33	7.49
Drilling Process	24.4	6.27
Assembly of Single Bed	38.7996	26.784
Sanding and Body Filling Process	31.84	3.57
Varnishing/ Painting Process	14.65	4.1
Drying Process	0	7.51
TOTAL	**190.1196**	**68.684**

To compute for Manufacturing Cycle Efficiency, the processes were classified as part of one of four Manufacturing Cycle Times.

Existing Manufacturing Cycle Efficiency

$$= \frac{Value\ Added\ Time\ (Processing\ Time)}{Manufacturing\ Cycle\ Time\ (Process\ Time + Queue\ Time + Moving\ Time + Inspection\ Time)}$$

$$= \frac{321.04\ minutes}{321.04\ minutes + 111.58\ minutes + 50\ minutes + 33.91\ minutes}$$

$$= \frac{321.04\ minutes}{516.53\ minutes}$$

$$= \mathbf{0.6215\ Or\ 62.15\ \%}$$

Result showed a 62.15 % of its manufacturing time spent in value added activities while 37.85% spent in the non-value-added activities.

Proposed Manufacturing Cycle Efficiency

$$= \frac{Value\ Added\ Time\ (Processing\ Time)}{Manufacturing\ Cycle\ Time\ (Process\ Time + Queue\ Time + Moving\ Time + Inspection\ Time)}$$

$$= \frac{261.43\ minutes}{261.43\ minutes + 53.99\ minutes + 22.96\ minites + 24.34\ minutes}$$

$$= \frac{261.43\ minutes}{362.72\ minutes}$$

$$= \mathbf{0.7207\ Or\ 72.07\%}$$

Result showed a 72.07 % of its manufacturing time for value added activities while 27.93% spent in the non-value-added activities. The improvement on the Manufacturing Cycle Efficiency of the proposed system is 9.92%.

B. Facility Planning (Workflow Efficiency)

Workflow efficiency formula was used as a key metric to identify the best possible workflow pattern for the process. The workflow patterns are represented in a string diagram. The company has two different sites. Figure 2 and 3 show the existing workflow pattern of the company and its distance in meters.

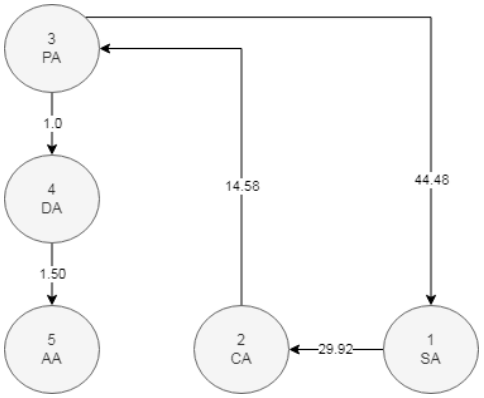


Figure 2. Existing Workflow Pattern of Site 1

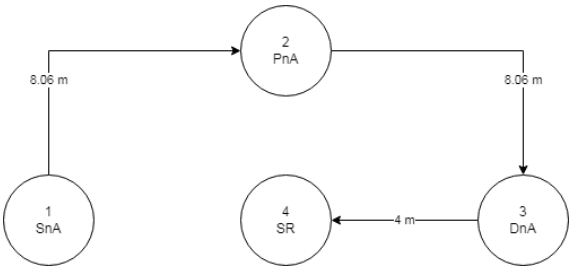


Figure 3. Workflow Pattern of Site 2

The computation of the distance covered from one workstation to another is computed using the distance formula and the distances are derived from the from-to chart shown in table 3 and 4.

Table 3. From-to Chart of the Existing Workflow Pattern of Site 1

FROM/ TO (unit in m)	STORAGE	CUTTING	PLANING	DRILLING	ASSRMBLY
STORAGE (SA)	0	29.92	44.48	44.34	44.18
CUTTING (CA)		0	14.58	14.51	14.53
PLANING (PA)			0	1.0	2.5
DRILLING (DA)				0	1.50
ASSEMBLY (AA)					0

Table 3. From-to Chart of the Existing Workflow Pattern of Site 2

FROM/ TO (unit in m)	SANDING	PAINTING	DRYING	SHOWROOM
SANDING	0	8.06	8	4
PAINTING		0	8.06	7

FROM/ TO (unit in m)	SANDING	PAINTING	DRYING	SHOWROOM
DRYING			0	4
SHOWROOM				0

Results show that the best solution for relayout is to use U-shaped Layout for both sites with an improvement of 19% for site 1 while there was an improvement of 62% for site 2 as shown in tables 4 and 5 respectively.

Table 4. Workflow Efficiency for Site 1 (Existing vs. Proposed)

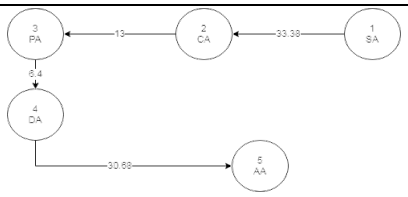
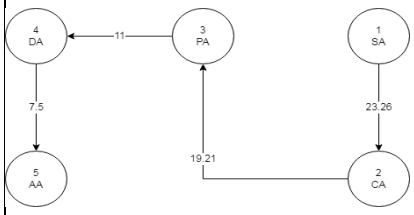
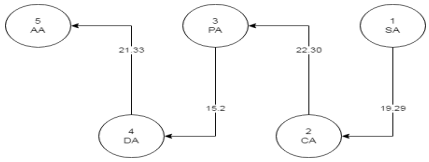
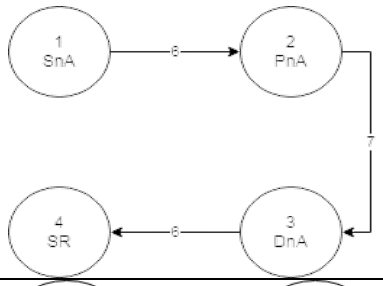
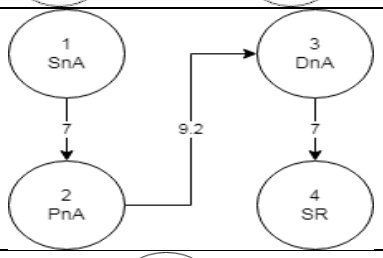
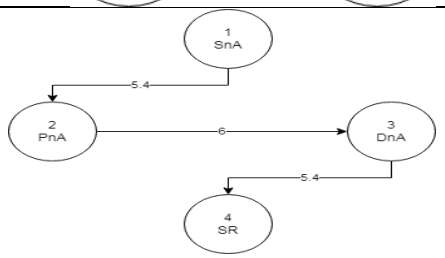
SITE 1				
SOLUTION	**STRING DIAGRAM**	**WORKFLOW EFFICIENCY**		**IMPROVEMENT**
		EXISTING	**PROPOSED**	
A: U-shaped Layout		52%	71%	19%
B: S-shaped Layout			58%	6%
C: W-shaped Layout			60%	8%

Table 5. Workflow Efficiency for Site 1 (Existing vs. Proposed)

SITE 2				
SOLUTION	**STRING DIAGRAM**	**WORKFLOW EFFICIENCY**		**IMPROVEMENT**
		EXISTING	**PROPOSED**	
A: U-shaped Layout		38%	100%	62%
B: S-shaped Layout			61%	23%
C: W-shaped Layout			60%	22%

Computation for Workflow Efficiency for Site 1 Solution A

$$Distance\ (between\ two\ points) = \sqrt{(X_1 - X_2)^2 + (Y_1 - Y_2)^2}$$

Where:
X_1 and Y_1 = centroid of the column department in the table
X_2 and Y_2 = the centroid of the row department in the table respectively

Solution:

$$Distance\ (between\ two\ points) = \sqrt{(52 - 19)^2 + (12 - 17)^2}$$

$$Distance\ (between\ two\ points) = 33.38\ \text{m}$$

$$Workflow\ Efficiency = \frac{Total\ Distance\ Travelled\ (TDT)}{Total\ Penalty\ Points\ (TPP)}\ x\ 100$$

$$Workflow\ Efficiency = \frac{1.26\ m}{1.78}\ x\ 100$$

$$Workflow\ Efficiency = 71\%$$

5.3 Proposed Improvements

The primary recommendation of the researcher is to re-layout the production area following the U-shaped flow pattern. Based on the evaluation of option and comparative analysis, the U-shaped flow pattern has the highest workflow efficiency. In site 1, the efficiency improvement is 19%, from 52% existing efficiency to 71% U-shaped efficiency. In site 2, the efficiency improvement is 62%, from 38% existing efficiency to 100% U-shaped; it would be beneficial to the production area to apply the U-shaped flow pattern.

OM Area	Opportunity Loss (per year)	Payback Period	Savings	Cost-benefit Ratio
Facility Planning	Php 372,151.01	2 months and 8 days	Php 340,687.01	10.83
Work Measurement	Php 372,151.01	2 months and 14 days	Php 337,831.01	9.84

Upon implementation, it incurs a cost of downtime, labor cost, materials cost, and opportunity cost. There will be a Php 340,687.01 in savings with a payback period of 1 month and 4 days in facility planning implementation. The cost-benefit ratio of facility planning is 10.83, which means that the benefit is greater than the cost of implementing the solution. In work measurement implementation, there is Php 337, 831.01 in savings with a payback period of 1 month and 7 days. The cost-benefit ratio of the work measurement is 9.84. This also means that the benefit is greater than the cost of implementing the solution. Obstructions in the layout process are those that can stop or slow the flow of the implementation process. The obstructions are the cost, weight of the machines, time, or the implementation period. The cost is being handled by identifying the cost-benefit ratio, savings, and the payback period. To handle the heavy machines, workers can disassemble the machine to reduce into small parts and can be moved faster and safer. Workers handle the time by minimizing their idle time and maximizing productive time.

As for the secondary recommendations, the researchers will recommend transferring all the processes in one location and creating a new operation layout where all the operations are placed in one location to avoid unnecessary process and production waste if budget allows. The 5S methodology is also recommended to be applied in the production area to sort and standardize the tools and equipment in the workstation by purchasing trash bins for proper waste disposal. Subsequently, the researchers recommend purchasing additional or replacement light sources in the workstations to minimize errors in the Cutting, Planing & Drilling, and Assembly stages of the process.

6. Conclusion

The furniture industry in the Philippines is growing and is highly competitive owing to many companies, both local and international. The industries producing furniture like Jimmy's Lumber and Furniture Enterprises should aim to have its operation to perform properly to cope with the standards and demands in the market. The company should have an excellent operation in inventory, capacity, quality management, and processes to help create a competitive advantage that can support an entrepreneur to compete in the business world.

From process strategy checklist, the researchers have surmised that the company uses a batch production process strategy to manufacture a moderate volume of variety of products, primarily frames for single beds. The company's existing layout of the production area has ample space for its current operations while also having unutilized areas. The facility's layout also does not conform to any of the standard flow patterns.
With the current facility layout, workers travel a considerable distance from one workstation to another when transporting materials. The facility layout does not follow any certain flow pattern and there are instances of backtracking throughout the process. The two problems result in a Workflow Efficiency of 52% and 38% for Site 1 and Site 2 respectively. The existing process also has 68.684 minutes of non-value adding processes and takes 321.04 minutes (5 hours and 21 mins) to create 1 unit of a single bedframe resulting in 37.85% waste in non-value adding activities caused by backtracking, delay, and scattered storage spaces in the process.

There are also problems with regards to the Lean aspect as there are numerous instances of unwanted waste around each individual workstation which stems from having no proper implementation of 5S in the workplace.

The primary recommendation from the researchers is to renovate the production area with the proposed U-shaped layout which increased the workflow efficiency for both Site 1 and 2 by 19% and 62% respectively. The prosed layout also took into consideration the existing columns of each site keeping costs to a minimum.

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