Process Standardization in the Upper Making Section of a Shoe Manufacturing Company through ProModel Simulation

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Abstract. Process standardization plays a significant role in variety of businesses and industries.It helps companies to achieve consistent outputs,increases efficiency andestablishesuniform processes in the production. The study focused on a newly-established shoe manufacturing company which experiences 14% longer working hours on the production of their upper making section due to inconsistent processes and improper material distributions.The study aims to increase the work efficiency by 10%-15% in the upper shoe making process. Results were validated by using ProModel software andshowsthat work efficiency increased by 21.59%with actual savings of PhP16,416 (351 USD)

Keywords: process standardization, work efficiency, shoe manufacturing, ProModel, simulation

1. Introduction

Process Standardization enables simplification of long and complex processes since industrial revolution time. It is mainly used by companies for increasing work efficiency, achieving consistency, and establishing processes. It became an effective tool used in production to calculate the right number of workers needed to finish the desired output.

Shoe making is one of the growing industries in the manufacturing world. According to Global Industry Analyst, Inc. Asia Pacific represents the fastest growing shoe industry among other nations with 8.1% increase in the past years. Shoe making companies mostly used manual and semi-mechanized processes. Thus it requires high level of skills and knowledge to attain the quality and designs trends that preferred by various target markets.

Different operational styles are adapted by manufacturing companies to provide best quality of products. However, these shoe companies faced major problems brought by wide range stages of production processes that result to failure in meeting customer's expectation- from the sourcing of raw materials to the inadequate employed manufacturing technologies and the low productivity of their workforce. Other added contributing factors on their competitive advantage are inconsistencies of workers, cost inefficiencies, optimization utilization of resources, process styles and several sets of products.

Based on 2015 report of Philippine Statistics Authority, its shoe manufacturing value sales rose by 8% .In Metro Manila, particularly in the City of Marikina, which is also known as the shoe capital of the Philippines, manufacturers are having big competition in getting their customers locally and internationally. They also formulate different distinct operational styles to have the most consistent products that help them to outmatch their competitors from time to time. Each pair of shoe undergoes to same processes and not all of it has the same exact quality. Uniformity and consistency in the production has been a big factor of each company in Marikina for which it lessen the total costs by having minimal errors and wastes during the production. Process standardization portrays significance to workers since it logically leads to simplification of process and variety reduction. It helps to increase the work efficiency and brings the company standards in line with the industry standards.

These study focus on the application of process standardization as a management technique of the shoe manufacturing company. It entails in establishing its own processes as well as utilization of workers in the production.

The newly established shoe company experienced 14% longer working hours due to inconsistent processes and improper material handling.. Upper shoe - making section is being considered due to significant bottlenecks occurs in the production compared to other sections in the production line such as sewing, lasting, sole attaching and finishing section. Majority of the predecessor sub-processes are being done in the later section. It means that more workers are assigned to finish the required number of output.

The objective of this study is to increase the work efficiency of the upper making section by 10%-15% upon utilizing standardization without compromising the much needed processes of the studied section. ProModel Software is use in validating the efficiency of the proposed process through simulation that projects of the ideal shoe output.

Different literatures in the application of process standardization in service, manufacturing, and supply chain industries were presented to further support how it helps the companies to robust.

2. Related Literature

Process standardization serves as an effective tool in reducing cost and effort done by the companies so as to increase the productivity of the workers at the end line. Among the related literature presented process standardization in the manufacturing industry are Fouque (1999) who aggregates the components in the production to reduce time and increase the productivity of the workers. Lee and Tang (1997) developed a mathematical model to determine the best compromise between the investment necessary for standardization and the profit resulting from the economy of scale. They considered the standardization of products and processes. A comprehensive study by Agard and Kusiak (2004) applied process standardization on data mining for extracting knowledge from industrial databases in support of standardization. Their study shows that standardization of process results in improving efficiency of the manufacturing process to produce new parts. Moreover paper presented Beimbornet. al (2009) summarize that process standardization within a firm can improve operational performance and reduce processing cost by eliminating errors, by achieving economic of scale and by facilitating communication.

In the service sector presented by Sarkar (2009) process standardization was used together with lean management in the shoe service industry and it results to consistency in costumer outcomes and ensures better productivity. Taurman (2009) proposed process standardization with the application of Kaizen in the streamlined processes such as quoting, order entry and product development. The application has proven successful in reducing cycle times on deliverables. Other paper presented in the service industry, Gudergan and Hoeck (2002) process standardization permits greater efficiency and effectiveness in customer utilization and acceptance in the price product. Jayaram and Vickery (1998) elementarily argue that process standardization simplifies the activities the activities and sub-activities of a given business process and thereby engenders cycle time reduction. Process standardization has been also well developed in the supply chain industry with different approaches. Boer *et al*. (2004) stated that process standardization does not only focus on time reduction but also on the provision of high quality and services. Moreover, it should go beyond on the individual enterprise and involve the whole value chain. In addition to Jayaram et al. (2000) conducted an empirical study at North America automotive industry and found out that among several process improvement variables, process standardization is the most influential enabler affecting delivery speed.

3. Case Methodologies

Standardized production process in the upper making section was established in thisstudy with the use of time and motion study (TMS) approachandproposed process validation using ProModelsimulation. In TMS approach, present and modified methods are shown to see the efforts done byeliminations and combinations of processes that improve the productivity of the workers.

3.1 Information Phase

3.1.1Upper Making Production

This newly established shoe manufacturing company produce products to well-known establishments in the Philippines. Productions of their shoes differ from the design of their customer but the processes on making a shoe has been always the same all throughout. These processes in the production includes mainly the upper making, sewing, lasting, sole attaching, and the finishing. Among all of these, upper making is considered as the bottleneck of the production since this is the beginning process wherein if there is a delay in the production due to certain reasons, the following processes also hinders to continue.

Table 1: Component Parts Identification of the Upper Making Process

Process	Definition
Clicking	The synthetic material is being cut on the designated shapes or design that will form the upper part of the shoe.
Counting and Separating	Clicks are being prepared and aligned according to size.
Marking	Clicks are being marked where to be cut and sewed.
Lining	Thin white laces with cement are being aligned to the edges of the upper part.
Combination	Combines the toe cap and inner lining to ensure the toe of a shoe correctly formed to the last.
Pasting	Cements are being put above the click to stick the thin white lace on the clicks.
Design Cutting	Edges are being cut according to the design.
Connecting of Parts	The cut parts of the click connect to the body of the upper to be pasted with cement to stick.
Putting and Folding with cement	Edges and the middle parts of the click is being hammered with cement.
Strap Marking	The strap is being marked and pasted with cement to connect in the hook.
Hook Marking	The hook of the lace is being marked and pasted with cement to connect in the lace.
Body sewing	All parts of the clicks are being sewed to connect.
Lace Sewing	The lace is being sewed to connect at the main body of the shoe.

3.1.2 Problem Identification

Preliminary observation in the production line of upper making section was done to identify existing problems that cause bottlenecks. Based on the historical data of the company, the workers spend additional 14% longer working hours to meet their monthly demand that affects the overhead cost of the company.

Using Pareto Analysis, problems in the Upper making section are indentifies as shown in Table 1. The chart shows that majority of the problem in the section are caused by unnecessary motion, inconsistent processes, and mishandling of material. These problems should take into consideration to avoid further problems the section such as transferring to one place to another long communication among working during working hours, inconsistent processes due to absence of proper standard procedures.

Table 2: Distribution Analysis of Problems

Identified Problems	FREQUENCY	%	RF
Unnecessary Motions	38	43.18	43.18
Inconsistent Process	19	21.59	64.77
Mishandling of Materials	10	11.36	76.13
Deficiency in Supplies	8	9.09	85.22
Sorting of Sizes	7	7.95	93.17
Utilize Machines	6	6.82	99.99
Total	**88**		

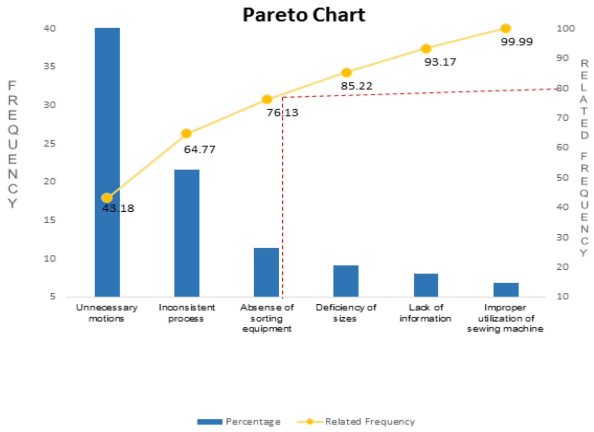

Figure 1. Pareto Chart

This Pareto chart of unequal distribution of causes and effects – 80% of the problems are caused by 20% of the factors. It was noticed that the problem 80% lies on the unnecessary motions, inconsistent processesand absence of sorting department. It only means that these major three problems, if not will be solved in time, it can incur a big factor in assuring the quality of the product thus resulting to longer working hours.

3.1.3 Objectives of the study

The primary objective of this study is to improve the work efficiency to at least 10% - 15% of the standard time on the production in the upper making section by process standardization through conducting time and motion study and use ProModel simulation to validate the result of the savings in time and convert it to monetary value.

3.2 Data Gathering/Tool Application

Productivity rate of the workers was recorded to identify the work efficiency throughout the production. Time and motion study was conducted to get the present normal and standard time in finishing the production of the section. Consequently, flow process chart was used to record the operational breakdown of the processes and carefully analysed it and indicate the method recommendations to further standardized the process and get theproposed normal and standard time of the production.

3.2.1 Productivity rate

Productivity of the workers has always been dependent on time and quantity of the work. By means of getting the productivity, work efficiency and inefficiency can be increase and eliminate respectively. To get the rate of productivity,

$$\frac{\text{Total Productive Time}}{\text{Total Productive Time + Total Unproductive Time}} \text{ X } 100 \quad (1)$$

The productivity rate summary of the observation is:

$$\% \text{ Productivity Rate} = \frac{564}{(564+251)} \text{ x } 100 = 69\%$$

Therefore, the unproductivity rate of the workers is 31% hence there are still lots of delays in the production that needs to be improved or eliminate.

3.2.2 Time and Motion Study

Stopwatch time study was used in conducting the study which was developed by Frederick Taylor in 1911. It is a common technique used for setting time standard in the manufacturing area. Similarly, the study used both of the timing technique method which are the snapback and continuous methods to have the most accurate and precise data. Upon doing the time study, the researchers were able to get the normal and standard time of each element on the upper making section.

a. Normal Time – it is the time needed by operator to perform specific job in a normal pace. To get the normal time, elemental average of total time obtained multiplied by performance rating.

$$NT = (EAT)x\ (PR) \quad (2)$$

Wherein:

EAT = Elemental Average Time

PR = Performance Rating, constant value for this is 100% for workers working in the normal pace.

b. Standard Time - the time required for a fully quantified, trained operator, working at a standard pace and exerting average effort, to perform the operation. In determining the standard time,

$$ST = (NT)x(1 + Allowances) \quad (3)$$

Wherein:

NT = Normal Time

Allowance = constant allowance is given if the company has no set standard; personal allowance is 7% while fatigue allowance is 4% with the total of 11%.

Table 3: Present Normal and Standard Time

Job Category	Function Verb	Function Noun	Rounded Normal Time(min)	Rounded Standar Time(min)
Preparation	Clicking	Material	6.27	6.96
Preparation	Counting	Material	2.97	3.30
Preparation	Marking	Material	4.2	4.66
Assembly	Lining	Material	3.54	3.93
Assembly	Combine	Material	6.30	6.99
Assembly	Pasting	Material	2.10	2.33
Assembly	Cutting	Design	4.18	4.64
Assembly	Connect	Part	3.03	3.36
Assembly	Folding	Cement	2.06	2.29
Finishing	Marking	Strap	4.63	5.14
Finishing	Marking	Hook	5.20	5.77
Finishing	Fold/Cut	Edges	2.25	2.50
Finishing	Sewing	Body	3.25	3.61
Finishing	Sewing	Lace	7.93	8.80
Total (min)			**57.91**	**64.28**

The table shows that all processes are expressed in two categories of function and the standard time of the elements is tabulated per job category. The present total standard time of making a pair of shoe is 64.28 minutes.

*Motion Study.*In this study, motion study was used to detail the work methods done by the workers in an effort to improve it. It also offers great potential for savings in any area of human effort and cost by simplifying/combining elements of one task with elements of another.

Once the time and motion study were already conducted and accepted, some techniques of it are being used to manipulate the final results of the data gathered and one of those is the flow process charts. It is a graphical presentation of all operations, inspections, delays, and storages occurring during the production or a procedure which includes information considered necessary for analysis like the operation duration and distance travelled. It is considered as a good way for developing new methods in the process.

Table 3: Flow Process Chart

Symbols	Process	Definition
○	**Operation**	It signifies the main steps in a procedure, process. Basically the part, product concerned is modified during the operation.
□	**Inspection**	It signifies an inspection or check for quality and quantity.
⇨	**Transportation**	It signifies the movement of workers, equipment from place to place.
D	**Delay**	It signifies the delay in the sequence of events.
▽	**Storage**	It signifies the controlled storage in which the equipment is received or issued from a store under some form of authorization.

The table above shows the symbols and definition of the processes include in the flow process chart.

Table 4: Present Operational Breakdown of Symbols in Each Element.

Job Category	Function Verb	Function Noun	Operation	Inspection	Delay	Storage	Transportation
Preparation	Clicking	Material	2	0	0	0	2
Preparation	Counting	Material	4	0	0	0	0
Preparation	Marking	Material	5	0	0	0	1
Assembly	Lining	Material	6	0	2	0	0
Assembly	Combine	Material	5	0	0	0	2
Assembly	Pasting	Material	5	0	1	0	1
Assembly	Cutting	Design	4	0	0	0	2
Assembly	Connect	Part	6	2	1	1	2
Assembly	Folding	Cement	5	0	1	0	0
Finishing	Marking	Strap	5	0	0	0	2
Finishing	Marking	Hook	4	0	1	1	1
Finishing	Fold/Cut	Edges	5	0	1	0	0
Finishing	Sewing	Body	6	1	0	0	2
Finishing	Sewing	Lace	5	0	0	0	3
Total (min)			**67**	**3**	**7**	**2**	**18**

The table shows that the present process breakdown has total operation (67), delay (7), and transportation (18) have the most number of processes that contributes to the longer working hours of the production.

3.3 Presentation of Results

3.3.1 Proposed Standard Time

The proposed normal and standard time in finishing the upper making section is formed through eliminating and combining of sub elements.

Table 5: Proposed Normal and Standard Time of Each Element. (In Minutes)

Job Category	Function Verb	Function Noun	Rounded Normal Time(min)	Rounded Standar Time(min)
Preparation	Clicking	Material	22.35	24.81
Preparation	Counting	Material	0.62	0.69
Preparation	Marking	Material	0.38	0.43
Assembly	Lining	Material	3.32	3.69
Assembly	Combine	Material	0.31	0.34
Assembly	Pasting	Material	1.82	2.02
Assembly	Cutting	Design	0.65	0.72
Assembly	Connect	Part	2.55	2.83
Assembly	Folding	Cement	2.06	2.29
Finishing	Marking	Strap	0.59	0.66
Finishing	Marking	Hook	1.75	1.94
Finishing	Fold/Cut	Edges	1.75	1.94
Finishing	Sewing	Body	2.48	2.75
Finishing	Sewing	Lace	4.77	5.29
Total (min)			**45.41**	**50.4**

The proposed standard time was reduced to 50.40 minutes which means there is a savings of 13.84 minutes upon the standardization of process.

3.3.2 Proposed Operational Symbols

Consequently with the proposed time, symbols were mostly reduce upon elimination and combination except for inspection which increased by one.

Table 6: Proposed Operational Breakdown of Symbols in Each Element.

Job Category	Function	Function	Operation	Inspection	Delay	Storage	Transportation
Preparation	Clicking	Material	2	0	0	0	2
Preparation	Counting	Material	2	0	0	0	0
Preparation	Marking	Material	2	0	0	0	1
Assembly	Lining	Material	5	0	2	0	0
Assembly	Combine	Material	3	0	0	0	0
Assembly	Pasting	Material	5	0	1	0	0
Assembly	Cutting	Design	4	0	0	0	0
Assembly	Connect	Part	5	2	0	0	2
Assembly	Folding	Cement	5	0	1	0	0
Finishing	Marking	Strap	4	0	0	0	0
Finishing	Marking	Hook	4	1	1	0	0
Finishing	Fold/Cut	Edges	4	0	1	0	0
Finishing	Sewing	Body	6	0	0	0	0
Finishing	Sewing	Lace	5	0	0	0	2
Total (min)			**56**	**3**	**6**	**0**	7

A reduction in the total operation (56), delay (6), and transportation (7) in the proposed operational breakdown is produced after standardizing the process through elimination and combination of each sub-element.

3.4 Work Efficiency

Work efficiency is increased by 21.59% with actual standard time of 13.88 minutes through the formulaof work efficiency rate:

$$\text{WorkEfficiency} = \frac{\text{PresentST-ProposedST}}{\text{PresentST}} \text{x100} \quad (4)$$

So therefore, the increase in the efficiency rate per pair is:

$$\frac{64.28 - 50.40}{64.28} x\ 100 = 21.59\%$$

3.5 ProModel Simulation

The ProModel simulation is use to validate the result of the study. According to Andradottir et al. (1997) it is a simulation and animation tool designed to model manufacturing systems of all types quickly and accurately. It also utilizes an optimization tool called SimRunner that performs sophisticated "what-if" analysis by running automatic factorial design of experiments on the model, providing the best answer possible. In the manufacturing sector research presented by Eryilmaz et al. (2012) used the application of ProModel to standardize the process of a shoe company. The simulation study was developed to see at what degree the variations of the models effect the throughput rate.

3.6 Sensitivity Analysis of Simulation

Effectiveness of any certain model depends its part on the reliability and accuracy of its output and sensitivity analysis is one way to addressmodel's imprecision and uncertaintieswith used of the simulation. This analysis aims to determine how much model outputs are expected to change due to changes in variables or parameters. It also tests the accuracy of the results of the system processfor which it can provide systematic assessments in the impact of value parameter imprecision and relative contribution of errors in different parameter values to that output uncertainty.

4. Results and Discussion

Upon running the ProModel simulation to validate the proposed process, it shows that the total exit or the output quantity of 230 pair shoes can be achieve for 35hours that is equivalent to 7 days.

4.1 Summary of Result

The table shows the cost for the present and proposed processes and the savings per month for the proposed.

Table 7: ProModel Statistical Result

Name	Scheduled Time (HR)	% Operation	% Setup	% Idle	% Waiting	% Blocked	% Down
Clicking	35.0	25.63	0.00	74.37	0.00	0.00	0.00
C and F of Materials	35.0	7.56	0.00	51.30	0.00	41.14	0.00
C and F of Materials Inbox	35.0	0.00	0.00	52.30	0.00	47.70	0.00
C and F of Materials Outbox	35.0	0.00	0.00	51.28	0.00	48.72	0.00
Marking	35.0	4.71	0.00	50.04	0.00	45.25	0.00
Marking Inbox	35.0	0.00	0.00	50.73	0.00	49.27	0.00
Marking Outbox	35.0	0.00	0.00	49.67	0.00	50.33	0.00
Lining	35.0	40.41	0.00	48.71	0.00	10.88	0.00
Lining Inbox	35.0	0.00	0.00	49.12	0.00	50.88	0.00
Lining Outbox	35.0	0.00	0.00	63.49	0.00	36.51	0.00
Combination	35.0	3.72	0.00	60.57	0.00	35.70	0.00
Combination Inbox	35.0	0.00	0.00	62.65	0.00	37.35	0.00
Combination Outbox	35.0	0.00	0.00	61.04	0.00	38.96	0.00
Pasting	35.0	22.12	0.00	52.86	0.00	25.02	0.00
Pasting Inbox	35.0	0.00	0.00	60.21	0.00	39.79	0.00
Pasting Outbox	35.0	0.00	0.00	58.86	0.00	41.14	0.00
Design Cutting	35.0	7.89	0.00	55.18	0.00	36.93	0.00
Design Cutting Inbox	35.0	0.00	0.00	58.03	0.00	41.97	0.00

Name	Total Exits	Current Qty In System	Avg Time In System (Min)	Avg Time In Move Logic (Min)	Avg Time Waiting (Min)	Operation (Min)	Avg Time Blocked (Min)
Shoes	230.00	230.00	633.89	0.26	455.87	27.93	149.83

The table shows the result of the proposed standardized process in the Promodel showing the total entities, utilization, average timein operation (min) and average time blocked (min).

Table 8: Present vs. Proposed (Process)

Method	Maximum Production/Day	Target Days	Productivity Rate
Present Process	13 pairs	18	69%
Proposed Process	32 pairs	7	91%

The table shows the difference between the present and proposed process, each maximum production/day, target days and each productivity rate.

4.2 Result of the Sensitivity Analysis

Table 9: Result of Sensitivity Analysis

Name	Replication	Total Exits	Current Qty In System	Avg Time In System (Min)	Avg Time In Move Logic (Min)	Avg Time Waiting(Min)	Avg Time In Operation (Min)	Avg Time Blocked (Min)
Shoes	1	392.00	93448.00	1060.73	0.26	866.97	27.93	163.57
Shoes	2	392.00	95518.00	1058.43	0.26	866.67	27.93	163.57
Shoes	3	392.00	94828.00	1058.42	0.26	866.66	27.93	163.57
Shoes	4	392.00	92988.00	1058.48	0.26	866.72	27.93	163.57
Shoes	5	392.00	97358.00	1058.48	0.26	866.73	27.93	163.57
Shoes	6	392.00	98508.00	1059.01	0.26	867.26	27.93	163.57
Shoes	7	392.00	98278.00	1060.46	0.26	868.70	27.93	163.57
Shoes	8	392.00	94598.00	1061.38	0.26	869.62	27.93	163.57
Shoes	9	392.00	96208.00	1058.97	0.26	867.22	27.93	163.57
Shoes	10	392.00	93448.00	1058.64	0.26	866.89	27.93	163.57

Based on the sample analysis done, the numbers of exits are still the same even on ten random arrivals. The process is still accurate and efficient even if it will incur possible delays in the arrival of the raw materials before doing the upper making process.

4.3 Cost- Savings Analysis

Table 10: Present vs. Proposed (Cost-Savings)

Method	Maximum Production/Day	Cost of Workers/ Day	Savings per Month
Present Process	13 pairs	Php 468 (10 USD)	Php 16,416 (351USD)
Proposed Process	32 pairs	Php 1152 (25USD)	

The table shows the difference between maximum productions per day. Cost of worker per day and savings per month in the proposed method.

4.4 Cost Analysis Evaluation

The savings is converted to a possible gain profit by proposing a standard time to the company. The maximum production will increase to 32 pairs per day thus having a savings per month of Php 16,416 (351 USD).

5. Conclusion

This paper developed and applied process standardization for the shoe manufacturing company to come up in optimization in the production of their upper making section. The target 10-15% was met and exceeded it through the application of the time and motion study. The results were validated by ProModel software which allows a realistic view of the proposed method. Possible savings of the company were also solved and it can help them to maximize the contribution with regards to profit. Future works of this case study may expand the tool used into multi objective and multi industry works.

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