An Experiential Learning Example Used to Illustrate the Lean Manufacturing Concept of Waste Elimination to Non-Operations Graduate Students

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Though lean manufacturing principles have traditionally been utilized in the manufacturing industry, the principles of waste elimination span many industries. Conveying this value to individuals outside of the manufacturing industry can be a challenge. However, the use of experiential learning simulations in teaching the concepts of waste elimination can be effective. This paper provides an experiential learning exercise conducted in an MBA class of K-12 teachers and administrators. The simulation provided can be replicated to any learning environment to provide further learning opportunities for students to practice and better understand how to eliminate waste and design a more efficient process.

INTRODUCTION

Teaching lean manufacturing principles can be challenging. Wasted processing steps that have accumulated through years of traditional process management can be difficult to overcome. However, the use of experiential learning simulations in teaching the concepts of waste elimination can be very effective. This paper outlines a method of waste elimination through the use of a hands-on experiential learning simulation.

Furthermore, the example outlined in the following pages was conducted in a Lean Six Sigma class, as part of a Master of Business Administration program designed for K-12 schoolteachers and administrators. The students were adult learners and the class was conducted over a four-day period. The specific example outlined in this paper was conducted on the second afternoon. The students were expected to have little to no manufacturing experience making the success of this particular experiential learning exercise transferrable to other environments.

The purpose of this paper is to provide a successful experiential learning simulation utilized in a Lean Six Sigma class that can be replicated in other learning environments. To accomplish its purpose this paper will provide a description of lean manufacturing and service, an explanation of the objective of the simulation, a description of the simulation that was conducted, show the results of the simulation, and end with a conclusion.

LEAN MANUFACTURING AND THE SERVICE INDUSTRY

With a limited amount of capital and a shortage of teachers, K-12 educators are in a position where the operations of their facilities and school systems need to be as efficient as possible. One way to assist schools in operating more efficiently is to apply the successful programs of Lean Manufacturing and Six Sigma to the operations of K-12 school systems.

Lean manufacturing is a concept of providing customer value utilizing the least amount of resources. In other words, lean manufacturing principles seek to eliminate as much waste or “Muda”, the Japanese word for waste, as possible while providing the customer with required value (Womack & Jones, 2003). There are many different tools and philosophies that attempt to achieve the goal of waste elimination, but at its core, eliminating waste means the process is using a higher percentage of its effort, adding value for the customer.

Lean Six Sigma principles have been shown to be effective in environments other than manufacturing. Lean Six Sigma has been shown to benefit organizations such as the banking industry (George, 2003), city government (George, 2003), and the financial services industry (Fraser & Fraser, 2009). Suárez-Barraza, Smith, and Dahlgaard-Park (2012), conducted a literature analysis on lean service where they provide examples of specific lean service in healthcare, education, banking and finance, airlines, hotels and restaurants.

Though lean manufacturing has been shown to be effective in helping industries other than manufacturing, the application of these principles can be difficult. Lean manufacturing was originally developed at Toyota to produce cars in a more effective and efficient manner (Womack & Jones, 2003; Ohno, 1998). The challenge for both educator and learner is to develop an understanding of an effective system used to produce cars and apply that system to an area very distant from manufacturing cars such as K-12 education.

The collision of Lean Six Sigma and K-12 education is necessary. With a limited amount of resources and an important service to supply the community, Lean Six Sigma can assist K-12 teachers and administrators with developing systems that assist them in better utilizing their limited resources.

OBJECTIVE OF THE SIMULATION

Experiential learning techniques can be beneficial in the comprehension of material. Experiential learning can take many different forms, but “Experiential-learning programs are designed to link theory and practice.” (Perrin, 2014, p. 1). Getting students involved in their own learning through activities is not new to teaching operations management concepts (Ewing, Ghandour, & Thompson, 2012). This simulation is an example of experiential learning in a simulation context.

The objective of this simulation was to provide students with a hands-on experiential learning activity to reiterate the principles previously discussed in a lecture. Realizing the difficulty of applying a concept originally designed to produce cars on an assembly line to the industry of K-12 education, a simulation was beneficial to show the principles are simple and applicable to all business processes.

A guiding factor in the implementation of lean manufacturing is the concept of customer-defined value. Womack and Jones (2003) indicate that the customer defines value. Taichi Ohno (1988) who is often credited with founding the Toyota Production System finds that there is both value added and non-value added work completed by a process or individual. Within the classification of non-value added work, work can be classified as waste or incidental work (Rother & Harris, 2001). Therefore the work can actually be broken into three types, value added, incidental, and waste.

Value added work, in essence, is work that the customer would see as adding value. For example, if the customer ordered a pepperoni pizza, putting the pepperoni on the pizza would be a value added work step. However, getting the pepperoni does not actually add value, but it has to be done. In this case, the work motion of getting the pepperoni would be called incidental work motion. Finally, when the operator puts the pizza in the oven and waits for the pizza to come out, this would be considered a wasted work motion because it does not add value for the customer and does not have to be done (the operator could be building another pizza while the other one is in the oven baking.) Many times the value added portion is the smallest. The goal is to eliminate the waste and reduce the incidental work, thus increasing the percentage of value added work content.

To accomplish the goal of eliminating waste and reducing incidental work, this simulation utilizes a process called a paper kaizen to identify and remove waste from a process so that it becomes more efficient (Rother & Harris, 2001). The paper kaizen is a simple process where each work movement to accomplish a task is classified as value added, incidental, or a wasted work movement. The wasted steps are then removed; the incidental steps reduced as much as possible, and the process redesigned with value added work being a much larger percentage of the overall work content.

To illustrate this concept during the lecture, students were provided work steps to complete a quotation process of a purchasing service. Then they were tasked with classifying each work motion as value added, incidental, or waste. They were then asked to remove the waste and redesign the process. The reason for the in-class exercise before the simulation was to show the application of the process to their individual environments. In reality, no matter the process, whether it is manufacturing, business process or service, there are steps to complete the process. Those steps can be classified as value added, incidental, or waste. Then the process can be improved through eliminating the wasted steps and redesigning the process.

Once the understanding of application is achieved, the simulation is a good experiential learning tool to provide an opportunity for the students to practice. The simulation is set up to support the lecture and is described in detail in the following section.

SIMULATION DESCRIPTION

After students are taught the concept via a lecture, a hands-on experiential learning simulation is conducted building simple PVC pipe trucks with different options. Figure 1 shows the parts of the PVC truck. There are 7 components that make up the truck, plus a piece of either orange or purple tape that will be placed on the base to signify the model. There are four different models to choose from: Orange Base, Orange GT, Purple Base, and Purple GT. Base models get the governor and GT models get the booster. The room is set up, as a traditional area might be set up. Figure 2 shows how the room was set up to begin this simulation.

FIGURE 1
PVC TRUCK PART ILLUSTRATION

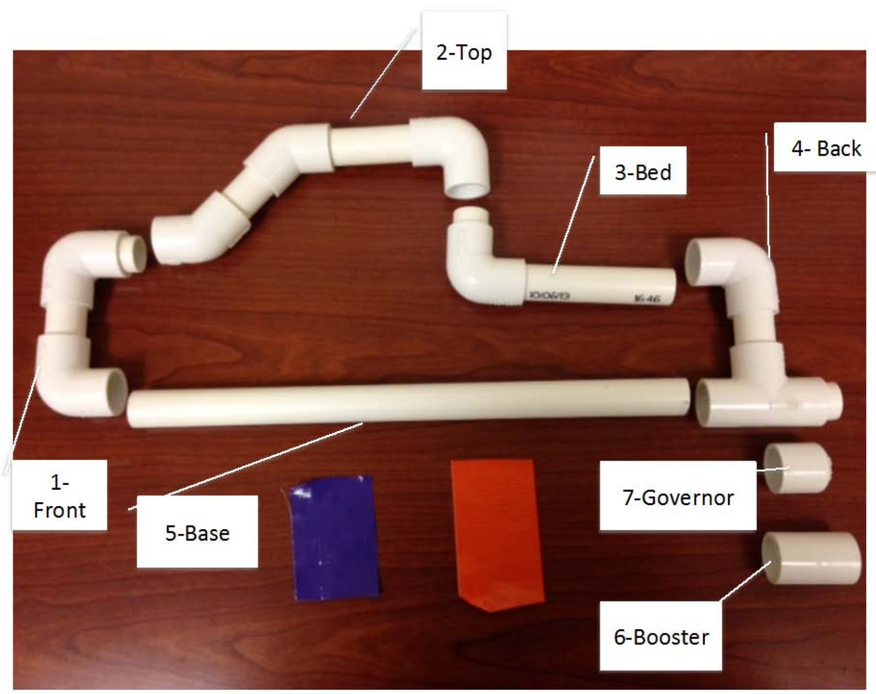
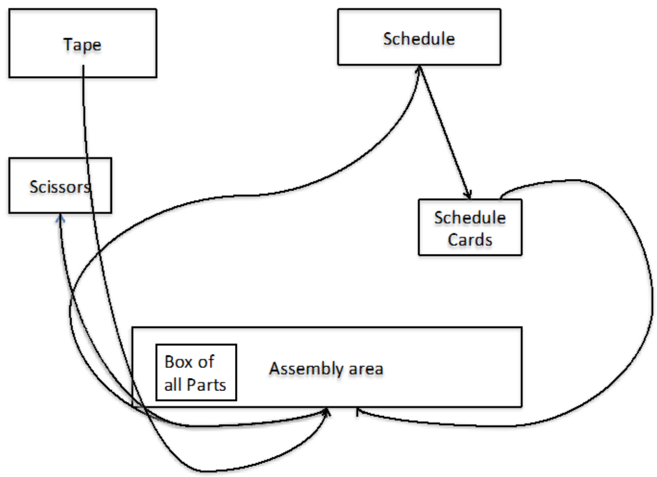


FIGURE 2
BEGINNING ROOM SETUP



The instructor builds the PVC truck walking first to the schedule to see what needs to be produced, then to the schedule cards to retrieve the schedule card that corresponds to the schedule. Next, the instructor walks to the assembly area and begins to assemble the truck. The instructor digs through the box of parts and finds the right parts to assemble the truck. Once the truck is assembled in either the GT or Base format, the instructor places the truck on the table and walks to the scissors, retrieves the scissors and delivers them to the assembly area. Next, the instructor walks to the tape, retrieves the correct color of tape that corresponds to the schedule and delivers the tape to the assembly table. Then the tape is cut and placed on the base of the PVC truck. The scissors are then returned followed by the tape. The completed PVC truck is then delivered to the customer and the process begins again.

The K-12 professionals were instructed to write down each step of the process. Table 1 provides the steps that were needed to produce the PVC truck. Each step then had to be timed to see the length of the process and to help identify the level of improvement. Once the work motions and times were collected the total time of the process was added and the paper kaizen process began.

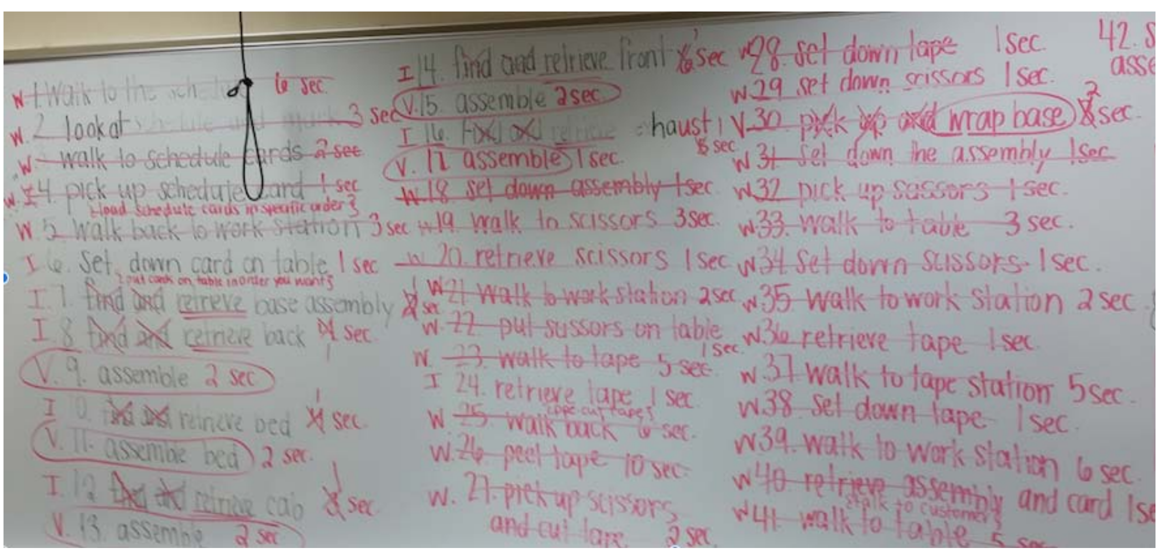
TABLE 1
ORIGINAL STEPS TO PRODUCE PVC TRUCK

Work Step	Description	Time (seconds)	Category
1	Walk to Schedule	6	Waste
2	Look at Schedule and Mark	3	Waste
3	Walk to Schedule Card	2	Waste
4	Pick up Schedule Card	1	Incidental
5	Walk back to workstation	3	Waste
6	Set down card on table	1	Incidental
7	Find and retrieve base	2	Incidental
8	Find and retrieve back	4	Incidental
9	Assemble	2	Value Added
10	Find and retrieve bed	4	Incidental
11	Assemble Bed	2	Value Added
12	Find and retrieve Cab	3	Incidental
13	Assemble cab	2	Value Added
14	Find and retrieve front	6	Incidental
15	Assemble Front	2	Value Added
16	find and retrieve exhaust piece (GT or Base)	5	Incidental
17	Assemble exhaust piece	1	Value Added
18	Set down assembly	1	Waste
19	Walk to scissors	3	Waste
20	Retrieve Scissors	1	Waste
21	Walk back to workstation	2	Waste
22	Put scissors on table	1	Waste
23	Walk to Tape	5	Waste
24	retrieve tape	1	Incidental
25	Walk back to workstation	6	Waste
26	Peel Tape (Difficulty finding end)	10	Waste
27	Pick up scissors and cut tape	2	Waste
28	Set down tape	1	Waste
29	Set down scissors	1	Waste
30	Pick up and wrap tape to base	3	Value Added
31	Set down assembly	1	Waste
32	Pick up scissors	1	Waste
33	Walk to scissor storage table	3	Waste
34	Set Down Scissors	1	Waste
35	Walk to workstation	2	Waste
36	Retrieve tape	1	Waste
37	Walk to tape station	5	Waste
38	Set down tape	1	Waste
39	Walk to workstation	6	Waste
40	Retrieve assembly and card	1	Waste
41	Walk to table	5	Waste
42	Set assembly down with card	1	Incidental

Total Work Content Before Improvement	114
Value Added Seconds	12
Value Added Content	10.53%

The paper kaizen process was next, where the work motions were categorized as a value-added step, an incidental step, or a wasted step. The class looked at each work motion and decided how it should be categorized. After each work motion was categorized, all of the wasted work motions were eliminated from the process. Figure 3 shows a picture of an actual whiteboard in the simulation room outlining the original steps and the classifications. This takes discussion because there may be improvements that need to be made to remove steps, such as having the tape delivered to the assembler by the piece instead of by the roll. This simple improvement led to removing the need to retrieve the scissors as well. Finally, the physical process must be changed to accommodate the new process.

FIGURE 3
ACTUAL WHITEBOARD USED IN A SIMULATION

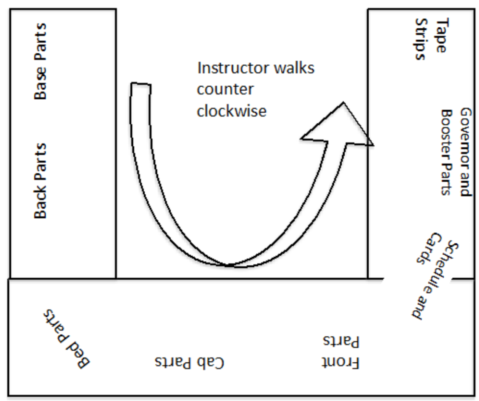


RESULTS OF THE SIMULATION

The original state of the process yielded 42 different work steps and the entire process took 114 seconds. In the before state, value added work content composed only 10.53% of the entire work.

After the paper kaizen process, the physical process was redesigned (See Figure 4), incidental work steps were reduced, and the waste was removed. This yielded a substantial reduction in work steps going from 42 different work steps to 14 work steps. Furthermore, the value added percentage of work content went from 10.53% to 60% of the work content.

FIGURE 4
PROCESS AFTER IMPROVEMENT



The plan was to produce a PVC truck, after the improvements, in 20 seconds. However, the PVC trucks were actually produced a little faster after all of the improvements were made. In a short time period, the class was able to utilize a new tool to eliminate waste, and create a more productive and efficient process.

TABLE 2
AFTER IMPROVEMENT WORK CONTENT

Work Step	Description	Time (seconds)	Category
1	Retrieve base	1	Incidental
2	Retrieve back	1	Incidental
3	Assemble	2	Value Added
4	Retrieve bed	1	Incidental
5	Assemble Bed	2	Value Added
6	Retrieve Cab	1	Incidental
7	Assemble cab	2	Value Added
8	Retrieve front	1	Incidental
9	Assemble Front	2	Value Added
10	Retrieve exhaust piece (GT or Base)	1	Incidental
11	Assemble exhaust piece	1	Value Added
12	Pick up Schedule Card	1	Incidental
13	Pick up and wrap tape to base	3	Value Added
14	Set assembly down with card	1	Incidental

Total Work Content After Improvement	20
Value Added Seconds	12
Value Added Content	60%

CONCLUSION

Teaching a concept such a lean manufacturing to a group of students that have little to no manufacturing experience can be a challenge. Utilizing a hands-on simulation as an experiential learning tool to enhance student learning worked well in this situation. After students gained the understanding that this methodology was applicable to their processes, the simulation gave them a way to practice the paper kaizen process and see the value of the exercise.

In this situation, the improvements were substantial. The paper kaizen process, though simple, can provide big improvements. As the students go back to their own processes with the charge to eliminate waste, they will be able to utilize this process to improve.

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