Design Improvement in the Workspace for Waste Reduction and Process Optimization

Veruschka N. Echevarría Rosa
Master in Manufacturing Competitiveness
Advisor: Carlos González, PhD
Industrial and Systems Engineering Department
Polytechnic University of Puerto Rico

Abstract *— In this current project will be demonstrated how a layout in the workspace can impact the efficiency of a process. An optimal design in the location of equipment and materials needed to execute a task can reduce all those activities that do not add value to the process allowing a continuous workflow. As a result, the aim is to reduce the time of the process, which increases productivity without compromising the quality of the product.*

Key Terms *— Layout, Optimal Design, Productivity, Quality, Workspace.*

INTRODUCTION

SDS-PAGE is the acronym for sodium dodecyl sulfate polyacrylamide gel electrophoresis and this is a method used in biochemistry laboratories to separate proteins by size and molecular weight. In this case, the method is used to corroborate the identity of the protein as part of the product quality testing. In order to carry out this method, acrylamide gel must be prepared. Although the gel can be obtained commercially, it is prepared in the laboratory. This step is done on the first day and once prepared it is given an expiration date of one week. This gel can resist different voltage gradients, which is what is used so that the protein can migrate and separate by weight. The second day consists of sample preparation and run testing. This process consists of preparing some wells in the upper part of the gel to be able to inject the samples and controls prepared. In addition to the samples and controls, the molecular marker is injected. The function of the marker is to estimate the molecular weight of the protein. There are a variety of commercially available markers with different ranges that make it possible to determine the molecular weight of the protein of interest. Currently, in the laboratory, there are three gel electrophoresis methods that are coomassie, silver, and western blot. All methods are used for the same purpose, which is the identity and purity of the protein. Each one develops differently. On the third day, once the protein migrates and is detached with voltage, it is scanned using a densitometer. This equipment saves an image of the gel and does a scan to determine that it does not have contaminants. Once this is complete, a photograph of the gel is taken and saved.

RESEARCH DESCRIPTION

Safety at work comes first. In the workplace, we often carry out different tasks or activities that require using dangerous reagents, glassware, the movement of heavy objects, etc. Additionally, there is a constant flow of people entering and leaving the work area, which can make the task we are performing even more difficult. This entails being cautious and alert as we want to work in a safe place and avoid accidents. Currently, I work in the laboratory of the biotech industry. Part of my tasks as a laboratory technician is to run a biochemistry test that requires equipment and reagents located in two separate laboratories.

RESEARCH OBJECTIVES

An organized workplace reduces the possibility of accidents and optimizes our tasks. This implies that the space is designed in a way that can reduce the waste of transportation, movement, waiting times, and extra processing. As part of the project design, the objective is to redesign the workspace layout where the task is executed so that everything necessary is found under the same laboratory and, with this, reduce the waste by above 20%.

RESEARCH CONTRIBUTIONS

"*The issue of layout is not only related to the process of designing a new production area solution, but has also importance in the existing production process*" [1]. If we have a clean and organized space, we can find what is necessary for less time, which increases productivity since the task can be fulfilled without mishaps. It decreases the possibility of making mistakes because everything will be in the same place, but it provides security for the employee. The prevention of occupational risk must be the priority of any industry. The workspace design is critical to reducing the waste generated and increasing the optimization of the task or activity carried out.

LITERATURE REVIEW

There is a methodology that seeks to minimize waste and, at the same time, maximize the efficiency of a process; this is known as lean manufacturing. Any activity that does not add value to a process or product is considered a waste. Waste is broken down into these categories: defects, overproduction, waiting, wasted talent, transportation, inventory, movement, and extra processing. Several tools within lean manufacturing focus on eliminating or minimizing the eight different types of waste that we can find within a process. In this case, we will be focusing on the tool known as a spaghetti diagram. According to the quality glossary definition of the ASQ (American Society for Quality), "*a spaghetti diagram is defined as a visual representation using a continuous flow line tracing the path of an item or activity through a process"* [2]. We will explain what we can find within this diagram to understand this concept better. First, it needs to be done a layout of the process flow what needs to be improved. This entails capturing the entire work area with the equipment used and the distance from each item required to execute the activity or task. Once this is captured visually, a line must be drawn with the walking pattern of an employee performing the task; it should be emphasized that the waiting times and all the stops of the employee must be reflected. Lines of different colors can be made to define employee walks, material flow, etc. Once this is captured visually, it can be more easily determined where the problem generates waste, such as transportation, movement, and waiting times. What should be done after defining the problem? The diagram must be redone with an arrangement of the equipment and materials. This results in the employee executing the task optimally, thus preventing accidents, shortening times, and avoiding generating quality incidents that compromise the product. We often need to pay more attention to the importance of layouts and movements within the work area. This tool can be used as a process improvement technique. This method allows an accurate simulation of the process, and as a benefit, having a visual diagram helps to focus attention on the problem. On the other hand, we also ensure the product or service quality since if we have all our tools and work equipment in the same place, the probability of making mistakes would be less.

METHODOLOGY

For this project, quantitative data will be collected so that a progression in the efficiency of the task and a decrease in the waste it generates can be measured. The problem arises in that a biological assay must be carried out to search for a protein's identity for a biotechnological industry. Several reagents and equipment are divided into two laboratories for this test. To measure this, a certified laboratory technician will be evaluated to perform the test. The time it takes and the efficiency of the process will be considered. This will be done over six consecutive weeks, and the progress obtained will be evaluated. It must be regarded that getting the final result of this test takes about two or three days. First, creating a layout of both laboratories with the reagents and equipment used is necessary. Second, a spaghetti diagram will be made to visualize the entire process. Here we can see the different stages of the

process reflected and have a current representation of what it takes to carry out the task. Third, the time it takes a technician to complete the job will be measured using a timer. Fourth, the data obtained from the employee will be compared. Then everything will be reordered in one place, the technician will be asked to do the task, and new data will be collected with the change. Ultimately, we seek to compare the data, evaluate the difference, and determine if there was a significant impact.

Figure 1: A spaghetti diagram is a powerful tool used to visualize the waste of a poor design in a layout of the work area. As a benefit, we can maximize the workspace and improve the area to increase efficiency.

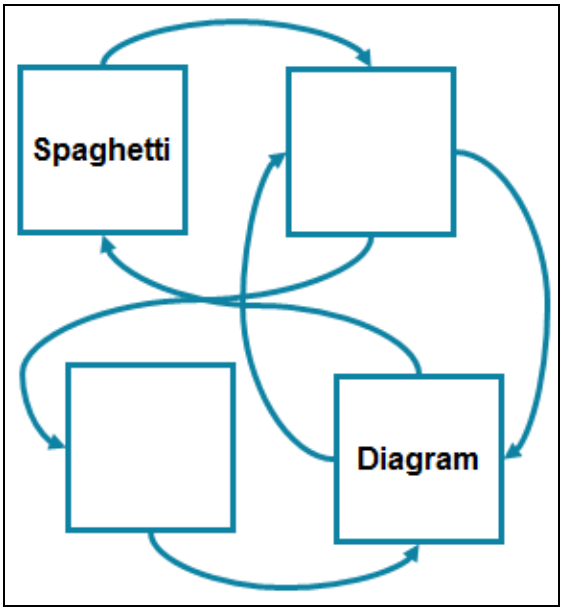

Figure 1
Spaghetti Diagram

Table 1: This table contains how each project phase will be carried out until its completion.

Table 1
Milestone

Phase 1	A current layout of the laboratories will be made with the location of equipment and reagents.	Due date March 20, 2023
Phase 2	Certified laboratory technicians run the assay.	Due date March 23, 2023
Phase 3	A spaghetti diagram will be made to visualize the current situation.	Due date March 31, 2023
Phase 4	Everything necessary to run the test will be reorganized in a single laboratory.	Due date April 10, 2023
Phase 5	The test will be rerun with the new layout.	Due date April 13, 2023
Phase 6	A new spaghetti diagram will be drawn.	Due date April 21, 2023
Phase 7	All collected data will be compared and analyzed.	Due date April 26, 2023
Phase 8	Report data obtained.	Due date April 28, 2023

Results and Discussion

Among the tasks and duties of an analyst is running a biological assay to determine the product's identity. This assay identifies the molecular weight of the protein of interest by gel electrophoresis. This assay can take two to three days since the first day consists of preparing the gel where the assay will be run. On the second day, samples are ready, and the gel electrophoresis assay is run. There are three different methods currently in the laboratory: western blot, silver, and coomassie. The sample preparation for these three methods is the same; what changes is the development of the gel. Western blot and coomassie last two days, while silver gel occurs the same day. One opportunity for improvement is that this test is carried out between two different laboratories. The biochemistry laboratory consists of two rooms; in one room are all the needed reagents and materials, and in another room is the equipment where the electrophoresis occurs. I understand that if the layout of the work area is improved and everything is located in the same place, this process can be optimized.

It should be noted that the days it takes for this test to be carried out will remain the same. On the other hand, the risk of an accident and the probability of failure will decrease. Heavy glassware is used for this assay, and reagents must constantly be moved from room to room. I propose

to improve the design of the work area to reduce the waste generated by running the test between two rooms. For this, a new design for the work area must be made, and using tools such as a spaghetti diagram, it would be possible to appreciate the optimization that this would bring visually.

Figure 2: This is a spaghetti diagram of the current layout with the location of the reagents and equipment used to run the assay. Each line color represents a day of the test.

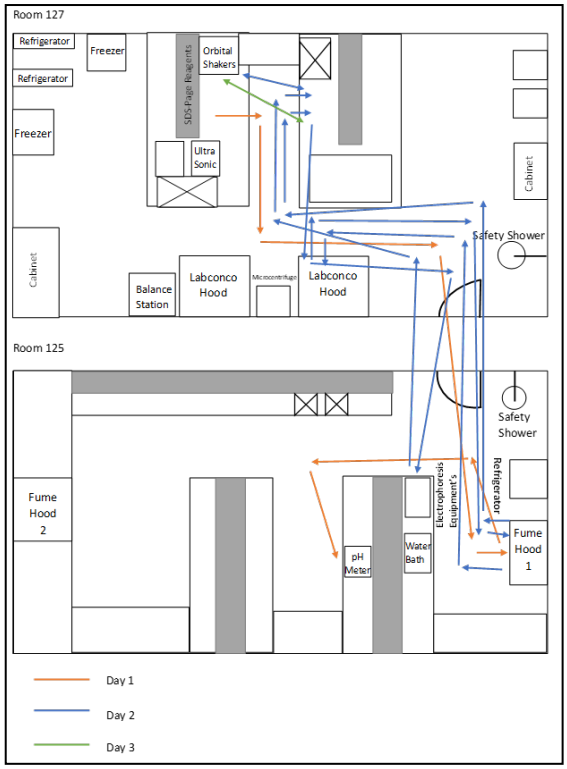

Figure 2
Spaghetti Diagram of Layout 1

The layouts were created with each component's location to visualize how the reagents, equipment, and materials are distributed between both laboratories. This assay, as mentioned above, is carried out between both laboratories. Room 125 is used to prepare the polyacrylamide gel inside Hood 1, to take the pH of a 4-L solution used in the assay, to run the electrophoresis, and to store the prepared gel inside the refrigerator until use. While in room 127, there are all the necessary reagents to prepare the polyacrylamide gel. The samples are ready inside the labconcos hoods, and the gels are developed using orbital shakers. I propose to move the electrophoresis equipment to room 127; this will make it easier to manage and carry out this test, thus reducing the risk of accidents or failures due to the handling of equipment, reagents, and heavy glassware between both laboratories.

Making these arrangements where some pieces of equipment are relocated makes it easier to run the test. In the second layout, we can see that the electrophoresis equipment that makes up the recycling baths and the power supply, where the voltage is discharged so that the proteins are divided by molecular weight, is moved to room 127. Another piece of equipment that was relocated is the pH meter necessary to take the pH of the running buffer solution stored in a four-liter volumetric.

Figure 3: This is a spaghetti diagram with the improvement made by relocating everything to one room. Visually we can appreciate the significant reduction of waste.

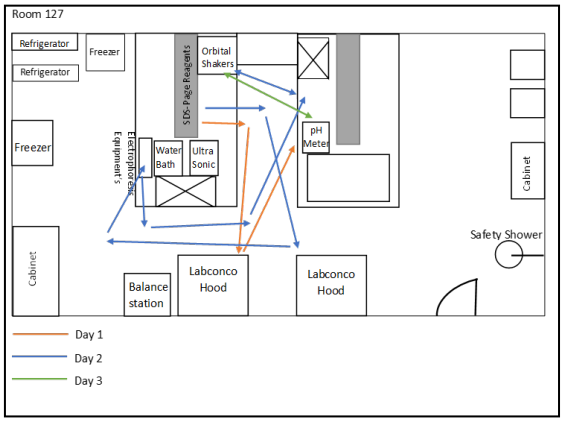

Figure 3
Spaghetti Diagram of Layout 2

Using the spaghetti diagram tool, the current layout of the work area was recreated with the equipment and the reagent cabinet used for the test. In addition, the paths that an analyst must walk daily to fulfill the tasks were marked. In this layout, day one takes approximately seven hours to complete the activity, day two takes seven and a half hours, and day three takes five. This was for 19.5 hours between the three days of testing. In the second layout, where an arrangement was made and

all the equipment was relocated in room 127, the task of day one is reduced to five hours, the activity of day two is reduced to six hours, and the activity of day three is reduced to approximately three and a half hours. This was for 14.5 hours between the three days of testing. This means that the time was reduced to about 25%, impacting transportation waste, movement, waiting, and extra processing. Also, it significantly reduces the chances of any safety incident while transporting heavy materials.

Figure 4: This table shows the reduction of hours when performing the different tasks involved in each day of testing. As can be seen, the first layout entails more working hours, while the second layout is more efficient since it reduces working hours by improving the work area's design.

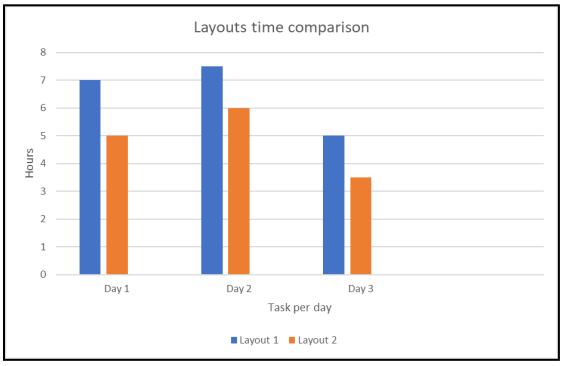

Figure 4
Layouts Time Comparison

Figure 5: This table shows how efficient each layout was. As we can see, there was an increase in efficiency for the second layout, where the improvements were made.

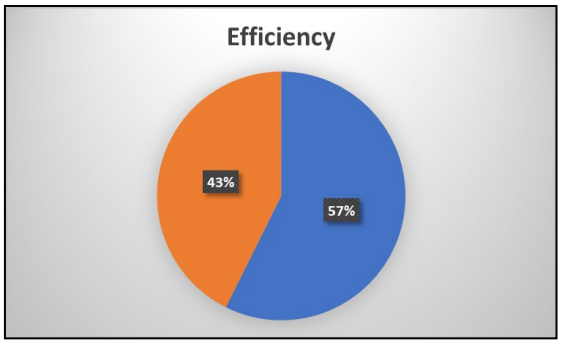

Figure 5
Efficiency

CONCLUSION

It has been shown that the layout of the work area is an important aspect to consider in order to increase efficiency in daily tasks. The problem with the initial layout was that its configuration opened up space for wasted time, which made all tasks take longer to complete and furthermore increased the probability of a work accident. By relocating all the equipment and materials into a single room, time was improved and employee safety was increased since employees work in a more organized area.

As we can see in Figure 2, it can be seen that it took around 19.5 hours between the three days of testing to complete all the tasks. With the improvements that were made, which can be seen in Figure 3, it was reduced to 14.5 hours, which is a positive significant impact. When we make the comparison and calculate the times, we can see that the second layout obtained 57% efficiency versus the first layout which obtained 43%. Now, the remaining time that we get after improving the times can be used for documentation. One of the benefits that we can mention that this layout change brings is that in most cases, the analyst performed the test and documented the next day since the test time took an entire shift. This allows ALCOA principles to be adhered to, which is an acronym for Attributable, Legible, Contemporary, Original, and Accurate. These principles concern everything that is data integrity. For any industry regulated by the Food and Drug Administration (FDA), or in our case that we are governed by the European Medicine Agency (EMA), it is extremely important that all the data generated is documented at the moment.

It is important to take advantage of the maximum time possible and to consider all the factors that may be affecting a process, such as the design of the work area. There are several tools that could be of great benefit in minimizing or eliminating this waste. The spaghetti diagram is one that helps to detect this waste visually so it is easier to rearrange the work design to maximize the efficiency of a process.

REFERENCES

[1] N. Daneshjo, V. Rudy, P. Malega & P. Krnáčová, "Application of Spaghetti Diagram in Layout Evaluation Process: A Case Study," in *TEM Journal*, 2021, vol. 10, no. 2, pp. 573-582. DOI:10.18421/TEM102-12.

[2] ASQ. (2023). *What is a Spaghetti Diagram?* [Online]. Available: https://asq.org/quality-resources/spaghetti-diagram.