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DMADV Approach in Increasing Efficiency in Production Operation: A Case Study in Metal Fabrication Industry Utilizing Pro Model Simulation

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Abstract

The study defines the importance of industry layouts and how an effective layout can significantly improve an organization's efficiency and productivity. With the aid and application of ProModel2018, two proposed layouts are designed, simulated, then compared to the original to find the optimal layout to maximize efficiency and minimize unnecessary movements and inefficiencies in the production process. The objectives of the study are to properly examine the current layout, determine the delays in the process and eliminate them, design and propose an improved efficient layout, and to provide recommendations based on the results for further improvements. To achieve this, a combination of Time and Motion Study (TMS), and qualitative and quantitative research was utilized in order to identify, corroborate, and eliminate inefficiencies through observations and interviews. With the data collected, two proposed layouts will be presented alongside the respective data to further corroborate the findings and show how each proposed layout compares to the original layout. Further observations also found out that there were far more problems present, which includes safety risks and operational risks due to the facility design. The proposed layouts were also inadvertently designed to cater to the safety of everyone involved in the line of production. At the end of the study a proposed layout will be suggested to be implemented by the organization to fully maximize the efficiency, productivity, and effectiveness of the production process of the organization.

Keywords
Pro Model, Efficiency, Layout, Facility Design, and Effectiveness.

1. Introduction
Every company has a strict quota and a direct line of operations that have to be met in order for a smooth operation process. This is all the more significant in manufacturing industries that are centered and built around a simple foundation of transforming raw materials into finished products. In order to achieve this, the efficiency in creating the products should be the primary focus of organizations in this industry. It should take precedence over everything the organization has to offer. This is more often the case in manufacturing industries as a more efficient production process will certainly equate to a faster rate of production, allowing organizations to reach the desired quota at a greater pace. The most significant cause that affects the production and efficiency in the manufacturing industry is the layout. The layout dictates the flow of materials during the production process and shows how each product is created to complete

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the final product. In most cases, the individual stages (machines) in the production process are situated in a convenient and efficient way so that the travel time is cut down significantly. A good layout can easily be differentiated from bad and great ones due to the different levels of efficiency in the process. The best layouts are the most efficient ones that allow organizations to meet quotas and deadlines. This study aimed to examine the current layout due to its essentiality in the manufacturing industry, and its importance in the production process that has the potential to make or break an organization's efficiency. To achieve this, the study utilized a software named Pro Model.

1.1 Objectives

Setting the direction for the paper was essential in order to keep track of the progress, as well as to identify a direction for the study. This was done to maintain an organized structure of the paper, as well as a proper order of sequences throughout the completion of the paper. In line with this, the following are the objectives of the study:

- To examine the current layout of the company;
- To determine the delays in the process and eliminate them;
- To design and propose an efficient layout for metal fabrication production Industry; and
- To provide result based recommendations for further improvements.

2. Literature Review

In industries, ineffective layout design can lead to increased expenses, decreased output, and energy waste. Delays and ineffective use of work are caused by unnecessary movement and transportation (Fahad et al. 2017). Additionally, poor layouts can lead to ergonomic problems that contribute to worker stress, frustration, and health hazards, eventually affecting output and satisfaction. In order to maximize productivity and promote a more positive and productive work environment, these issues must be addressed. Badharinath et al. (2024) have demonstrated the benefit of applying the Systematic Layout Planning (SLP) technique to increase a production unit's performance and efficient use of space. Their study demonstrated a substantial decrease in total travel distance, from 1,227 sq. ft. to 799 sq. ft., leading to heightened productivity and reduced material handling expenses. Bottleneck problems, unproductive flow, and inappropriate excessive movement between tasks were encountered in the study of Radhwan et al. (2019). They intend to improve the current plant layout by transforming it. As a result of the optimized layout's significant improvement in efficiency from 74.49% to 93.40%, processing times were shortened by up to 10% and productivity was improved. In the study of Ochogba et al. (2019), underscore the crucial role of effective plant layout in the implementation of technical education programs in Rivers State, Nigeria. They highlight that a well-designed plant layout can create an optimal learning environment for students, facilitating the acquisition of practical skills essential for industrial applications. Therefore, integrating plant layout analysis and design into technical education curricula is emphasized as a means to elevate the quality of education and adequately equip students for the demands of the workforce. Production layout planning is a vital part of any manufacturing or production plant. It involves creating and determining the best layout for your production to promote efficiency, productivity, and safety.

A good plant layout has many advantages, including better production, lower costs, and improved safety (Heller 2023). Layouts are critical to a company's overall operations, as they enable a consistent flow of people, material, and information. Having an efficient layout in production also has its advantages. According to Somengil (2021) it promotes safety, productivity, and efficiency by limiting accidents, improving ergonomics, addressing bottlenecks, decreasing delays, improving communication, maximizing space use, maintaining quality control, and allowing for effective supervision. Designing a facility's layout is a crucial part of cutting manufacturing operations expenses. Significant gains in productivity, material handling costs, travel distance, space utilization, labor expenses, and more can be obtained by strategically placing workstations, machines, and material flow (Kovács, 2019). Increasing productivity across a range of sectors through layout optimization. According to Hanggara (2020), Big Boy Bakery, a small-scale food industry in Indonesia, optimized its production facility layout and increased productivity through the application of Systematic Layout Planning (SLP). Bigger rivals put pressure on the bakery to increase the quantity and quality of its goods. The bakery used SLP to identify other layout options that took into consideration critical production components, like strategically placing operations, in order to cut down on wasted time and trip expenses. It was anticipated that the suggested layout modifications would greatly aid in Big Boy Bakery's growth by boosting output and efficiency. Zúñiga et al. (2020) utilizes the simulation based optimization methodology for the facility layout design and it has significantly improved the system in the manufacturing industry. The application of it efficiently assists managers and stakeholders in the company making wise decisions regarding the production planning. In the study of Septiani et al. (2020) a cable manufacturing firm prioritizes optimizing the structure of their finished goods warehouses, especially for haspel types of cables. The study initially determines a total displacement time of 140.27 hours using ProModel simulation software. Haspels are grouped in the warehouse according to a designated storage strategy that is suggested to increase efficiency. Two scenarios are assessed: the first one uses the dedicated approach for haspel grouping and results in a displacement time of 139.21 hours; the second scenario adds material handling enhancements and reduces displacement time to 128.08 hours, which is an 8.69% reduction from the first simulation. ProModel's effectiveness stems from its capacity to model actual conditions and assess possible enhancements, offering perceptions into ideal layout arrangements that save displacement time and boost warehouse productivity. Also, the study by Yadav (2022) highlights the value of simulation modeling in assessing solution parameters in an actual system and testing various decision outputs, offering insights into production duration and aiding in process optimization. The study also emphasizes the use of ProModel simulation to optimize the production process by locating bottlenecks and examining material flow, enhance travel time efficiency and lessen traffic congestion in Surabaya City, and evaluate the effectiveness of various hospital sizes and their impact on patient flow. Furthermore, the use of computer simulation, more especially ProModel software, to improve the effectiveness and performance of custom production processes is illustrated in a case study by Rosová et al. (2020). In addition to saving money, time, materials, and energy, the study emphasizes the advantages of employing simulation modeling as a scientific approach in research and practice. It also streamlines real-world practice activities. The authors created a realistic manufacturing process model using the ExtendSim simulation program, and then they applied the process redesign to the model to cut the production time by nearly half. Alsaadi (2022) emphasizes how ProModel makes it easier to find inefficiencies and bottlenecks in the assembly line building construction. ProModel incorporates comprehensive statistical distributions of processing data, allowing researchers to simulate different situations and evaluate how they affect productivity and resource use. Almamlook et al. (2019) highlights the way ProModel's simulation outcomes offer valuable insights for enhancing efficiency at every level of the manufacturing process. Through efficient resource allocation and process simplification, ProModel enhances productivity and lowers expenses in the context of assembly lines.

The literature review presents a thorough examination of various studies emphasizing the significance of well-designed layouts in industries to enhance productivity, cut costs, and foster a positive work atmosphere. Despite numerous studies showcasing the advantages of layout optimization methods like Systematic Layout Planning (SLP) and simulation-based approaches such as ProModel, there exists a noticeable gap in research regarding how these methods are implemented and integrated across different industries and regions. While the reviewed studies demonstrate successful applications of layout optimization in specific settings like manufacturing plants, food industries, and warehouses, there is limited discussion on how these techniques can be applied more broadly across various sectors and operational scales. Additionally, there is a lack of investigation into the challenges organizations face when adopting and implementing these optimization strategies, including issues related to resource availability, technological constraints, and organizational culture. Furthermore, there is a need for further research into the long-term sustainability and scalability of optimized layouts, as well as the potential socio-economic impacts of these interventions on workforce dynamics, job satisfaction, and community development. Understanding the broader implications of layout optimization beyond immediate productivity improvements could offer valuable insights for policymakers, industry professionals, and academic researchers aiming to promote sustainable industrial growth and enhance societal well-being. Hence, future research should prioritize addressing these gaps to deepen our understanding of effective layout design practices and their implications for various stakeholders in the industrial landscape.

3. Methods

To achieve the objectives of the study, the study utilized real time observation at the metal fabrication, along with time and motion study to gather necessary data from each station of the current process for the study to be able to run a simulation using Pro Model and analyze the current facility design. Thus, the study can be considered to be a combination of qualitative and quantitative. To further understand the methodology of the study, figure 1 below displays the detailed process of the methodology from the start up to the end of the study.

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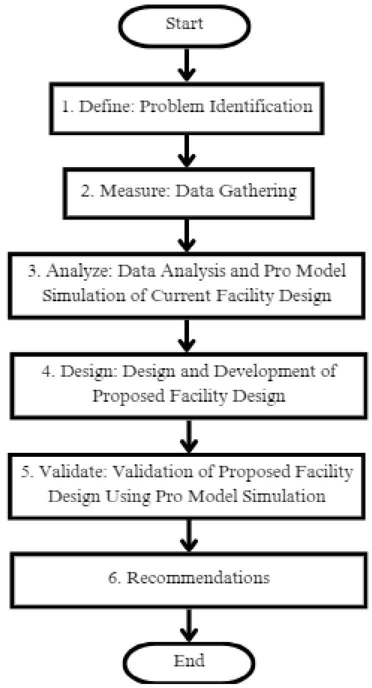

Figure 1. Case Study Methodology

1. *Define: Problem Identification:*
   Involves identifying the problem in the metal fabrication using observation and time and motion study, this includes causes of inefficiency, or delays in the production such as unnecessary distances or obstacles between stations, or inefficient movement of workers in the facility. In addition, the study also included an interview with the manager of the metal fabrication, this to better understand the situation and the problems that the organization faces.

2. *Measure: Data Gathering*
   Aside from the mentioned observation, time and motion study, and interview, the study also utilized literature review as part of data gathering, this is to further enhance the study and support its statements.

3. *Analyze: Data Analysis and Pro Model Simulation of Current Facility Design:*
   After data gathering, the study can then proceed to utilize gathered data and input the requirements for the Pro Model Simulation, with the aid of the software, the study was able to further determine causes of inefficiency and analyze the process within the production as the software will also provide charts and results after running the simulation.

4. *Design: Design and Development of Proposed Facility Design:*
   This phase involves the design and development of the proposed facility design for the metal fabrication based on the analysis and results obtained from the current facility design.

5. *Validate: Validation of Proposed Facility Design Using Pro Model Simulation*
   To validate the proposed facility designs of the study, the software Pro Model was utilized as a method of validation as the simulation will provide results to determine if the designs are more efficient than the current one, this method is the most cost effective as it does not require implementing or testing the design in actual or real life to determine whether it is effective or more efficient. This way, there is no risk of loss of resources should the design result to be inefficient.

6. *Recommendations*
   The last and most important part of the study is the recommendation, as this contains the proposed solutions to the identified problems and to further improve the processes in the metal fabrication.

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Figure 2. DMADV Approach

To further enhance the methodology, the study also utilized the concept of the DMADV approach, which stands for define, measure, analyze, design, and validate. According to Purdue University (2021) the DMADV is a known methodology primarily focused on developing and improving processes by developing or designing a new product, service, system, or process. To achieve this, the following phases must be incorporated:

1. *Define:*
   This phase can be simply understood as defining the main purpose or goal of the study, a well-defined goal will help the study to stay on track and organized.

2. *Measure:*
   This phase includes identifying critical quality factors or characteristics to be measured or analyzed, along with the requirements and measuring the production capability as well. Moreover, this phase can also be classified as the data collection process.

3. *Analyze:*
   This phase is where the data analysis will take part, including the assessment of the data gathered for the development of the new design.

4. *Design:*
   The design and development will take part in this phase.

5. *Verify:*
   The last phase is where the design must meet the identified requirements and ensure effectiveness. This phase is also an essential part to avoid wasting resources.

4. Data Collection

The data gathering for this study was conducted with the use of interview and direct observations of each of the elements present in the process, such as observing the amount of time needed to complete each process, how much time is needed to complete the process with a more skilled worker, including delays and lapses observed that have been used as basis for setting allowance factors. Therefore, two observers at the very least were always present to observe and record data. It was their responsibility to measure the time taken for each element of the process by means of using the timer on their phones, or by utilizing stopwatches. This data was then recorded on paper, and then transferred into an excel file. These served as primary data for the study. Additionally, in order to corroborate the times taken and measured, another source of primary data for the study was also gathered; the facts given by the employees and management by means of talking or conducting interviews. However, being in a metal fabrication factory, maximum attention is required to not cause any injury. Thus, interviews were strictly done during break time, free time, or whenever an opportunity arose. This is so that the observers were not the cause of any delay or problems by interfering with the process. Additional sources of information and data were also taken from books, journals, and previous studies all tackling a similar study. This was considered to be secondary research and data for the study that supported the hypothesized improvements as basis for further analysis and suggestions.

6. Results and Discussion

Table 1 above displays the thematic analysis of the interview conducted with the owner or manager of the metal fabrication. The goal of the interview is for the study to better understand the situation or the context in the organization. The manager started the discussion by understanding the capability of the production, the manager emphasized its importance and how this is the first thing we must consider when accepting orders or when developing a new facility design. Moreover, the manager mentioned that the following things that we need to consider in assessing production capacity are the limitations within the production, this limitation includes the capability of the machines, determining if the production has enough manpower or raw materials to meet customer needs, and ultimately customer satisfaction. Further, to aid in the identification of the problem, the manager was also asked about the challenges that metal fabrication faces, in terms of challenges, the manager emphasized on two challenges, one being the reality of working under limitations, wherein the manager suggested that this way of thinking will help other production

Table 1. Thematic Analysis of the Interview with the Metal Fabrication Manager

Major Theme	Sub Theme	Direct Quote from the Interviewee
Assessing Production Capability	Facility Capacity	*"An item usually takes days to finish and it also depends on the material size, that is why it is important to also know if the production can handle it"*
		"You must know the content of the production along with its capacity, you must also know the limit and market needs"
	Comparing Market Needs with Production Capability	*"We also need to consider the market, it is important for us to know what is needed, how many are needed, for us to satisfy the customer"*
	Inventory	*"To me, material preparation is all but common sense, all the material you often use must have a stock ready, before we proceed with the production itself, we must also consider the materials we have in stock"*
Challenges the Organization Faces	Limited Resources	*"Based on experience you always work on the context of the limited resources you have its always in this context that this is the limitation, you cannot assume that everything is okay, because if you assume that, you cannot prepare for the worst things that might happen"*
	Worker Attitude	*"Another concern that we cannot quantify is the attitude of the worker, this is part of reality and this is one of the most difficult things to control, unlike machines, when you say stop, it will stop, but for manpower sometimes its a different story"*
Facility Design	Facility Design Advice	*"In terms of layout design, another thing that you must also consider is the space and mobility"*

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managers prepare for the worst things that can happen, working, and preparing with consideration to limitations will help organizations resilient. In addition, the manager also mentioned the challenges with regards to the workers, the one thing that managers cannot control are the attitudes of the workers, and can also have an effect on the productivity of the others and eventually to the whole production process. Furthermore, the manager also gave advice when it comes to facility design, of all the things that must be considered, it is also imperative not to disregard the space and mobility when developing a new design as this can also affect the overall efficiency. In conclusion, with the information gathered from the interview, a deeper understanding of the context will aid in the development of the proposed facility designs of the study, with a goal of fostering continuous improvement.

5.1 Results

The figure above displays the screenshot of the Promodel simulation of the current layout of production in the organization. The process starts with the inventory or stock of materials in the middle as displayed in the figure. The materials or inventory are resupplied depending on the demand and or order of customers. The raw material from the inventory will then be fed to the printing machine, which can be described as a huge advanced machine that receives data from the office computer at the right corner, the data fed to the machine is composed of the specific dimensions or measurements of the design requirements of the customers, this comes in different designs, shapes, and sizes as to which the machine will then cut and create. After the machine is done, the workers will then take the output and place it at a table for them to cut the basic frame or shape that the machine created, they will then send the parts individually to different pressing machines to undergo a process and achieve the details of the design. After the parts are customized further into the pressing machines to achieve the required detail, they will then be transported to the welding table for assembly. Once the parts are assembled it will then be stored in the next room to be in queue for painting or powder coating. The next process is then to place the product into the oven to dry the paint or coat to make sure that it sticks and achieve the desired color and appearance of the product. Lastly, the product will then be transported to the area where the workers will have it packaged and ready to be picked up or delivered.

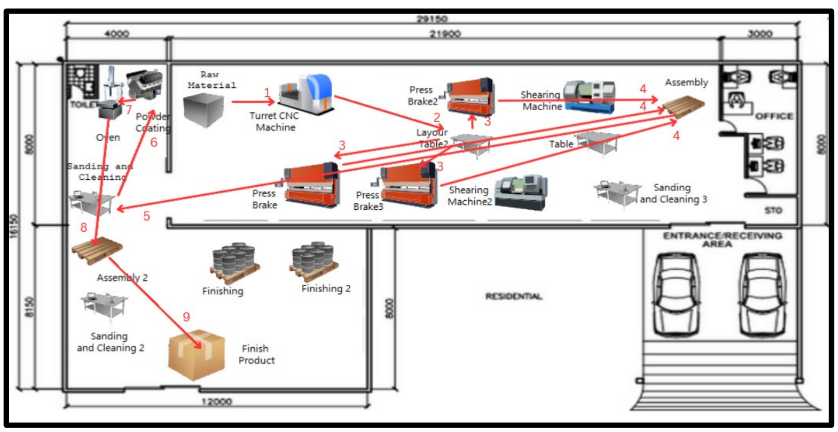

Figure 3. Simulation of Current Facility Layout

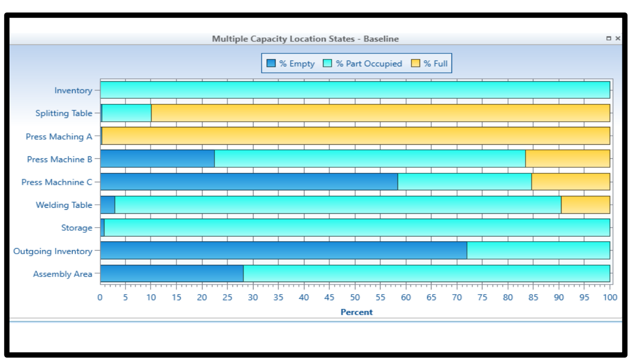

Figure 4. Simulation Result of Current Process

Figure 4 displays the utilization of each of the processes in the simulation. As shown in the figure, it can be noticed that the inventory is never empty, this is because the organization or company keeps track of its inventory, wherein should the item come close to depletion or the item goes below 50% of the stock, the organization will immediately contact suppliers and order the item. Moreover, it can also be observed that the splitting table is the second most occupied station or process while the most occupied is found to be the pressing machine A or pressing machine 1, the pressing machines have different data and results as they process or mold different parts of the product, some pressing machines like pressing machine C or pressing machine 3 as shown in Figure 3 is utilized when working on big parts or shapes depending on the required fabrication for the metal. Further, the welding table is the least to be fully occupied, but the results indicate that it is often utilized where less than 5% is the percentage where the station is empty. In addition, the storage can be observed to be never full, this indicates a good result as this means that even though it takes a long time for the painting and oven to finish, it is still sufficient to keep the storage from reaching its maximum capacity. On the other hand, outgoing inventory is 70% empty, which is also an indication of a good result, this can be interpreted as the finished products do not stay long in storage but are picked up or delivered to customers, this will help achieve deadlines which is essential for customer satisfaction. Overall, utilization of the stations is high in percentage which means no resource is being wasted and maximum utilization is also a factor in achieving efficiency. In line with this, according to Chan (2024), higher utilization of assets wherein in this case machines, this can be translated into increased efficiency which also leads to profit maximization.

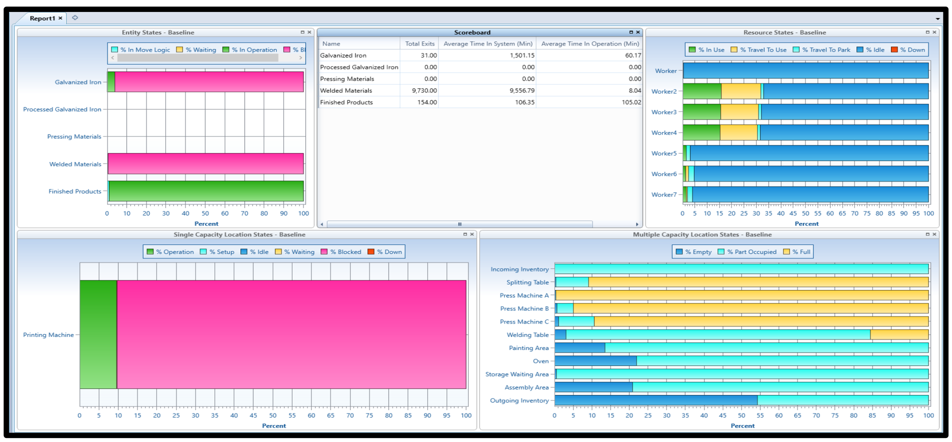

Figure 5. Summary of Simulation Results of Proposed Layout 1

The summary of the initial proposed layout is presented in Figure 5. The bottom left of this overview shows how this collection and the original differ significantly from one another. This time, there is just one system that is acting strangely or that performs noticeably worse than the rest. This indicates that from three machines to only one machine that needs to be taken into account. Since the blocked percentage in this scenario can reach 90%, the printing machine is the only one that needs to be closely monitored. As a result, the procedure was moving along more quickly than anticipated and was only being impeded by the printing machine's sluggish functioning. Although the process is essentially printing and is therefore limited to the size, shape, and amount of prints necessary to fulfill customer requirements, there were very few to no modifications that could be made to it. This compilation's top center section displays the total number of dispatched finished goods. Sixty products more than the original pattern, or 154 total final products, were available. The simulation result named the pressing machines into pressing machines A, B, and C which is the same as pressing machines 1, 2 ,and 3. Since the corporation meticulously maintains track of its inventory, it is also evident from the number that the inventory is never empty. Furthermore, one can observe that Pressing Machine A, not the splitting table, is the most populated station. This is because Pressing Machine A was located closest to the dividing table and, as a result, was typically the first to be filled with materials. Furthermore, three distinct shape kinds and a range of material sizes are being pressed by Pressing Machines A, B, and C. However, the outgoing inventory was 15% smaller than the initial layout, being empty 55% of the time. This was the outcome of the painting area and oven requiring longer than normal completion times. This could be prevented by replacing the existing manual painting process with a more automated one. The products being shipped out right away to maintain customer satisfaction could also be explained by the general emptiness of the outgoing storage. This was not only effective, but also makes good use of the resources and machinery available to boost productivity, which ultimately maximizes profit.

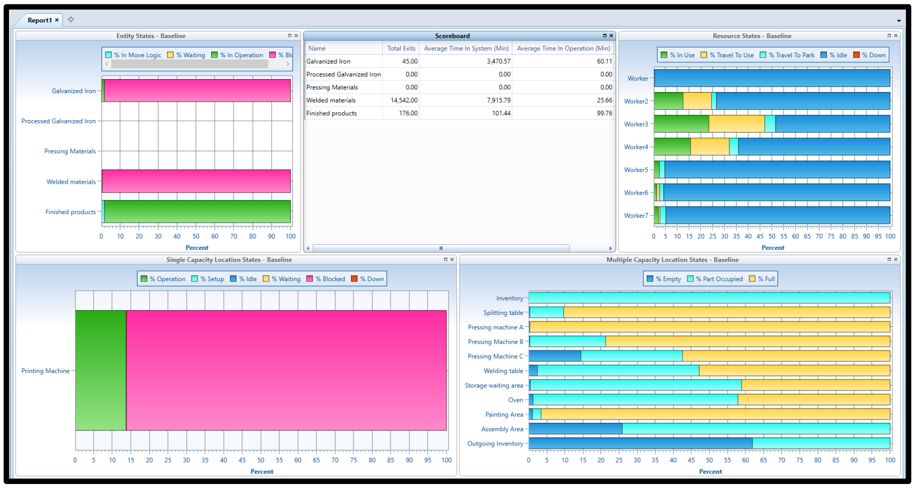

Figure 6. Summary of Simulation Results of proposed layout 2

The summary of the second suggested arrangement is displayed in Figure 6. Similar to the initial plan that was suggested, the printing machine is the only one that is blocked. The printing machine is halted by the lengthy process around 85% of the time. Aside from that, there weren't many issues with the other devices that could have disrupted the workflow or created major delays. 174 completed goods were gathered and shipped, as indicated by the top middle portion of the chart. Twenty more products than the company's initial intended layout and eighty more over the original. Other than the modifications to the painting area's operations, everything else is similar to the first proposed layout. This is to be expected because there was less travel time due to the storage being closer to it, but was also because the painting area was nearly always full, indicating that the layout and the modifications made in the second proposed layout were far more efficient than what the company hoped for. Once more, as a result of the higher efficiency and the ending outgoing inventory that was emptier than the initial recommended plan, the products are apparently being transported out more quickly than in the previous simulations.

5.2 Proposed Improvements and Validation

The figure above shows the simulation of the proposed production layout 1. Initially, the plan aimed to enhance worker mobility and machine access by relocating the inventory closer to the entrance and away from the center. The printing press was moved nearer to the office where prints and patterns originate, enabling quicker data transmission to the machine without obstruction delays. Output from the machine was placed on a nearby table without altering the layout significantly. Substantial changes occurred when workers divided materials and moved them to pressing equipment. Machines were initially arranged side by side to prevent collisions during transit between stations, a problem identified in the initial design. To facilitate faster movement between stations, the welding table was relocated to accommodate heavier loads during assembly of smaller components into larger products. Apart from final storage, which was moved to a more accessible area, the remainder of the stations remained unchanged in their original location.

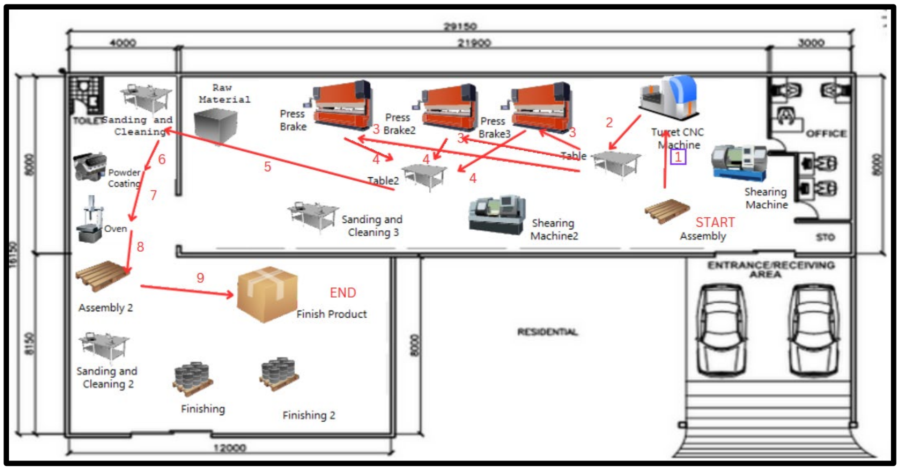

Figure 7. Promodel Simulation of Proposed Layout 1

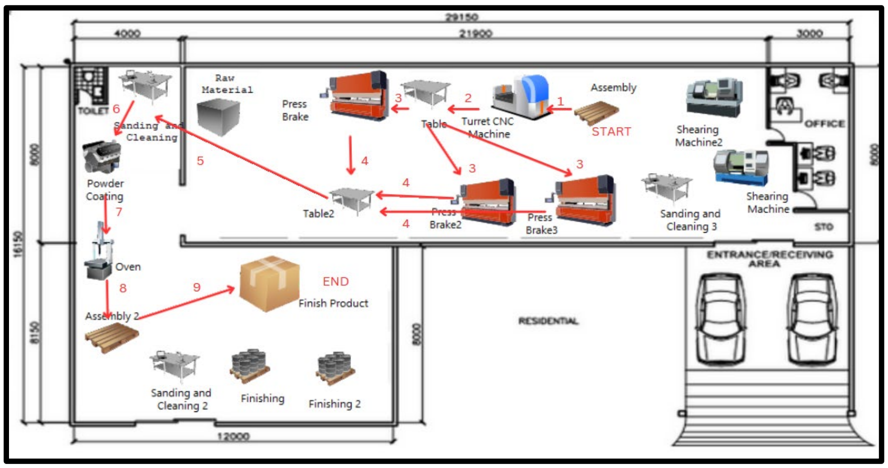

Figure 8. Promodel Simulation of Proposed Layout 2

The second proposed layout for the company is displayed in Figure 8 above. The first and second rooms have undergone major modifications this time. The first room's modifications included moving a few machines to better fit the initial plan that was suggested. The inventory is now situated between the office and the printing machine. This action was taken to ensure that the raw materials would not interfere with the signal from the office to the printing machine, as they are typically arranged level on the ground. The modification was also made to shorten the distance between the inventory and the printing machine. Pressing Machines 2 and 3 were relocated to the first suggested layout's location of the inventory. This was done in an effort to minimize the amount of empty space in the work area. Additionally, the path from the welding station to the storage space remains unobstructed by this modification. Building on that, the storage area in the second room was relocated to the location of the painting area, which had been moved to the location of the oven, which had been moved to the location of the storage area in the original arrangement. Similar to the first room, these modifications were made to enable employees to travel between stations more quickly, which lessens both their burden and the overall distance between each station. For instance, after being removed from the oven, the unfinished product must be delivered to the assembly area, which, in contrast to both the first and second proposed layouts, was now located directly adjacent to the oven.

6. Conclusion

To conclude, the paper was able to complete the objectives that were determined at the start. More specifically, with in-depth interviews and diligent observations, the proponents were able to find the inefficiencies in the process due to the layout of the individual machinery. This also helped to design a proper layout for the company that helped in their

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search for the most optimal layout, as well as where the machinery and equipment in the process line should be in order to eliminate the existing delays and decrease the mental and physical workload the workers were facing. Additionally, the utilization of ProModel 2018 helped to envision the current layout better and helped to show more flaws in the layout that could be changed and improved upon. The proposed layouts were created this way, which also helped to find the delays in the current layout. This then helped to envision the proposed layout as the proponent based on their findings in the current layout on the proposed layouts. For example,redesigning plant layouts done by Kumar et al. (2017) reveals that these can cause significant improvements in process flow and expenses. In addition to that, the research by Ahmed and Alkhamis (2018) proves that with the optimum layout, one could establish higher production efficiency as well as eliminate the likelihood of delays, which is consistent with the findings that show the improvement was 54%. The proposed setup has seen efficiency improve by 2%, as shown in the second layout.

References

Ahmed, A., and Alkhamis, T., A simulation-based approach for facility layout optimization. *Journal of Manufacturing Systems*, 47, 79-90, 2018.

Almamlook,R.,Alden, Q.,Frefer, A., Knew, S., and Agarw,Y., A simulation model for productivity efficiency improvement using pro-model: case study of pip factory, *Revista de Ciencias Sociales*. 26. 133-142, 2019.

Alsaadi, N., Assessment and Enhancement of the Manufacturing Productivity through Discrete Event Simulation. *IOP Conference Series. Materials Science and Engineering*, *1222*(1), 012011, 2022.

Badharinath, E., Reddy, V. D., Kumar, P. S., and Damodaram, A., Optimization of manufacturing plant layout using Systematic Layout Planning (SLP) method. *MATEC Web of Conferences*, *393*, 01005, 2024.

Chan, J., Asset Utilization, Available: https://rb.gy/s2moqo , April 10, 2024.

Fahad, M., Naqvi, S. A. A., Atir, M., Zubair, M., and Shehzad, M. M., Energy management in a manufacturing industry through layout design. *Procedia Manufacturing*, *8*, 168–174, 2017.

Hanggara, F. D., Facility layout planning in small industry to increase efficiency (Case Study: Big Boy Bakery, Batam, Kepulauan Riau, Indonesia). *Journal of Industrial Engineering Management*, *5*(2), 11–20, 2020.

Heller, A., 5 basic principles of production layout planning you should know, Available:https://www.vistable.com/blog/factory-layout-design/5-basic-principles-of-production-layoutplanning/, Accessed on April 22, 2024.

Jain, M., Performance Rating: Meaning, systems and evaluation, Available: https://www.yourarticlelibrary.com/employee-management/performance-rating/performance-rating-meaning-systems-and-evaluation/9054, August 30, 2016.

Kovács, G., Layout design for efficiency improvement and cost reduction. *Bulletin of the Polish Academy of Sciences Technical Sciences*, vol. 67, no. 3, pp. 547-555, 2019.

Kumar, R., Raj, T., and Shankar, R., Optimization of facility layout using multi-criteria decision-making techniques. *International Journal of Production Research*, 55(18), 5277-5290, 2017.

Ochogba, C., Obulor, Deebom, T.M. and Tambari, The role of plant layout in the implementation of technical education programmes in River State, Nigeria, *British International Journal of Education And Social Sciences,*vol. 6, no. 1, pp. 20 - 25, 2019.

Purdue University, Available: https://www.purdue.edu/leansixsigmaonline/blog/dmaic-vs-dmadv/ , Accessed on May 17, 2024.

Radhwan, H., Shayfull, Z., Farizuan, M. R., Effendi, M. S. M., and Irfan, A. R., Redesign of bahulu production layout to improve the efficiency of process flow. *AIP Conference Proceedings*. 2129, 020153, 2019.

Rosová, A., Behún, M., Khouri, S., Cehlár, M., Ferencz, V., and Šofranko, M., Case study: The simulation modeling to improve the efficiency and performance of production process. *Wireless Networks*, *28*(2), 863–872, 2020.

Septiani, W., Divia, G. A., and Adisuwiryo, S., Warehouse Layout Designing of Cable Manufacturing Company using Dedicated Storage and Simulation Promodel. *IOP Conference Series. Materials Science and Engineering*, *847*(1), 012054, 2020.

Somengil, Sweet disposition: the importance of an efficient layout, Available: https://blog.somengil.com/sweet-disposition-the-importance-of-an-efficient-layout/, November 4, 2021.

Yadav, V. (2022). *Process mining techniques for pattern recognition: Concepts, Theory, and Practice*. CRC Press.

Zúñiga, E. R., Moris, M. U., Syberfeldt, A., Fathi, M., and Rubio-Romero, J. C., A Simulation-Based Optimization Methodology for facility layout design in manufacturing. *IEEE Access*, *8*, 163818–163828, 2020.

Biographies

Miguel Louis B. Belen is a 3rd year Industrial Engineering student at the Technological Institute of the Philippines. He had previously lived in Europe, specifically in Germany and had held a few part-time jobs that covered a wide variety of tasks. From simple cashier work to aiding smaller companies improve their services and efficiency. Using his knowledge of leading the student body from the student council position, and the vast knowledge acquired from his multitude of experiences in part-timing, he returned to the Philippines in 2020 to begin and finish his college. He is currently a member of the Organization of Industrial Engineering Students (ORIENTS), as well as an active member of the Literature and Languages Society (LLS).

Rochelle Ann V. Dela Cruz, is a third year at the Technological Institute of the Philippines as an Industrial Engineering student, she is a member of the Organization of Industrial Engineering Students (ORIENTS), and was part of a team that designed and developed the Lunaclen prototype. It is a saltwater-powered flashlight that can be used in urban and rural areas to give light, especially in areas without electricity, and it was made especially during calamities. She participated in activities such as badminton and dance group in her previous school, which helped her to improve her communication and understanding skills as well as her performance skills.

Janelle S. Flores is a 3rd year Industrial Engineering student at the Technological Institute of the Philippines. She was elected as the Treasurer of the Core Team for Project Feasibility in 2024 wherein she was also part of a team of proponents who designed and developed a prototype named Lunaclen, the prototype is a saltwater-powered flashlight. Her contribution showcased her innovative spirit and dedication to advancing sustainable technology. Janelle is currently a member of the Organization of Industrial Engineering Students (ORIENTS).

Andre Brian S. Gellido is a 3rd year Industrial Engineering student at the Technological Institute of the Philippines. Motivated and focused on achieving goals, he is pursuing a bachelor degree in Industrial Engineering. Actively participating in Industrial Engineering events such as APEX, where he was a part of a team called Wayfarer that developed an outdoor style backpack with an integrated water filter inside. In the near future, he is committed to applying the engineering concepts to increase production and efficiency in a wide range of industrial environments.

Prince T. Hernandez is an Industrial Engineering student at the Technological Institute of the Philippines, he was a mentee under the Supreme Student Council program entitled Young Leaders Empowerment and Advancement Program in 2023. The following year he got an offer from a registered student organization, wherein he accepted the position offered and served as Head of Logistics for the Junior Data Science and Artificial Intelligence Association of the Philippines in 2024. In addition, he also currently works part-time as an online English Tutor for Japanese students under the company Weblio Philippines Inc. from 2023 up to the present time.

Bryan Tyrus Serfa Juan, a third-year Industrial Engineering student at the Technological Institute of the Philippines, combines his academic pursuits with a passion for innovation and problem-solving. Outside the classroom, He engages in extracurricular activities, including membership in the Engineering Society and volunteering initiatives. With a strong work ethic and a drive to make a difference, He is poised to excel both academically and professionally in the field of Industrial Engineering.

Nikko Luis Tabasa is a student of Technological Institute of the Philippines in Quezon City, Manila, Philippines. A third-year student who aims to be a professional industrial engineer. He has published research articles and project feasibility study. His research interests include in simulation, optimization and data analytics.

Maricar M. Navarro has the prestigious title of ASEAN Engineer (AE) and Professional Industrial Engineer (PIE) recognized by the Philippine Institute of Industrial Engineers (PIIE). She is currently an Associate Professor and a Professor in the Graduate School Program of Technological Institute of the Philippines. She has over 17 years of Industry, academic and research experience. Her areas of expertise are optimization of production processes, facility layout design, warehouse operations, and service delivery. Currently, she is pursuing interest in financial optimization and decision-making in operations research. She holds both a master's and a Ph.D. in Industrial Engineering from Mapua University. As a committed member and Professional Industrial Engineer, Dr. Navarro actively contributes to the Philippine Institute of Industrial Engineers (PIIE).

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