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Research paper

Implementation of New Workflow Layout for Capstone Design Project

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Abstract

In completing a capstone design project, students were allowed to use all facilities in a mechanical workshop (including machining area, assembly area, and welding area). However, the main problem was they had a very limited space and time to do their work due to the poor arrangement of raw material, machines, and tools. Therefore, this study was conducted to create a systematic process workflow layout. After implementing the new improvement of process workflow layout, a time study analysis and a satisfactory survey were conducted. The study found that total average transportation time could be reduced from 313sec to 102sec with 67.14% of reduction. As for satisfactory survey, it was found that most of the users were satisfied with the new process workflow layout; 7.41% of the users found it very convenient, 75.93% convenient and 18.52% moderately convenient.

Keywords: *Design project; material management; transportation time; workflow layout; workstation*

1. Introduction

Students have been assigned to complete a project under a subject Mechanical Engineering Design (MEC332). Since they were a large group of students, they were divided into several small groups. Roughly, there were about four to six groups per semester depending on the number of students in that particular semester. Since the workshop had been filled up with the equipment and machines, there were very limited spaces in the workshop. The improper arrangement of materials and tools could affect the progress of the project [1 & 2].

The former workshop layout required the students to go to several workshop areas to take the tools or to use the equipment or machine for each work. For example, they had to go to the machining workshop to take the tools, and brought them to the assembly area. Considering the time and energy consumed in between the processes, it was suggested to redesign the workflow to make it more efficient and time-saving. 5S is a workplace organization method that uses a list of five Japanese words: S1: Seiri (Sort); S2: Seiton (Set in order); S3: Seiso (Shine); S4: Seiketsu (Standardize) and S5: Shitsuke (Sustain). Since the major concern of improvement in the workshop organization was to increase the performance of all workshop users which would affect the productivity as well, this 5S method was chosen as its focus was on reducing the waste, budget and time. Therefore, this study was conducted to acquire the efficient process workflow and proper layout arrangement by:

1) introducing 5S method to facilitate the work process.
2) rearranging workflow into a better layout.

1.2. Problem statement

Earlier, the students had a very limited space to work and to store the part. Only certain areas were allowed for the students to do their project work. In addition, this MEC332 subject had only four hours per week and at the same time they had to cooperate with other groups to use the equipment and tools. With that time constraint, the appearance and the quality of the product had been affected.

Moreover, the former workflow process was not properly designed. The students had to go to several areas before working on their project in order to take the tools and then moved to another area to work. This had affected their time management.

Lastly, there was no proper workstation for each group to complete their project. All groups were assigned to complete their project in an assembly area, thus some tools and materials might be assorted with others.

2. Literature review

Working performance and working efficiency are the most important factors to be considered in achieving any target. They depend on the working environment in order to improve. Several techniques or methods can be applied to achieve that and one of the famous methods is by implementing 5S.

Many studies found the implementation of 5S method has given positive impact on the workers [3 & 4]. Basically, this method consists of five elements which originated from Japanese language; they define the steps on how to organize a workplace.

As reported by [5], this effective method should be done in order to achieve good efficiency, improve relationship as well as customer satisfaction. Other than that, it also highlighted several key points such as communication, education, reward and recognition, time management and organization structure in achieving a successful organization [5].

It is also a useful method to improve employee performance in any organization without any limitation on different kinds of products or services and the organizations need to consider it as a part of their strategy [6].

As demonstrated by [7], the efficient implementation of the 5S method had resulted in the improvement of productivity and environmental performance. Consequently, it could help reducing waste in manufacturing.
A researcher stated that poor management of materials had affected the whole project performance in terms of time, budget (cost), quality and productivity [2].
Other than that, [8] found that by applying 5S in the industry, it could improve the quality, productivity, and efficiency of the industrial organization and finally could also give a positive impact to the overall performance.
On the other hand, the process workflow layout also gives high impact to the productivity. Better design workflow layout improves time management a lot.
A study by [9] has concluded that re-arranging layout and optimizing the arrangement of workstations will reduce the movement of goods, lead times and increase production capacity.
[10] verified that converting the workflow into a straight line material flow can slightly reduce the risk of operator fatigue and reduced operator motion loss.
Besides, the staff working performance is important, and their performance can be improved even with some changes of plant layout [11].
In addition [12] demonstrated that there are several alternatives of the layout design that can be created. The best layout will be selected to achieve the objectives such as reducing material handling costs, increase safety or employees, improved their productivity and reduce delays [12].
Last but not least, [13] determined that by improving the layout can also increase the machine utilization, at the same time can improve the process flow by reducing the distance of moving materials and increase the efficiency as well.

3. Methodology

This research was conducted at the Faculty of Mechanical Engineering workshop. The research had started by implementing 5S method and new process workflow layout. Then, after implementing both methods, time study analysis was conducted to determine the total transportation time while completing the project. It was then followed by distributing a satisfactory survey to all users including students and staff. The research methodology was illustrated in Figure 1.

Fig. 1: Methodology Flow Chart

Direct observation was conducted to get the general information regarding the environment and layout of the workshop. Based on the observation, there were only three areas involved in the project; the machining area, welding area and assembly area (Refer Figure 2).

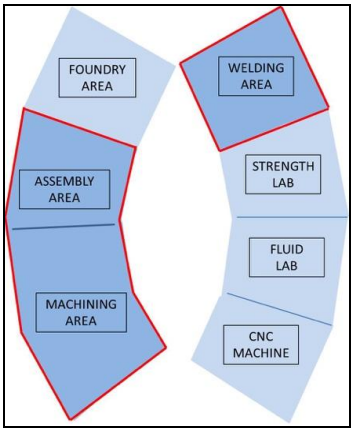

Fig. 2: Three areas that involve in the research study.

The project that had been assigned to the students was related to product design for human and material transportation purpose. Some examples of the projects were an amphibian vehicle (could be used on land and water), scooter, and lifting machine as shown in Table 1.

Table 1: Students' Projects

Amphibian Vehicle	Scooter	Lifting machine
		

Based on former plant layout, it was clearly demonstrated that there was no proper workstation for students' discussion as well as no space for them to store their part or product.

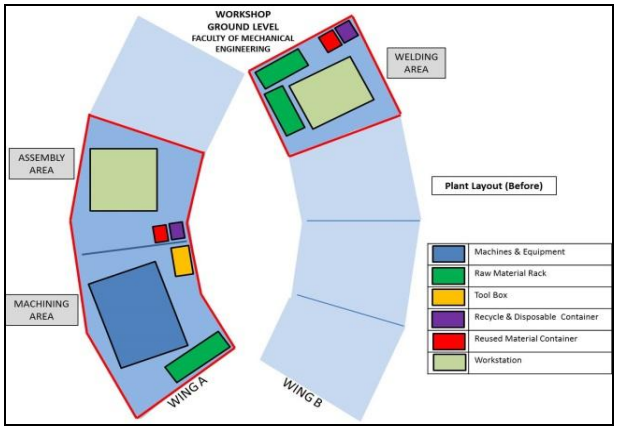

Fig. 3: Former Plant Layout

For implementing 5'S' methods, it started with the first 'S' which was "sort". By sorting, all the materials, tools, parts, and equipment were gathered and later were sorted into necessary and unnecessary items [14, 15 & 16]. Those unnecessary items were eliminated while the necessary items were sorted again into several categories. For example, tools, materials, and equipment.
The second 'S' was "set in order". In this step, all the sorted items were organized into specific job requirement in each station. Then, the category was labelled [17]. In the workshop, the materials were divided into several categories such as raw materials, used, recycle, reused, or waste material. This could help in reducing waste material as they could be reused for other purposes. Besides, a floor plan or area diagram for the machines, tools, and equipment was prepared as well so it could ensure all items will always be there after usage.

Third 'S' was to "shine". This step required the students or any workshop user to clean up the area after using it and make sure all tools and equipment were kept back to their place by referring to the labels.
The fourth 'S' was "standardized". Standardize is defined as a process that involves creating a reliable way of doing jobs and practice, or also known as standard operation procedure (SOP). This was to ensure that the first 3S were maintained and to avoid the previous condition [18]. The 5S organization was required to prepare the procedure for students and other users. Other than that, it was also suggested to create a checklist for the staff and technicians to check after the students had used the workshop.
The last 'S' was "sustained". In order to sustain, they need to adopt all 4S into daily life. Awareness should always be highlighted and instilled in all workshop users. Other than that, ample time should also be allocated for them to do 5S so they could easily follow the schedule. Fully support from the management to the related individuals was also needed to enhance and to maintain this 5S concept in the workshop. In addition, rewards and recognition would be the best way to keep the staff's enthusiasm of this 5S implementation. By doing this, they will be and feel more appreciated [18].
Upon completed the 5s methods, it is then followed by time study analysis and satisfaction survey to check on their efficiency.

4. Result and discussions

4.1. Implementation of 5S

By implementing 5S methods, the arrangement in the workshop was getting better. Table 2 shows the workstations for each group that had been segregated. Each group had their own area for discussion as well as for assembling their product.

Table 2: Condition of workshop before and after implementing 5S method

Before	After
	
	

4.2. Time study analysis

A time study of transportation time for the previous layout is shown in Table 3. The transportation time includes material transportation time and toolbox transportation time. Five observations data were collected from normal performance rating student. The normal performance rating is the condition where the students were completed their task at relax movement (not too slow or too fast), which the performance rating was 100%. Average transportation time was calculated based on five observations data.

Table 3: Average transportation time for previous layout

No.	Activity	Average transportation time (sec)
1.	Take toolbox from machining area to the assembly area	69
2.	Bring toolbox from assembly area to welding area	48
3.	Take raw material at machining area	9
4.	Take material from machining area and bring to assembly area	82
5.	Take material from machining area and bring to welding area	105
	TOTAL	**313**

For the new layout, there was no more toolbox being located in the machining area, therefore students did not have to take a toolbox and bring it to the assembly area because it had already been provided in each workstation there. Besides, the students only had to bring the toolbox to the welding area if they needed it. As for raw materials, they were provided at all areas in the workshop, so the material transportation time was highly reduced. Table 4 shows a time study of transportation time for the new layout.

Table 4: Average transportation time for new layout

No.	Activity	Average transportation time (sec)
1.	Take toolbox from machining area to the assembly area	10
2.	Bring toolbox from assembly area to welding area	42
3.	Take raw material at machining area	9
4.	Take material from machining area and bring to assembly area	23
5.	Take material from machining area and bring to welding area	18
	TOTAL	**102**

Figure 4 shows the comparison of total transportation time for previous layout and new layout. While the percentage of reduction of total transportation time for previous layout and the new layout is shown in Table 5.

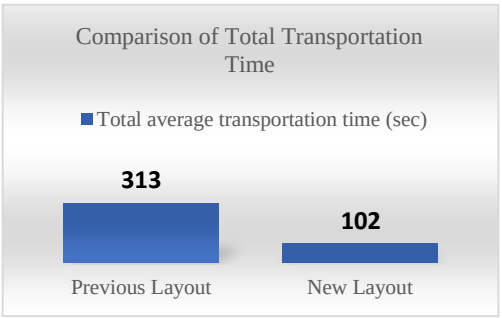

Fig. 4: Comparison of total transportation time between previous layout and new layout

As shown clearly in Table 5, 67.41% of total transportation time was reduced after the implementation of new layout. The students did not waste their time to get the toolbox or materials from the machining area and brought them to the assembly area or welding area. However, they needed to bring the toolbox from the assembly area to the welding area if required.

Table 5: Reduction percent of total transportation time for previous layout and new layout

	Previous layout	New layout	% of reduction
Total average transportation time (sec)	313	102	67.41%

Since each area was provided with the material container, the students managed to reduce the transportation time, and the fabrication process was able to be completed smoothly.

4.3. Satisfactory survey

The satisfactory survey was carried out among 54 users (including students and staff). This online survey was distributed to the students who had completed the subject, were undergoing the subject, and the staff who had been using the mechanical workshop before and after the implementation of new process workflow layout.

4.3.1. Safety in the workshop

The users' satisfaction result in using the new process workflow layout isshown in Figure 5.

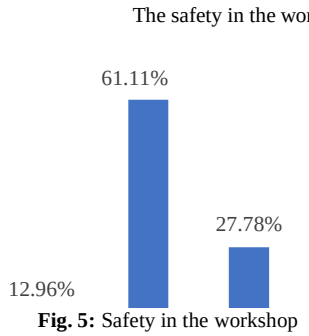

Fig. 5: Safety in the workshop

Based on Figure 5, 61.11% (33 respondents) agreed that the safety in the workshop was good after implementing the new layout. The workshop had a standard operation procedure (SOP), signage, labelling, the floor plan for machines, tools and equipment, a proper workstation with the partition for each group, and good arrangement of the toolbox, material container, and disposable container, that prevented the students from hazard or accident. It was because the 5S method had made the surrounding area more clean and clear, all the tools and equipment were well organized, thus made the process of taking a tool be much easier.

4.3.2. Comfortability, convenience, and suitability of the new layout

This was to obtain the users' level of satisfaction in terms of their comfortability, convenience as well as the suitability of the new process workflow layout in completing the project. The satisfaction results are shown in Figure 6.

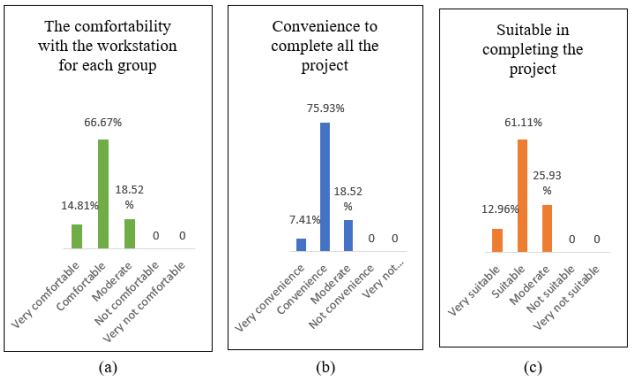

Fig. 6: (a) Comfortability, (b) convenience and (c) suitability of the new process workflow layout

After providing a workstation for each group, 66.67% (36 correspondents) agreed it was comfortable for each group to have their own workstation (refer to Figure 6 (a)). While 75.93% (41 correspondents) agreed that the layout was convenient to complete the project (refer Figure 6 (b)). Finally, 61.11% (33 correspondents) agreed that the new layout was suitable for completing the project. (refer Figure 6 (c)). This had shown the students' satisfaction in storing their product and material at their own workstation. Each workstation could also give privacy to each group as it had partition so the possibility of tool and materials to be assorted with others could be reduced or eliminated.
Other than that, each workstation was provided with a whiteboard to aid the students' discussion. This had shown that the new layout was more comfortable, more convenient and more suitable to complete the project.

4.3.3. Total transportation time

With the new process workflow layout, transportation time had finally been reduced. Based on the survey, it was reported in Figure 7.

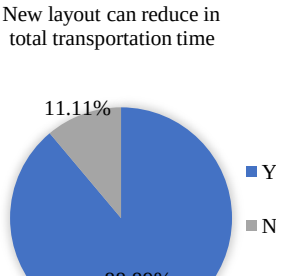

Fig. 7: New layout can reduce in total transportation time

As shown in the figure, 88.89% (48 correspondents) stated that the new layout could reduce total transportation time. This happened as they did not have to take the toolbox from the machining area to the assembly area or welding area. The materials were also provided at each area. As a result, the total transportation time was reduced.

4.3.4. Previous layout Vs New layout

In order to prove that the new process workflow layout was better than the previous layout, the survey had been done to compare these two conditions. The result is shown in Figure 8.

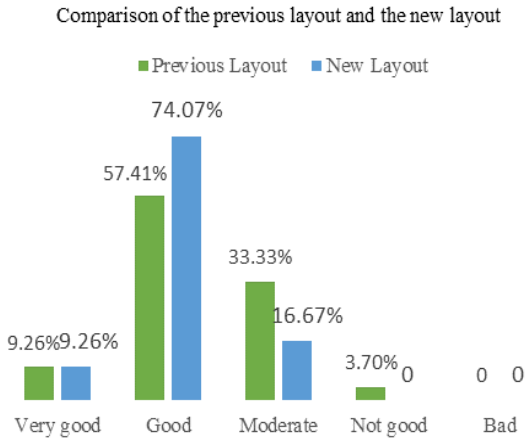

Fig. 8: Comparison of the previous layout and the new layout

For the previous layout of the workshop, 57.41% (31 respondents) agreed it was good, but for the new layout, the number had increased to 74.07% (40 correspondents). The result showed that there were more satisfied users with the new layout. Some of them chose very good for both layouts. This might be because of comfortability and safety that both layouts could give, but the new one could reduce their transportation time. Other than that, there were

also users who voted not good for the previous layout because they needed to move a lot; to the machining area each time they entered the workshop to complete their project.

4.3.5 Maintaining the new layout

Overall, to ensure that all users were satisfied with the new process workflow layout, their response on whether this new layout could be sustained was asked. The result was shown in Figure 9.

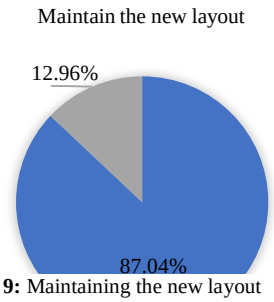

Fig. 9: Maintaining the new layout

Based on the figure, 87.04% (47 correspondents) agreed to maintain the new layout. This showed that the students and staff were satisfied with the new layout because they were able to complete their project efficiently and effectively with the good working environment.

5. Conclusion

In conclusion, the implementation of the new process workflow layout could directly eliminate the transportation time. Therefore, the total time to complete the project could also be reduced and students could work effectively and efficiently. Other than that, the new workstation provided in the assembly area also gave a positive impact to the students because each group had their own discussion and assembly area, thus all areas were well organized. Last but not least, most users were very satisfied with the new process workflow layout.

Acknowledgement

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