Exploring an Approach Enhancing the Area Experts' Involvement in Layout Design and Improvement: an Empirical Experience

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Abstract— **This paper focuses on an empirical layout improvement project. In the implementation process of the project, the authors followed an enhanced procedure to increase the involvement of the area experts in the layout design process, which assured the successful realisation of an appropriate layout solution satisfied to both the project team and the top management of a case company. In this paper, the project, the enhanced procedure and the designed new layout for a shop floor in the case company by applying the procedure are introduced, and the summarised evaluation on the new layout and the enhanced procedure is also presented.**

Index Terms— **Layout, Area experts' involvement**

I. Introduction

Layout refers to the arrangement of workspace in an organization, in order to minimise the cost and flows' distance as well as increase the smoothness of the travel of personnel, materials and/or vehicles between the facilities/machines (departments) and on the floor; the design of the layout is a very important issue of the operations systems, the modification and rearrangement on the existing layout are also a complicated and costly activity [9] [3] [5] [2] [10] [6]. Layout issue, with its influential position to an operations system's efficiency and effectiveness, has been recognised and studied [10] [7] by many researchers.

A. The main approaches dealing with the layout issues

There are a few groups of approaches tackling layout solution development. These include:

- Algorithmic approaches [10] [4] [2].
- Procedural approaches [2] [1] [8].
- Company area team development approaches [3].

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Algorithmic approaches mainly use quantitative data for the generation of a layout; the generated layouts from the algorithmic approaches normally need further improvement for satisfying the real world constraints; this type of approaches needs the designer to be trained for a higher level of mathematic modelling, thus it is not much favoured by the real world enterprises.

Procedural approaches can combine the quantitative and qualitative objectives when developing a layout plan [1] [8]. This type of approaches is more appropriate to be used for layout arrangement [2] [10]. However, to assure the appropriateness of the generated solution, the area experts' input and the designers' knowledge and experience are necessary.

Among the procedural approaches, systematic layout planning (SLP [8]) is a popular design tool within academic circle and real world organizations in tackling the layout arrangement issues [10] [2]. As contended by [2] and [10], SLP has 11 steps composing its working procedure, namely:

1) Collecting and sorting the data including product, quantity, routing, supporting and time information related to the operational processes;

2) Analysing the density of the material/traffic flows between different machines or units;

3) Analysing the closeness between different machines or units;

4) Following the result from the previous steps, positioning the spatial relationship between machines and units into a diagram;

5) Based on the concrete situation deciding the required amount of the floor space;

6) Calculating the currently available floor space in the premise;

7) Input the size information of the machines/units into step4 – spatial positioning diagram;

8) Considering the constraints to the layout, making relevant modification;

9) Giving further considerations to the practical limits to the layout;

10) Developing more alternative layouts for comparison and

an optimum one selection;

11) From the alternative options choosing a most appropriate one.

Company area team development approaches refer to a team of area experts in a company be in charge of developing the layout based on their experience and knowledge of their own premise [3]. Even though this could be a method taking more time and effort from the designers, it is a meaningful tool for layout development, since human experience is very important in facilitating layout decision-making and for final selection of the most appropriate design.

B. The main approaches dealing with the layout issues

The case company is a manufacturing enterprise, whose products are much demanded in the market. To satisfy the market need, it intends to produce more and thus there is a need to expand its operations, meanwhile to improve its productivity. They also planned to buy more machines.

This company is developed gradually with the increment of machines installed following the expansion of the production, due to the increasing market demand. This led to the current shop floor machinery physical layout not well regulated and planned, which results to the following problems:

1) The travel routes for materials, personnel and transporting vehicles are very complicated and snaked;

2) Quite some spaces between machines are very narrow, inconvenient for material inventory and maintenance;

3) Inventory space is very stringent, and the irregularly positioned machines make some of the layout areas' shape also irregular, which eats up some space otherwise can be used for inventory;

4) Currently, there is no any space for installing the new ordered machines.

The authors were asked by the company management to help out on dealing with these issues. They want to have the current layout rearranged, and the new machines should be properly placed in the new layout; if possible, they want more spaces could be explored based on their current company territory. As mentioned previously, there are three possible approaches could be used for the layout design problems; however, there is difficulty for any of them alone to be used for the project, due to the case company and this project owning some special characteristics:

• The company management would like to have rearrangement of all the current positions of the production machines and production units;

• For the machines in the production units need to be performed re-layout, majority of them are not heavy ones, that means they can be relatively easily re-positioned; thus to a large extent, the re-layout could be regarded as a new design of the shop floor machines' positioning;

• Besides the authors, the re-layout project team consisted of the company personnel who have extensive and long time experience and knowledge of the current shop floor layout and machinery as well as production related routing/material handling processes;

• From the primary stage communication with the company personnel, the authors found that the people are very cooperative with each other, and when discussing an issue together through face to face communication, they can get inspiration from each other, and creative ideas are very easily to be promoted.

• The authors have plenty of experience in the field and skills to facilitate this kind of brain-storming like small group works.

Thus, through consideration on the aforementioned layout design approaches and the property of this particular project, the authors decided to use an adapted combination of procedural approach – SPL and company area experts team development approach, termed as enhanced procedural area team approach (PATA), carried out through a series of on-spot group works. The contents of the PATA and the corresponding group work sessions will be introduced in next section.

This paper is structured in the following way. After the introduction of the PATA and the group work sessions, the real world implementation of PATA for the re-layout work will be presented, following that is the result from the re-layout design, then a primary evaluation on the re-layout outcome and the PATA will be summarised, the conclusion and future research finalise the paper.

II. ENHANCED PROCEDURAL AREA TEAM APPROACH (PATA) AND CORRESPONDING GROUP SESSIONS

By comprehension of the SPL procedure and the contention of company area team development approaches, the designed PATA has four steps:

Step 1, By using the collective intelligence of the project team, to do the following work:

• Analysing the density of the material/traffic flows as well as the closeness between different machines or units, based on the experts' knowledge of product, quantity, routing, supporting and time information of the operational systems;

• Diagramming the relative spatial relationship between machines and units.

The special point here is that due to the case company's products themselves' structure are relatively simple and similar, the flows and closeness can be simplified and represented by a few major products, and also based on the extensive experience of knowledge from the area experts, the above mentioned two aspects of the work can be accomplished simultaneously, of course the iteration will often happen for re-modification of the previous arrangement of the machines due to new ideas' creation through group discussion.

This step is implemented through the group session 1 to 3.

Step 2, Enrich the spatial position diagram by

• Sizing the machines according to the real machines' dimensions following a certain scale;

• Deciding the demanded amount of the floor space for this new layout design.

This step is performed in group session 4.

Steps 3, Correspond the draft layout design from the previous step to the concrete situation of the shop floor, by

putting the constraints and practical limitations to the machines, together with the consideration of the currently available floor space in the premise

• Making relevant modification on the designed layout;

• In case of not enough current space for the new layout, finding the position and amount of the extra area needed, plan a proposal for finding extra space.

This step is carried out in group session 5 and 6.

Step 4, Instead of finding alternative options of layout, the project group will focus on

• Making further iteration of modification on the above layout and deciding extra space in case of need, through exchanging design ideas obtained from step 3;

• Here the collective intelligence will be used and promoted to a great potential.

This step is implemented in group session 7, 8 and 9.

A point to mention is that the role of the authors here in the group sessions is not just a team member, but also a facilitator and guide of group discussion.

Figure 1 depicts the steps of PATA and their corresponding work group sessions.

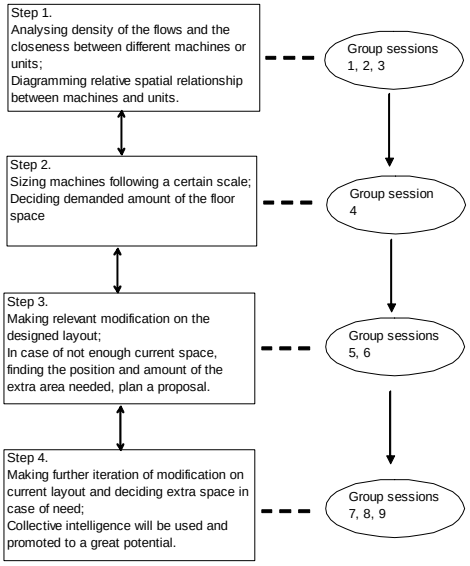

Figure 1. Steps of PATA and their corresponding work group sessions

III. Applying PATA in Practice

In this section, the implementation scenario of PATA in Shop 1 of the company will be presented and discussed regarding the effectiveness of PATA, namely an enhanced area expert procedural approach's applicability.

In Shop 1, the machinery layout is affecting the efficiency and effectiveness of the flow of materials, personnel and transportation vehicles.

The main problems include:

• The distance between machines have not been well planned and arranged, some machines have close relationships are far away parted, while others are too close to each other, giving very little space between machines.

• Some machines do not follow the routings of the main products consequently, namely, the manufacturing steps of the products are not exactly corresponded by the flow of the machines' layout, there are "jump backs" of operations.

• The current machines' layout arrangement makes some of the inventory areas in an irregular shape, which eats up some space otherwise can be used for inventory purpose.

• The shop floor vehicle passageway is too narrow, giving too much inconvenience for the materials handling.

Figure 2 illustrates the flows in Shop 1 (not to scale).

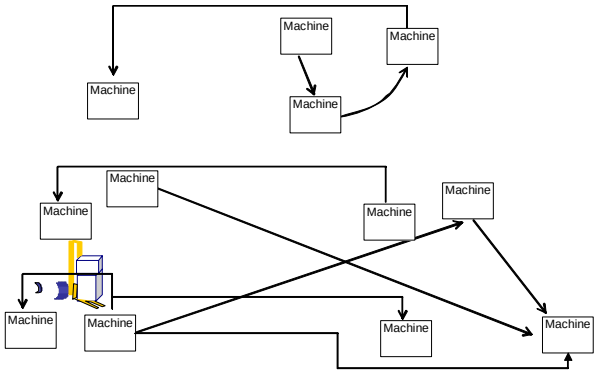

Figure 2. The layout arrangement in Shop 1 before the redesign

Based on the above information, the project team members worked together through all the sessions for designing a new, more appropriate layout. The reason for the first step to hold three sessions is because that the redesign needs many times of iteration on modification of the previous arrangement and discussion, also team members need time to check on spot, and to cool down the brain due to arguments of different ideas. If for some points a consensus can not be reached in the previous sessions, they can be put down to be decided in a later session. It turned out that this strategy worked well. In these three sessions, the relative positioning of the machines has been primarily decided. Also, the current density of the material/traffic flows has been identified, the closeness between different machines/units has also been measured/analysed. Based on these information, the group members made a calculation following the requirements of the technique, safety, etc., and designed a new set of blueprint parameters of spatial positioning of the machines and units. These parameters will be the starting points of maturing the new layout arrangement.

Then in session 4 of step 2, the machines' dimension has been added to the diagram, plus the extra space for each machine due to the safety, maintenance and inventory requirements, which in total set the general space amount for each machine. The machines are separated based on the

distance requirements for different type of machines. Figure 3 is a part of the dimensioned blueprint machines diagramming for Shop 1 .

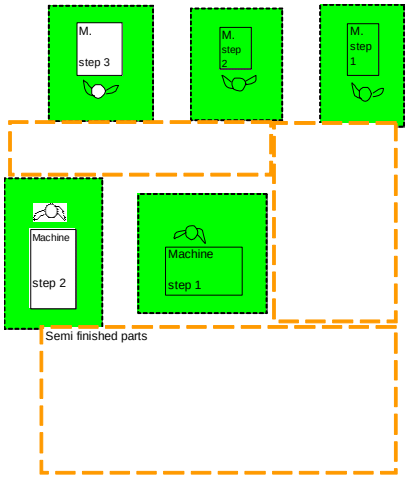

Figure 3. Part of the dimensioned blueprint machines' diagramming

In session 5 and 6 of step 3, the group mainly spent their time on the spot, to check machine by machine with regard to the constraints, limitations and the availability of the currently usable space.

Through these sessions, the first completed draft version of the new layout for Shop 1 is determined.

In the following three sessions of step 4, team members checked each aspect of the new layout design, try using their full potential and capability to make modification on the design, to assure a real satisfied layout redesign to both the group members and the top management, with consideration of the relevant situations in the company. At the last session, the top management has been invited to a presentation by the team, with the aim to further obtain the refinement suggestions/requirements from the highest level authority of the company.

After all the sessions, the team has finalised the new layout design for Shop 1, which is deemed satisfied and appropriate (currently optimum) by both the team members and the top management.

Figure 4 is the general flows' illustration of the new layout.

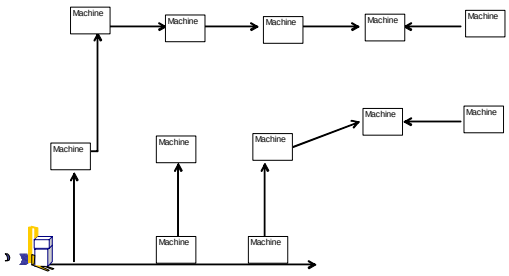

Figure 4. Layout arrangement in Shop 1 after the redesign

IV. The Primary Evaluation of the Re-Layout and the PATA Approach

After the confirmation of the redesign plan of Shop 1, the team made a comparison of the redesigned layout and the previous layout arrangement, in the aspects of the smoothness of the flows and the available inventory areas.

For the smoothness of the flows, from Figure 4, we can see that in the new layout the complexity of the routings is reduced, and the distance between the machines has been well designed by taking the relevant factors into consideration.

For the inventory areas improvement, Table 1 provides a summary.

Table 1. Comparison between the redesigned and the previous layout

Inventory Area (m^2)	Previous layout	Redesigned layout
Shop 1	80	120

Regarding PATA itself as an approach, besides that the increased inventory areas and smoothness of the flows by applying PATA, demonstrate its effectiveness, the authors have also made an investigation during the sessions when the group members applying the PATA procedure. Table 2 summarises the general assessment from the team members and the management/staffs from the case company.

Table 2. Primary evaluation of the PATA approach

Assessment / Evaluation criteria	Very low	Low	Acceptable	High	Very high
Level of effectiveness in facilitating decision making				X	
Level of efficiency in facilitating decision making			X		
Level of usefulness for the layout design process					X

From the above evaluation, we can see that only the efficiency level is not very ideal. Actually, this is not a surprising comment, because from the observation in the sessions, PATA is not very efficient due to the intention of more experts' expertise and intelligence involved in the decision-making, namely, much iteration due to new ideas' creation and previous errors' detection impedes the efficiency. However in general, PATA is effective and useful for the generation of an appropriate layout plan, which can provides the improvement on the operations performance through better flows and space usage.

V. Conclusion and Future Research Work

From the application scenarios and the implementation result, we can have the confidence in the effectiveness and usefulness of PATA to the practical layout design, namely, a more area experts' experience and knowledge involved layout arrangement design process is a feasible strategy and can bring a satisfied outcome, as illustrated in this paper the increased inventory area and smoothness of the flows after the redesign.

Meanwhile, the outcome of the application of PATA in Shop1's re-layout process, demonstrates another important issue, i.e., a better layout can bring an organization higher level of productivity as well as operational efficiency and effectiveness.

However, the current application of PATA is just used for one shop floor with not too many machines, and the situation is not very complicated, either. The next step is to apply PATA in the design of layout in a more complicated environment, to check its practicality and applicability; also if it is possible, to apply it in other enterprises under different industrial context, to view its usefulness and enrich its procedure and contents.

References

[1] Apple, J.M., *Plant Layout and Material handling*, 3rd Ed., Wiley, New York, NY, 1997.

[2] Chien T.-K., "An empirical study of facility layout using a modified SLP procedure", *Journal of Manufacturing Technology Management*, Vol. 15, No. 6, pp. 455-465, 2004.

[3] Canen, A.G. and Williamson, G.H., "Facility layout overview: towards competitive advantage", *Facilities*, Vol. 14, No. 10/11, pp. 5-10, 1996.

[4] Caredarelli, G. and Pelagagge, P.J., "Simulation tool for design and management optimization of automated interbay material handling and storage systems for large wafer fab", *IEEE Transactions on Semiconductor manufacturing*, Vol. 8, No. 1, pp. 44-49, 1995.

[5] Djassemi M., "Improving factory layout under a mixed floor and overhead material handling condition", *Journal of manufacturing technology Management*, Vol. 18, No. 3, pp. 281-291, 2007.

[6] Elbeltagi, E. and Hegazy, T.M., "Genetic Optimization of Site Layout Planning", *AACE international Transactions, ABI/INFORM*, pp. IT.05.1-IT.05.8, 1999.

[7] Meller, R.D. and Gau, K.Y.), "The facility layout problem: recent and emerging trends and perspectives", *Journal of Manufacturing Systems*, Vol. 15, No. 5, pp. 351-366, 1996.

[8] Muther, R., *Systematic Layout Planning*, 2nd Ed., Cahners Books, Boston, MA, 1973.

[9] Sha, D.Y. and Chen, C.-W., "A new approach to the multiple objective facility layout problem", *Integrated Manufacturing Systems*, Vo. 12, No. 1, pp. 59-66, 2001.

[10] Yang, T., Su, C.-T. and Hsu, Y-R, "Systematic layout planning: a study on semiconductor wafer fabrication facilities", *International Journal of Operations & Production Management*, Vol. 20, No. 11, pp. 1359-1371, 2000.