Systematic layout planning aided by multi-criteria approach in a Brazilian restaurant

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Abstract: The objective of this article is to plan the layout of an industrial kitchen, through the application of the Systematic Layout Planning (SLP). It is established layout indicators with specific application in the food business and MAUT is used for aiding the multi-criteria decision making process.

Keywords: Systematic layout planning, Performance indicators in restaurants, MAUT.

INTRODUCTION

A layout, according to Slack et al. (2002), is one of the most evident characteristics of a productive operation, because it determines the "shape" and appearance of its environment. In carrying out processes, among other factors, greater fluidity in the use of resources is sought, in order to transform information, personnel or materials into the marketable final product or service (Hronec 1994). Therefore, changing the way these environments are organized directly influences the way processes flow, which evidences the importance of a good layout for business performance (Bougoure and Lee, 2009).

In small businesses, processes' performance is usually observed through an empirical analysis (Dora et al. 2014). However, there are methods and tools that apply for this purpose, providing an objective assessment of the performance of processes. As stated by Müller (2003), the indicator system has the role of unfolding the strategic targets to the procedures and return its performance, i.e., to facilitate the application of the PDCA (Plan-Do-Check-Act) method to ensure the managerial control over the outcome. The same goes for improvement projects, which should be planned according to targets for specific indicators, which will be measured and then analyzed to assess the performance of the changes made (Ruiz et al. 2014).

The food sector presents few evidences of solutions such as process management, since small and medium-sized restaurants rarely have a system that ensures the measurement of their performance and the action on any deviation (Horng et al. 2013; Ho 2011). The application of such management methods is frequently hampered by cultural factors, as structural changes are occasionally needed (Wang and Zhang, 2013). It is not enough to strengthen just one area because the client is serviced by inter-functional processes (Kavanaugh 2014) and feels the effect of the worst performance within these processes. Therefore, one must adopt a continuous improvement approach in the organization, acting on its critical processes (Rodgers 2011).

This article aims to apply the Systematic Layout Planning (SLP) in the kitchen of a small southern Brazilian restaurant in order to analyze the production and information flow, formulate layout alternatives and, then, suggest a better physical distribution of its processes. In addition, the implementation of specific performance indicators, based on the factors that contribute to improving quality and efficiency in accordance with the customers' perspective, to support the kitchen layout alternative decision is proposed. The best layout alternative is selected through application of a multi-criteria decision making tool. Throughout the paper, a theoretical discussion on the subject will be presented, followed by the proposed methodology description. In conclusion, the obtained results and the conclusions of the work are presented.

SYSTEMATIC LAYOUT PLANNING

The restructuring of the layout is done in order to optimize the work process, always ensuring the security of the flow of materials, people and information (Monks 1987). There are several layout planning algorithms that can be used, with its own peculiarities, pros and cons. The Systematic Layout Planning (SLP) is a highly used methodology, especially in small to mid-size companies, due to its accessibility (Gilbert 2004). SLP aims to regulate a series of procedures for selecting the best layout for the factory facilities and help in the subsequent decision making by the company (Silva and Moreira, 2009). However, a dense initial research on existing flows, procedures and activities on the facility is fundamental to better identify the limitations of the study (Trein and Amaral, 2001).

According to Tortorella and Fogliatto (2008), SLP has three macro steps: (i) analysis, (ii) research and (iii) selection. The first step is the collection of company data, the process flow and the activities related to it. To obtain the flow, the distance traveled by the materials in the layout is generally calculated, and such information is subsequently aggregated to the “From-to Chart”. As for obtaining the data from the related activities, it is a description, from those activities that need to be physically close to each other to those that are irrelevant or even undesirable (Thompson 2010). The compilation of this information results in the “Relationship Map”. According to Silva and Moreira (2009), the map relates the areas with each other and the reasons for their corresponding proximities. An importance degree scale for these interrelationships is used. It is also necessary to assess the required space for the departments and the available area in the facility so that the relationships of proximity can then be of significant use (Muther and Wheeler, 2000).

The second step comprises the design of different layout alternatives. Therefore, a “Relationship Diagram” is established, arranging the various sectors according to their required proximity. Based on this diagram, it is possible to start the construction of the options of the “Block Diagrams”, which considers the various constraints of the project (Yang et al. 2000). Finally, the selection of the best layout alternative is performed, by comparing the several characteristics of the arrangements. Several criteria can be selected to compare the performance of the layouts. The importance of involving the company's employees in the choice of criteria should be noted, since they will be directly affected by the new layouts and will benefit from the project improvements (Muther and Wheeler, 2000).

The system of indicators of a company aims to help management and controlling various aspects related to operational efficiency, such as ergonomics, finance and production (Baraban and Durocher, 2010). The literature addresses the most appropriate indicators applied to the context of this article (Brann and Kulick, 2002). Based on this survey, key operational performance indicators for the sector of grouped restaurants were consolidated in four dimensions, as suggested by Pavani and Scucuglia (2012): people, processes, financial and market. Table 1 chronologically shows the frequency of appearance of performance indicators directly or indirectly related to the food service in the literature.

The consolidated literature review highlights the importance of three main indicators: productivity, work-in-process (WIP) and traveled distances. The first one indicates the degree of utilization of the resources (human or material) available for the production (Kavanaugh 2014). WIP represents how much inventory is placed throughout the production process due to inefficiencies of the system (Dora et al. 2014). The indicator “traveled distances” during the execution of the processes is relevant because it is directly related to the layout arrangement and will help measure the performance of the proposed changes in the alternative (Ruiz et al. 2014; Malekshahi 2013). Aside from the process indicators aforementioned, several studies (Huan and Yu-Qiang, 2011; Ho 2011; Reich 2011) assess financial results by means of operating costs impact, which represent the effect of any change on the organization of the system. In the dimension "people", the most frequent indicator mentioned in the examined literature is "work-related accidents" (Horng et al. 2013; Reynolds and McClusky, 2013). Regarding market dimension, "customer satisfaction" is the indicator that receives more attention in the food service's layout planning literature (Reich 2011; Baraban and Durocher, 2010).

Table 1 – Appearance frequency in literature of performance indicators for food service layout

Authors	People			Process					Financial		Market	
	Absenteeism due to injuries	Accidents at work	Employees' satisfaction	Productivity	Work-in-process (WIP)	Productive capacity	Productive area utilization	Traveled distances	Operational costs	Re-layout costs	Customers' complaints	Customer satisfaction
Kavanaugh (2014)	×	×	×	×	×						×	×
Dora et al. (2014)			×	×	×	×	×		×			×
Ruiz et al. (2014)			×	×		×		×		×		×
Horng et al. (2013)			×	×			×			×		×
Malekshahi (2013)						×		×	×	×	×	
Reynolds and McClusky (2013)		×		×			×	×				
Wang and Zhang (2013)	×	×	×		×			×			×	×
Heung and Gu (2012)	×	×	×		×			×			×	×
Huan and Qiang (2011)	×			×	×	×		×	×			
Ho (2011)									×		×	×
Reich (2011)			×						×		×	×
Rodgers, S. (2011)					×		×	×		×		
Baraban and Durocher (2010)	×	×	×	×		×	×	×		×		×
Thompson (2010)				×		×	×		×	×	×	
Manikas and Terry (2009)					×	×	×	×				
Zago et al. (2008)		×		×	×			×	×			
Ryu and Jang (2007)	×	×	×		×		×	×				
Walker (2007)		×	×	×	×			×		×		×
Chen and Yunhong (2006)				×	×	×	×	×	×	×	×	×
Hwang and Ko (2003)				×	×			×	×	×		

METHOD

The method presented in this paper comprises six main steps, as shown in Figure 1. The first step involves collecting qualitative and quantitative data related to the current scenario in order to enable the comprehension of the restaurant production process and the system parameterization in terms of certain aspects such as production demand, area, material flow, employees, machines, etc (Tompkins et al. 2010). During this step, the professionals involved in the kitchen routine are interviewed, so they can suggest and criticize the current layout of their work environment. The collected data is categorized according to a PQRST (product, quantity, route, support and time) classification suggested by Yang et al. (2000). In the second step, the material flow is analyzed and the relationship intensity among the process units is quantified, so the required proximity is respected and prioritized during the layout development. Moreover, the production area is divided into two main areas: (i) operation preparation and (ii) flow of operation during the service (Huan and Yu-Qiang, 2011). This division is recommended by the fact that there is a significant difference in the relationship between the amount of moved material and period of the day in which happens its more intense usage (Malekshahi 2013). Step three includes the practical limitations of the available facility to the layout problem, restricting the alternatives to the real scenario and avoiding the so called "movement of monuments", which are difficult or costly areas or work stations to be changed the position (Walker 2007).

In step four, based on all information gathered so far, it is defined the process units (PUs), which can be classified according to three main groups in the restaurant kitchen: (i) health and hygiene, (ii) food storage and (iii) production processing (Chen and Yunhong, 2006). Such PUs are rearranged according to the layout requirements in order to develop several layout alternatives, whose operational performance is evaluated and ranked according to the pre-defined criteria in step five. The proposed criteria is based on the literature review about performance indicators for food service layout and, therefore, it is selected the most adequate indicators to the specific needs of the case study. It is highly important to consider which of these indicators reflect the implemented layout improvements (Heung and Gu, 2012) and which are easily monitored by management in order to ensure processes' quality in accordance with expected standards (Ryu and Jang, 2007). Finally, step six provides a multi-criteria assessment for all layout alternatives previously generated in order to select the best overall alternative. For that step, the proposed decision making tool for the assessment of each of the layout alternative is the multi-attribute utility theory (MAUT) (Kliemann 2014). This method allows the decision maker to structure a complex problem in an objective manner. The fact of assigning weights to criteria requires the involvement of the senior management in the selection process, since they will indicate the most important indicators to the business (Reynolds and McClusky, 2013; Hwang and Ko, 2003).

Figure 1 – Proposed method

RESULTS

The case study was conducted in the kitchen of a small southern Brazilian restaurant that aims to improve its layout, so that it may effectively support the manufacturing of the whole production mix offered in the current menu. Therefore, the analysis focused the most critical period, the dinner service, since it offers both customized meals and a buffet service. The night-shift production team consists of five employees: a chef, three assistants and a cleaning assistant. All of them were interviewed during the data collection step. The current menu comprises three options of salads, three different meals for children, nine desserts, four different appetizers and twenty-eight hot meals, totaling 47 different meals. Regarding the demand scenario, a 12-month analysis was performed with data supplied by the restaurant management. Figure 2 shows the average number of customers served daily on the night. From month 4 to 12, the daily demand has reached a different pattern with an average of 106.5 customers and a variation of 6% on the average over the period. However, this monthly average is not sufficiently representative because there is a high variation in demand during the weekdays, since the variation coefficient is up to 35% within a week.

The service time is directly related to revenues. Because it is a slow food kind, the cuisine served by the restaurant has a great time of service, which is enough for customers to interact with the theme and relaxed environment, consuming other products meanwhile. However, deviations of that time can cause customer dissatisfaction, such as an undue delay in the delivery of customized meals. The average lead time for the kitchen staff to process a request is approximately 15 minutes, but at peak periods this time can reach 35 minutes, which influences not only customer satisfaction, but other indicators of operational performance. When analyzing the average time of customers in the restaurant, it is noted that in periods of high demand the retention of these customers is above average, prolonging the waiting list and decreasing the tables' turnover, i.e. serving less people in a particular timeframe.

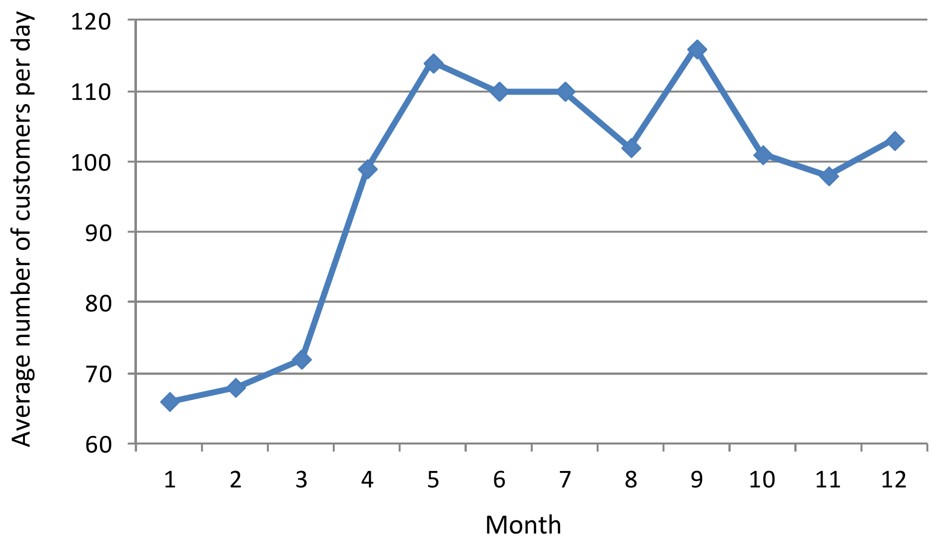

Figure 2 – Average of customers served per day on the night shift from April/2013 to March/2014

The initial preparation activities are equally distributed among the four assistants. However, during the final steps of food preparation, two assistants are dedicated to serving customized meals, one in organizing and maintaining the buffet service and the fourth is responsible for assisting the two areas. The cleaning assistant is in charge of washing dishes that return from the dining room and the ones used by the other assistants during the operation. Even with independent tasks the production flow is not linear, which causes interruptions among employees' activities inside the kitchen. Moreover, usually they walk with utensils on hand, such as knives, forks, pots and hot molds, implying risks to workers. Accident indicators confirm such risks, since during the last twelve months eight injuries without absenteeism were recorded in the restaurant, with 7 of them related to production professionals, usually by cuts or burns.

The restaurant production area should be designed so that there are physical conditions for handling food in a safe manner, avoiding the cross flow between unprocessed raw materials, finished products and production residues. In the kitchen under study there are two access doors, one connecting it to the main dining room and another to the storage area. The first one is for the output of finished products and clean dishes for the end customer during the dinner service and the second one is where raw materials enter and segregated process residues leave in bins. The kitchen staff does not have access to the stock of raw materials, which is performed only by the employee in charge of it. This employee receives requests for materials, separates the ordered items and delivers them in baskets to the production area. The required materials are placed in the defrost refrigerators outside the kitchen, where the assistants have access.

Once finished the food preparation activities, it is started the assembly and delivery of products. After assembled, food for the customized meals and the buffet service is delivered to the waiters for distribution through the same access door, which can sometimes overload the physical space. The dishes that return dirty from the main dining room are placed by the waiters in the wash sink through an opening called serving hatch. From there, the cleaning assistant is responsible for washing and making them available again for the operation. In addition to the movement of materials between the kitchen and other sectors, there is an intense movement of tableware and utensils in the production area. They are used by the assistants during the execution of their activities. The layout of the kitchen, therefore, must meet the requirements for adequate food preparation in the early hours of production, as well as for the period of high demand.

The division of the kitchen areas by activities is crucial for assembling the diagram. Based on the current layout of the restaurant kitchen, shown in Figure 3, the area was divided into thirteen PUs. The allocated PUs, subsequently detailed, correspond to the following: (i) asepsis sink, (ii) bin 1, (iii) bin 2, (iv) washing, (v) refrigerator 1 (R1), (vi) refrigerator 2 (R2), (vii) refrigerator 3 (R3), (viii) freezer 1 (F1), (ix) salads, (x) customized meals, (xi) buffet service, (xii) grill and (xiii) stove. Then, the relationship map was established among PUs (see Figure 4) based on employees' interviews and process analysis.

Besides the thirteen PUs, another preparation area independent from the others has been identified outside the kitchen and, therefore, disregarded in the relationship map. It is located between the kitchen and the main dining room because there is not enough space in the kitchen area to place it. It is called "taco shop" and is constituted by a gas-heated plate, a refrigerated counter, and the cooking space of the chef that operates it. In this article, the possibility of adding this sector of 2.90 m² to the internal area of the kitchen with the improvements of the layout of the site will be studied.

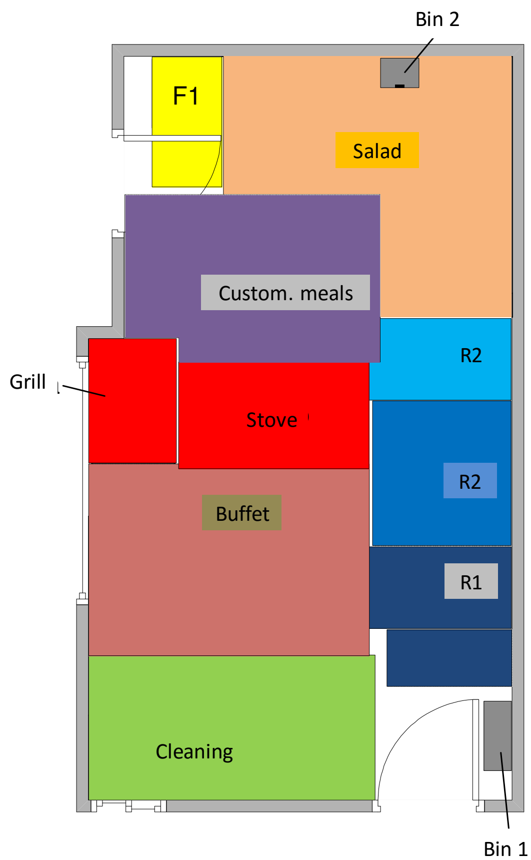

Figure 3 – Current kitchen layout

By rethinking the layout, it is necessary to carefully consider each PU area to ensure that there will be enough space for relocation. The kitchen is 3.66 m long and 6.16 m wide, with an area of 22.55 m². The area of each PU is presented in Table 2. The constraints regarding the hydraulic system concerns the three sinks already installed and the sewage system, which are not allowed to be moved because of the difficulties in reinstalling them in another wall of the facility. A similar situation happens with the gas pipes, which follow underground until the next wall to the stove, where there are the opening valves. Another point that cannot be changed is the location of the serving hatch between the kitchen and the dining room, because it is an original opening of the building. Its location, however, is suitable for the initial kitchen layout, since it gives direct access to the washing PU, so that the path traveled by the customers' dirty dishes to the washing section is optimized.

	PUs	1	2	3	4	5	6	7	8	9	10	11	12	13
1	Asepsis sink													
2	Bin 1	5												
3	Bin 2	0	X											
4	R1	0	0	0										
5	R2	0	0	0	0									
6	R3	0	0	0	0	0								
7	Salads	0	1	5	5	9	9							
8	F1	0	0	0	3	3	3	1						
9	Custom. meals	1	1	5	3	9	1	1	1					
10	Buffet	1	5	1	5	9	5	5	1	1				
11	Washing	0	9	0	0	0	0	1	0	5	5			
12	Grill	0	X	X	X	X	X	0	X	9	5	0		
13	Stove	0	X	X	X	X	X	5	X	9	9	0	9	

Proximity relationship	
9	Absolutely important
5	Especially important
3	Important
1	Regular proximity
0	Not important
X	Undesirable

Figure 4 – Relationship map

Table 2 – Areas of the PUs

PU	Length	Width	Area (m^2)
Asepsis sink	0.85	0.70	0.60
Bin 1	1.14	0.46	0.52
Bin 2	0.57	0.46	0.26
Refrigerator 1	0.67	1.20	0.80
Refrigerator 2	1.20	1.20	1.44
Refrigerator 3	0.64	1.20	0.77
Washing	2.60	0.72	1.87
Salads	2.22	0.83	3.24
	1.02	1.37	
Freezer 1	0.55	1.20	0.66
Custom. meals	1.22	0.71	0.87
Buffet	2.01	1.34	2.69
Grill	0.57	0.37	0.21

Three main alternatives were developed. The first alternative included the replacement of R3 and part of the salad area, which is occupied by a simple table and a refrigerated counter, in order to decrease the walking distance the refrigerator. Thus, the proposal is to consolidate R3 to salad. In addition, the location of the bin is changed to the displaced R3. This new layout also proposes the transformation of the door between the freezer and the grill in a serving hatch counter, so as to prevent the waiters from entering the production area. The window next to the buffet would become a second serving hatch, so that the food can be distributed by the waiters. Therefore, the distance of the finished products to the buffet service is reduced.

The second alternative considers the advantage of replacing refrigerators for refrigerated counters. Thus, the freed space can be used to aggregate the taco shop next to the customized meals area, only relocating the freezer and R3. By distributing the layout without moving the stove and the grill, a trivial improvement of the layout is observed, because the location of this equipment is not the best solution to optimize the flow of people and materials within the kitchen.

The design of the third layout alternative has only considered the critical constraints imposed by the owner of the building, not significantly changing electrical, hydraulic and gas installations. The first aspect to note is the expansion of the total productive area, because, besides the kitchen, the PUs have expanded into the space where today is an aisle for access of the stock to the street. This aisle, as reported by the restaurant management, is an unproductive area because the access of received goods is done through another door, leaving that space to store surplus materials. Food safety standards do not allow access of packages brought from outside the restaurant to the food handling area. However, what is observed in salads is that the material is received directly from the supplier, cleaned, packed and allocated in the appropriate refrigerator. Such receiving procedure facilitates cross-contamination of food and, therefore, it was decided to split salads into two sectors: (i) for reception and preconditioning of groceries outside the production area and (ii) for operation within the kitchen. By rearranging the operation of the salads and installing refrigerators and freezers, it was possible to transfer the taco shop into the kitchen. The oven, previously classified in the stove area, was expanded because new equipment must be installed due to safety requirements. The flow within the PUs is unidirectional, from the kitchen back into the dining room, going through cooking, assembly, and distribution. The window between the kitchen and the dining room becomes the serving hatch of finished products, and the door that connects these two environments must be changed into a window to distribute the products from the taco shop.

Then, the layout alternatives were evaluated according to the most cited performance indicators for food service layout: productivity, WIP, traveled distances, operating costs` impact, work-related accidents and customer satisfaction. Productivity was calculated by the number of plates served per hour for the same product, in comparison with the current layout. For WIP, it was quantified the intermediate stock in the production area. Traveled distances involved the number of steps walked by the employees in the preparation of a new meal. The operating costs impact was measured based on incurred costs for changing the current layout according to the proposal. In the people criteria, the amount of work-related accidents was chosen as the main indicator. As a way to measure the performance of the layout from market and customers' perspective, order waiting time order was selected as key indicator.

Finally, the MAUT was applied for selecting the best layout alternative. For that, importance weights were established for each indicator during interviews with restaurant staff (see Table 3). The order waiting time was considered the indicator of greatest importance, because it directly affects customer satisfaction. Its impact is easily measured when the customer perceives positive improvements in the environment. Once the criteria weights were set, each layout alternative was qualitatively evaluated according to the selected indicators. A twenty-point continuous scale was used, being "zero" a much lower performance than shown by the current layout, and "twenty" as the maximum score, such that the expected performance is much higher than the current one. The layout alternative score was the weighted sum of each indicator score, shown in Table 3. This multi-criteria analysis pointed the third alternative as the best layout to the restaurant kitchen.

Table 3 – Multi-criteria assessment – MAUT

Criteria	**Indicators**	**Weight**	**Altern. 1**	**Altern. 2**	**Altern. 3**
People	Work related accidents	15	7	10	10
Process	Productivity	20	7	14	15
	Traveled distances	15	5	10	15
	WIP	15	10	10	15
Financial	Operating costs impact	10	15	10	3
Market	Order waiting time	30	10	10	17
Total		105	920	1.130	1.440

CONCLUSIONS

The production and information flows of a theme restaurant kitchen were studied in this work in order to propose improvements in its layout. The application of a systematic layout planning approach was proposed, in order to assess the current scenario and the relationships among the PUs, developing alternatives that meet the restaurant requirements and correct critical issues. A wide literature review was carried so the proper layout indicators were used to measure the performance of each layout alternative. As a supporting tool for the decision making process, the multi-criteria method called MAUT was adapted to facilitate this step.

The results from the implementation of this layout involved a reduction in WIP by removing refrigerators and the freezer from the production area, leaving only refrigerated counters. Further, the displacements of the cooking assistants were minimized because the cooled material needed during the operation was repositioned. Also, the access of the oven, stove or grill was simplified, since just a movement of rotating the body on its axis is required. This directly contributed to the increase in staff productivity, besides better production area utilization.

It is worthy to note that there were difficulties in implementing the method regarding the creation of layout alternatives. The existent practical limitations have generated an initial difficulty to expand the layout possibilities, due to dealing with huge structural changes. Moreover, the understanding of the demand variation was important to plan the production area, because the way activities were distributed over the six workdays. The study of this variance is a key element on the restaurant's layout planning and a recommended opportunity for further research.

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