Faculty of Engineering's Canteen Layout Improvement Based on Systematic Layout Planning (SLP) and Ergonomic Approach

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Abstract

The canteen room is a public facility used by visitors to eat, where the scope itself is a place to sell and buy food. Sometimes the canteen is used as a communal space, namely a space for conversations between individuals or groups. By utilizing this canteen space as a communal area, there are many diverse user activities, the behavior of different individuals can be influenced by themselves and the surrounding environment. Therefore it is necessary to conduct research to determine the behavior patterns of canteen room users on the Campus of the Engineering Department, University of Indonesia. The research method used is by using the SLP method and ergonomic approach, RULA aspect analysis, also collecting data by visiting the research location directly. Then the data is analyzed and produces factors that affect the effectiveness of the room. The canteen room at the Department of Engineering, University of Indonesia still has a major problem, namely room effectiveness, the distance between furniture is too close to make space for movement and walking to be disturbed. Therefore, it is necessary to relocate the canteen space.

Keywords
Canteen, Systematic Layout Planning, Ergonomic and Effectiveness.

1. Introduction
Canteen is a commercial business place that provides food and drinks to the public at their place of business. The canteen is a form of public facility, which exists apart from being a place to sell food and drinks as well as a meeting place for all kinds of people, in this case students and employees who are in the campus environment (Depkes RI 2003). For students and lecturers as users of the canteen that is located in university, their function besides eating and drinking, is sometimes used as a communal space, a space for communication between people or groups so that the canteen is very important as a lecture facility.

On the other hand, students who use the canteen regularly, the food purchased makes a significant contribution to their total food intake and nutrition; therefore it makes sense to ensure the best food possible is available to enhance their ability to learn and take in the information presented to them in class.

However, there are several problems that are often found in canteens, such as there is a layout problem between the raw material warehouse and the production area where the positions of the two departments have an excess of more than 29 meters and require more than 10 minutes for one move (K. Bintang Bagaskara et al. 2020), there are too many products provided so that workers do not move effectively with the existing layout (J. Chen et al. 2006), problems with accessibility, the small area of the room and the distance between the furniture is too close which makes the space crunch and the road disturbed (K. Salsabila Dhia et al. 2020), also school canteens especially kitchen areas are usually limited in space and force workers to stand for long periods of time in an almost static motion, causing pain and discomfort (Gumasing et al. 2020). Broadly speaking, it can be interpreted that the main problem in the canteen lies in ergonomics and its effectiveness, such as the canteen layout and facilities are not in accordance with ergonomic standards, lack of space and poor layout design. Therefore, a re-layout of canteen

facilities and layout is needed to create an ergonomic space, good layout design, proper physical environment design and finally increase effectiveness as well as canteen's capacity.

1.1 Objectives

The objective of this research is to make a relay out of the canteen in Faculty of Engineering Universitas Indonesia also considering ergonomics approach in consumers' perspective, which is the tables and chairs for them to eat and drink, thus the area of the canteen can be more utilized and the tables and chairs need to be redesigned thus the comfort of customers in the canteen can be increased.

2. Literature Review

2.1 Facility Layout

According to Gopalakrishnan (2003), the overall effectiveness of the production system can be affected by layout significantly. Many algorithmic approaches have been developed in the layout research domain in order to incorporate the important aspects related to performance. These include the systematic layout planning procedure, steepest descent search method by pairwise exchange, graph-based construction method simulated annealing and genetic algorithms. Based on these many computer-aided layout routines have been developed such as CRAFT, MCRAFT. As to the process layout which is always regarded as comparatively more complex than other types (fixed position layout, cell layout and product layout), the design method commonly used is to find the appropriate solutions among alternatives based on relation analysis between departments (Slack 1998). However, this method could scarcely be found in solving the layout problems in mass customization operations.

Facility layout is a function that involves analysis (synthesis), planning and designing of facilities linkages between physical facility arrangements, movement of materials, activities related to personnel and the flow of information needed to achieve optimal performance in a series of related activities. Where facility design has objectives, among others, achieving organizational/enterprise vision through improvement of material handling, controlling material flow and achieving 'good housekeeping', increasing the effectiveness of personnel, equipment, space, and energy, minimizing investment costs, supporting regular and adaptable maintenance processes, and support worker safety and satisfaction. Facility design has principles, namely total integration, minimal material transfer distance, work process flow, space utilization, job satisfaction and safety, and flexibility, where several problems are often encountered, including space availability (placement of complete facilities in a separate room). available), material flow process (settings for smooth flow of movement), material handling (unavoidable material movement), and flexibility (adjustments in case of further investment).

2.2 Systematic Layout Planning (SLP)

The systematic layout planning (SLP) is a tool used to arrange a workplace in a plant by locating two areas with high frequency and logical relationships close to each other. The process permits the quickest material flow in processing the product at the lowest cost and least amount of handling. The following are the steps for the preparation and research by the SLP method: First, Preliminary Data Collection and Activity. Second, Operation Process Chart to break down the whole process of the consumer while buying the food and beverage in the canteen. Fourth, Production Order (routing sheet), the part is routed from the first machine to the second machine and so on until you have a finished part that will be united with other parts. The form used to describe this routing is called the route sheet (Matthew 2013). Last, Activity Relationship Chart (ARC) and Activity Relationship Diagrams (ARD).

2.3 Ergonomic Approach on Facilities and Workstation Design

Previous studies and researchers have revealed that workers in school canteens are exposed to the risk of occupational injuries and musculoskeletal disorders. The study of Niu et al. (2011) shows that staff in school canteens suffer from long working hours and are overloaded on hands. They are exposed to improper posture such as bending and awkward manual lifting. Canteen workers are also exposed to work injuries due to working on high surfaces and poorly designed workplaces. Workers experience pain and discomfort in the shoulders and upper limbs due to lifting the arm position during work postures (Pekkarinen et al.2015). Repetitive work activities such as cutting, grinding, and washing can also cause muscle fatigue and stress. Because of this, workers experience pain and discomfort in their wrists, hands and shoulders (Sri Paiboon Ji and Taptakarnporn 2014). In all types of work, workload and improper posture can cause employees to experience injuries and musculoskeletal disorders (Szabo, 2004). Risk factors that can lead to occupational musculoskeletal disorders and discomfort can occur including

awkward postures, material handling, repetition, force, mechanical compression, vibration, temperature extremes, glare, inadequate lighting, and duration of exposure (Gumasing and Pacheco 2018; Gumasing and Sasot 2019).

Therefore, employees who spend a lot of time at work may develop problems related to the ergonomics of musculoskeletal disorders. For this reason, it is important to consider ergonomics. Ergonomics is the study of people working effectively in a workspace. For a canteen kitchen, that means having an ergonomic space, good layout design, and proper design of the physical environment. Ergonomics is the science of adjusting workplace conditions and job demands to the abilities of the working population. The goal of ergonomics is to reduce stress and eliminate injuries and distractions associated with muscle overuse, poor posture, and repetitive tasks.

3. Methods

This research method uses the Systematic Layout Planning (SLP) method. In using the SLP method, researchers used to design the relationship between canteen visitors and canteens. In conducting the SLP method, researchers get alternatives that go through several stages (K. Salsabila Dhia et al. 2020):

1. Operation Product Chart (OPC)
   OPC is used to map or describe the operation and inspection processes that occur in a production process, the flow of a product from start to finish, and semi-finished products.
2. Routing Sheet
   Routing sheet is used to determine the quality of the product to be made and how long it will take to work on each of these product activities.
3. Activity Relationship Chart (ARC)
   This method connects activities in pairs so that all activities know the level of the relationship. Activity relationships within an organization or company can be viewed in terms of organizational linkages, flow linkages (equipment flow, material flow, people flow, information flow, and financial flows), environmental linkages (security, safety, temperature, noise, lighting, and so on), and also process linkages.
4. Activity Relationship Diagram (ARD)
   ARD is useful for planning and analysis of activity relationships between each department. As a result, the data obtained will then be used to determine each department's location through an Activity Relationship Diagram.
5. Rapid Upper Limb (RULA) Assessment
   Rapid Upper Limb Assessment (RULA) is a method for assessing the posture, style and movement of a work activity related to the use of the upper limb.

4. Data Collection

The actors of the canteen in the Faculty of Engineering Universitas Indonesia include sellers and consumers, where the material handling flow of the sellers start from the entrance gate of Faculty of Engineering to the canteen that is located at the back of the faculty (see Figure 1.) The canteen consists of the first (see Figure 2.) and second floor (see Figure 3.), where the first floor consists of eating areas in inner canteen (see Figure 4.), canteen TI (see Figure 5.), canteen metallurgy (see Figure 6.), and sellers' stand (see Figure 7.), also the second floor consists of eating area as well.

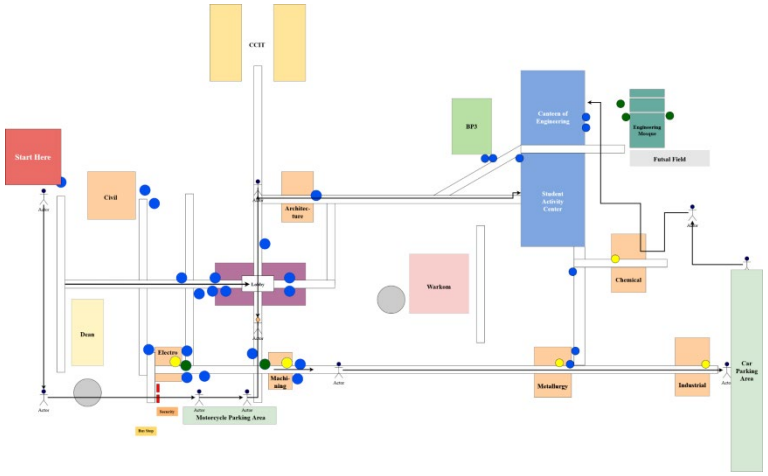

Figure 1. Canteen's material handling flow

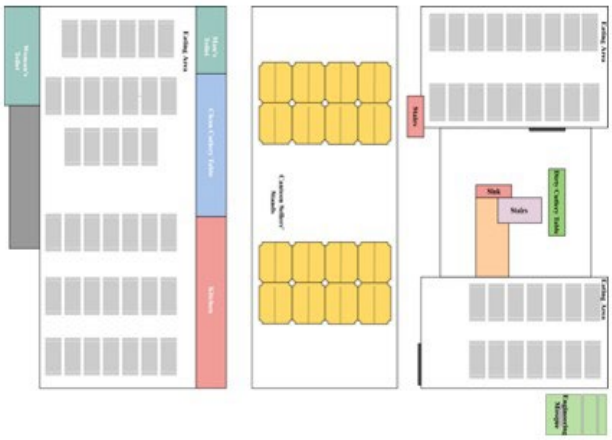

Figure 2. Layout canteen first floor

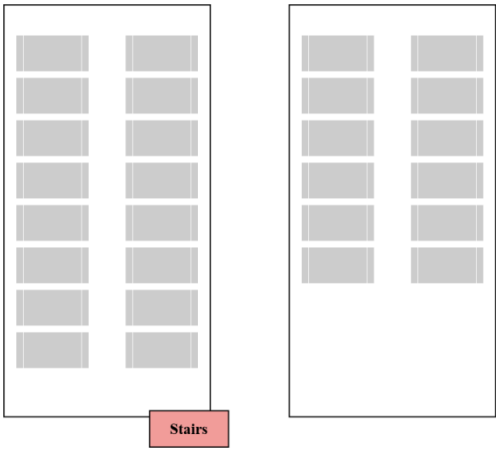

Figure 3. Layout canteen second floor

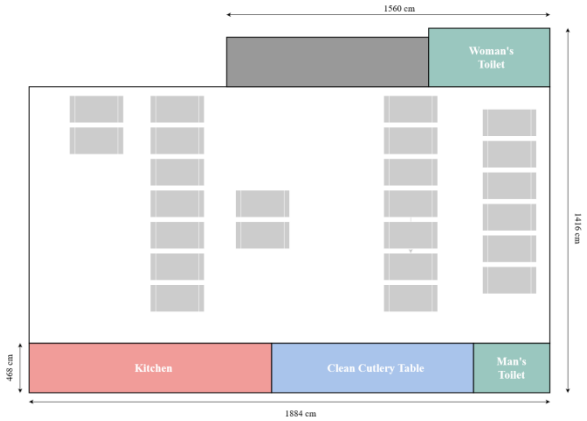

Figure 4. Layout inner canteen

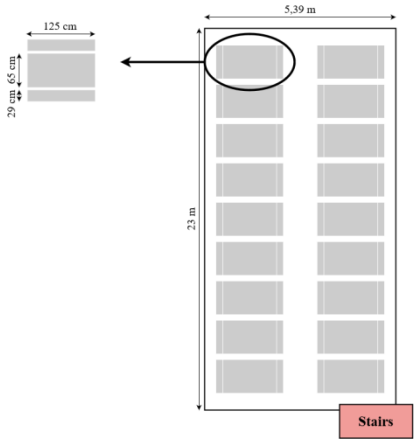

Figure 5. Layout canteen TI

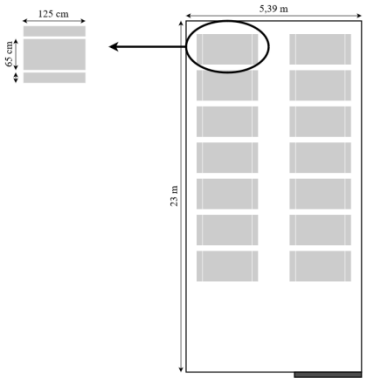

Figure 6. Layout canteen metallurgy

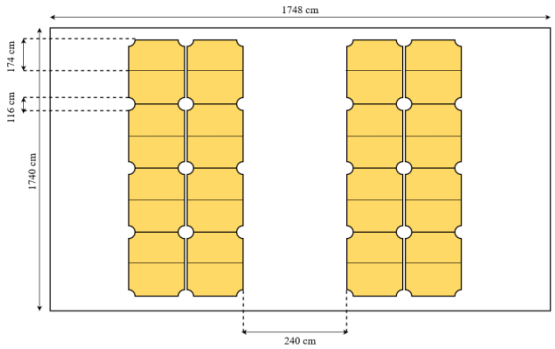

Figure 7. Layout canteen sellers' stands

6. Results and Discussion

5.1 Numerical Results

In order to get the improved layout also ergonomics tables and chairs of the canteen, there are five methods that are used, such as Operation Process Chart (OPC), Route Sheets, ARC (Activity Relationship Chart), ARD (Activity Relationship Diagram), and RULA (Rapid Upper Limb Assessment).

5.1.1 OPC (Operation Process Chart)

Operation process chart (OPC) represents the sequence of operations to be performed on a component. It gives a bird's-eye view of the various operations, inspections, and storage done in sequence for all the components that go into a particular product or assembly (Kiran and D. R. 2019). The operation process chart is classified into two categories based on the products that are sold in the canteen, such as OPC for finished food or drink and OPC for processed food or drink. OPC for finished food or drink refers to the process of consumers who buy the instant food or drink whereas OPC for processed food or drink refers to the process of consumers who buy the products that need to be processed or products that are not instant (Figures 8 and 9).

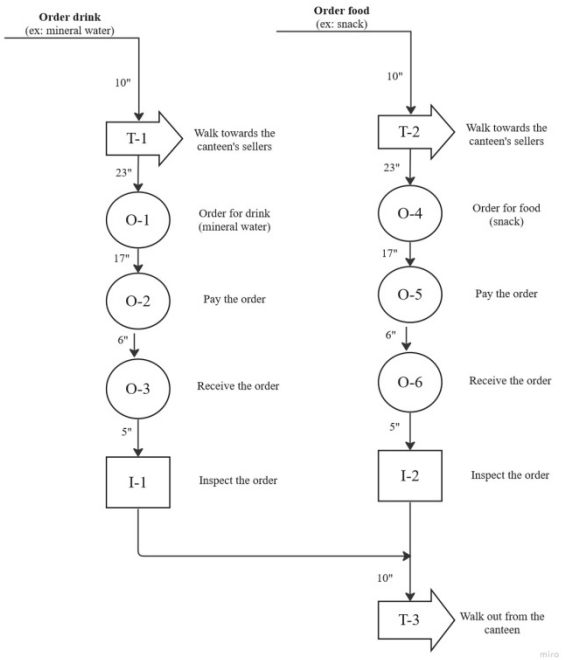

Figure 8. OPC for finished food or drink

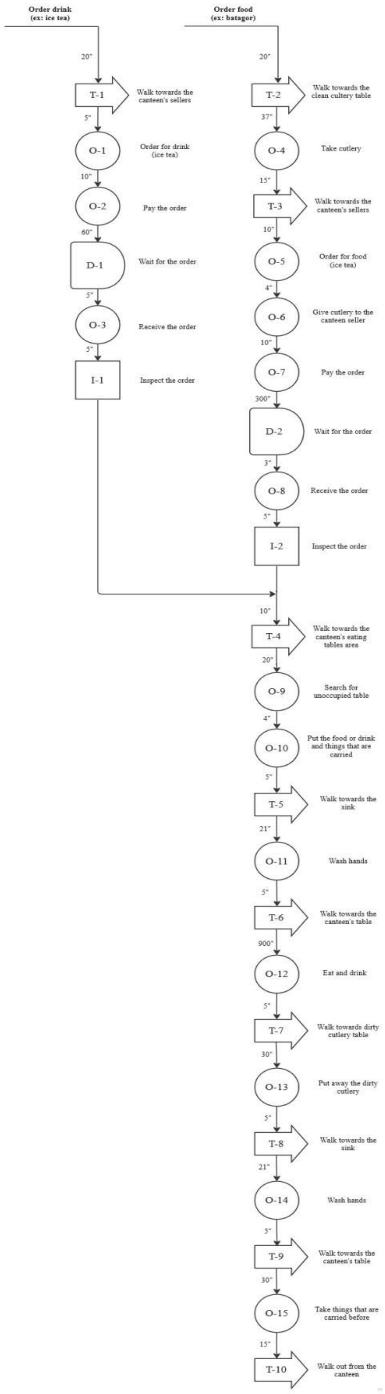

Figure 9. OPC for processed food or drink

5.1.2 Route Sheets

Route Sheets for finished and processed food are being made (Table 1). The sequence of steps required for consumers to acquire a single product, finished or processed product, is referred to as the routing (Stephens and Meyer 2013). The part is routed from the first step to the second step and so on until the consumers have a finished

product. The form used to describe this routing is called Route Sheets. The Route Sheets include operation description, equipment type, take time, and cycle time of the buying process for consumers' product of the preference in the canteen (Table 2).

Table 1. Route sheet for finished food

Operation	Operation Description	Equipment Type	Takt Time (min/ pc.)	Avg. Cycle Time (sec)	Avg. Cycle Time (min)	Pc./ Hr	Hr/ 1000 Pc.
O - 4	Order for food or drink		0,482	23	0,383	156,522	6,389
O - 5	Pay the order	Smartphone or wallet		17	0,283	211,765	4,722
O - 6	Receive the order			6	0,100	600	1,667

Table 2. Route sheet for processed food

Operation	Operation Description	Equipment Type	Takt Time (min/ pc.)	Avg. Cycle Time (sec)	Avg. Cycle Time (min)	Pc./ Hr	Hr/ 1000 Pc.
O - 4	Take cutlery	Clean cutlery table	0,482	50	0,617	97,297	10,278
O - 5	Order for food or drink			10	0,167	360	2,778
O - 6	Give cutlery to the canteen seller	Cutlery		4	0,067	900	1,111
O - 7	Pay the order			10	0,167	360	2,778
O - 8	Receive the order			3	0,050	1200	0,833
O - 9	Search for unoccupied table			20	0,333	180	5,556
O - 10	Put the food or drink and things that are carried	Table and chair		4	0,067	900	1,111
O - 11	Wash hands	Sink		21	0,350	171,429	5,833
O - 12	Put away the dirty cutlery	Dirty cutlery table		30	0,500	120	8,333
O - 13	Wash hands	Sink		21	0,350	171,429	5,833
O - 14	Take things that are carried before	Table and chair		30	0,500	120	8,333

5.1.3 ARC (Activity Relationship Chart)

Activity Relationship Chart (ARC) or Relationship Map Work is an activity or activities between each part that describes an important lack of proximity between rooms or workstations. In other words, ARC is a map that is arranged to determine the level of relationship between activity that occurs in each area one with other areas in pairs.

ARC is used to analyze the degree of relationship or the relationship between the activities of a station and another station (Muther 1955) (Figure 10).

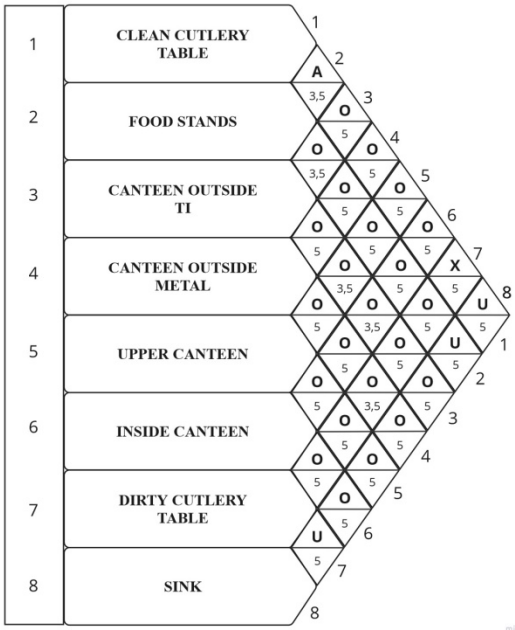

Figure 10. Activity Relationship Chart (ARC)

5.1.4 ARD (Activity Relationship Diagram)

Activity Relationship Diagram (ARD) is a relationship diagram between activities (department or workstation) by level priority of its proximity, so it is the expected minimum handling fee. At the time of compiling, ARD is very likely to cause errors because we depart from the assumption that all departments are adjacent to each other. As for what is meant by error here is a circumstance in which the workstation gets priority one cannot occupy its position to be near each other without being there barrier from other workstations (Rozak et al. 2021) (Figure 11).

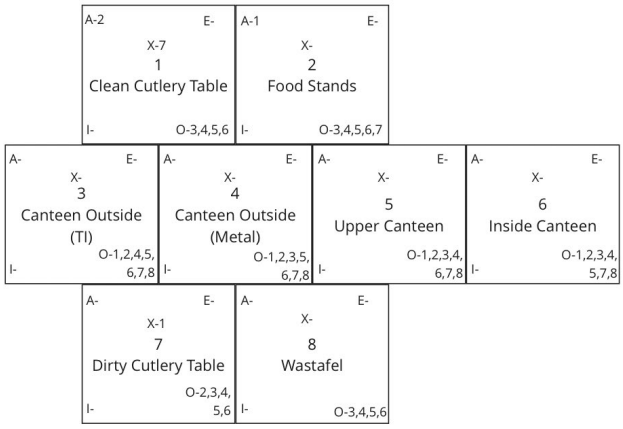

Figure 11. Activity Relationship Diagram (ARD)

5.1.5 RULA Assessment

RULA Assessment of consumers that are eating in the table and chair which are provided in the canteen is being made. The Rapid Upper Limb Assessment (RULA) was developed to “rapidly” evaluate the exposure of individual

workers to ergonomic risk factors associated with upper extremity MSD. The RULA ergonomic assessment tool considers biomechanical and postural load requirements of job tasks or demands on the neck, trunk and upper extremities (Ergoplus 2022). It is obtained that the RULA score is 4, which means that the canteen's table and chair need to be investigated even further and changed (Figure 12).

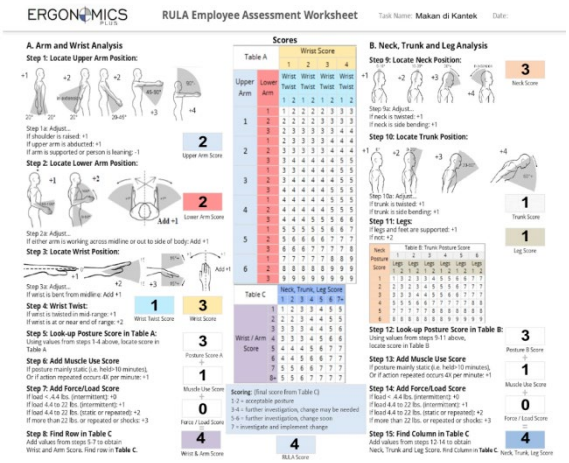

Figure 12. RULA assessment for eating activity in the canteen

5.2 Graphical Result

The Figure 13 is a graph of the comparison of cycle time per operation in the process of purchasing finished food. There are three operations in this process. The graph shows that the longest cycle time is in operation 4 (O-4), namely when ordering food or drinks.

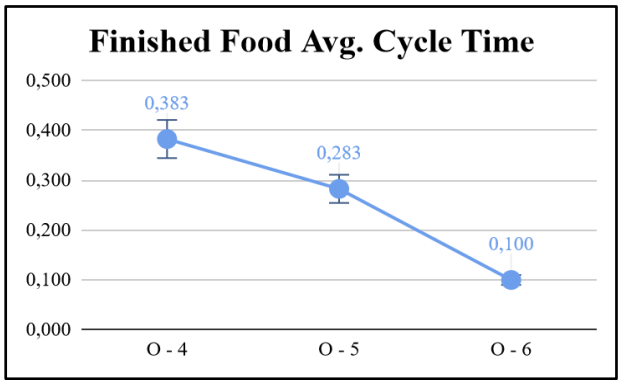

Figure 13. Finished food operation's average cycle time

The Figure 14 is a graph of the comparison of cycle time per operation in the process of buying processed food. There are 14 operations in this process. The graph shows that the longest cycle time is in operation 4 (O-4), namely when taking clean cutlery.

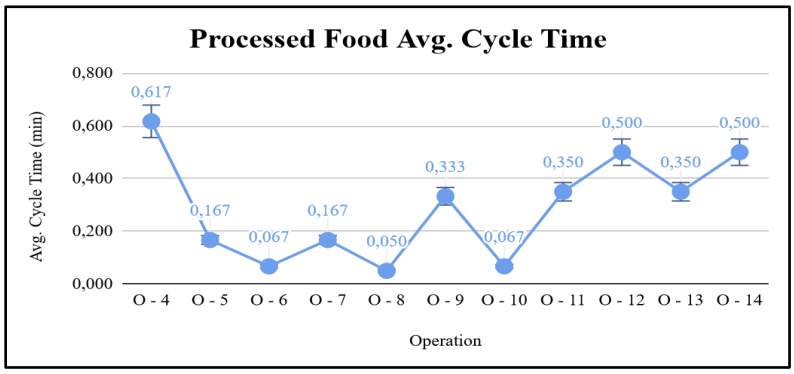

Figure 14. Processed food operation's average cycle time

5.3 Proposed Improvements

Based on the problem statement, the proposed solution is to focus on increasing the canteen productivity by redesigning the canteen layout and improving the comfortable place to eat according to the ergonomic approach. Figure 15 shows the redesign of the Faculty of Engineering's canteen layout. The proposed design of the canteen includes the following list:

1. Put additional tables and chairs in vacant space at the eating area to accommodate more consumers to eat and drink.
2. Maximize the stand seller space in order to give the buyer a place to queue.
3. Adding clean cutlery to the north of the canteen.
4. Redesign sellers stand by adding more space in the kitchen to optimize the productivity and reduce operation time.
5. Redesign the chairs of the canteen align with ergonomics standards.

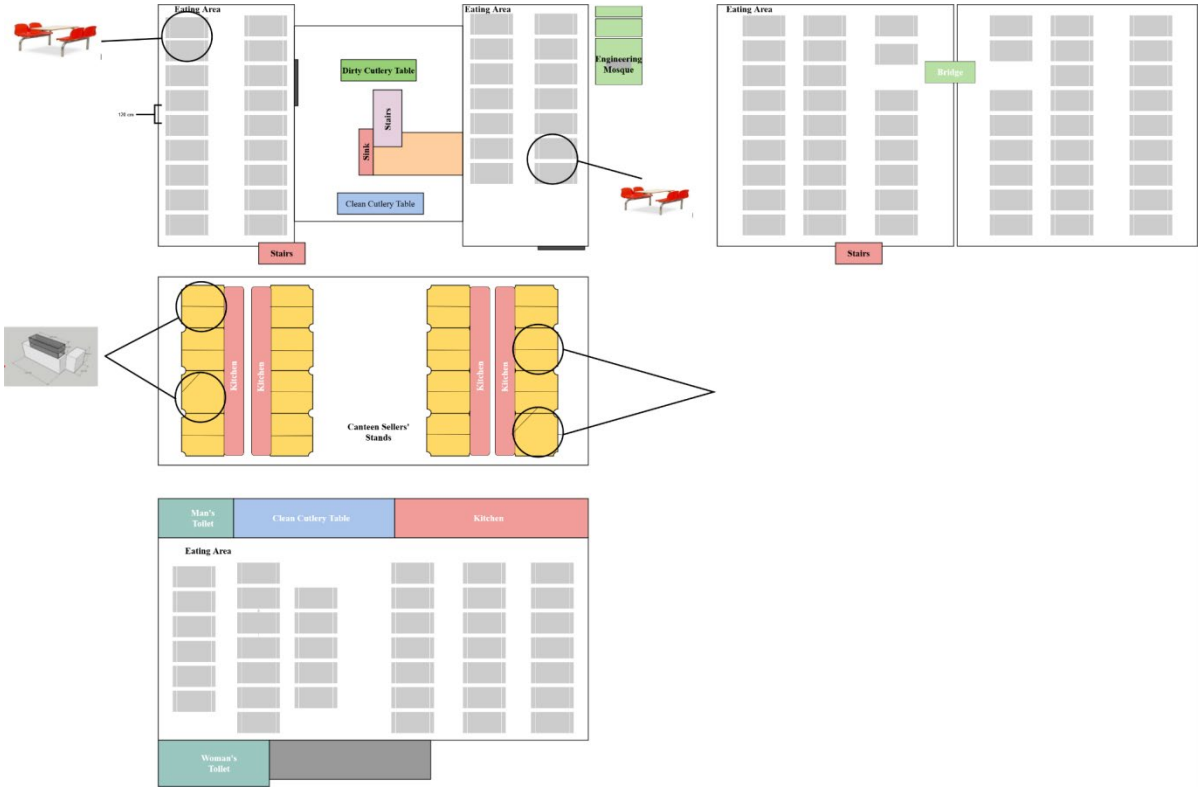

Figure 15. Proposed redesign canteen layout

The results of the RULA assessment have proven the condition is at level dangerous for the student's body proportion. As a result of the need for the redesign of tables and chairs for the Faculty of Engineering Universitas Indonesia's canteen. In aim to improve their comfort, health, safety and productivity, the researchers used the principles of anthropometry to ensure that the design will match the body dimensions of users. Below are the anthropometric dimensions for the proposed tables and chairs design (Table 3 and Figure 16).

Table 3. Anthropometric measurements of chairs

Back Rest Chair			
Category	**Actual**	**Body Reference**	**Recommended**
Seat length	1,24 cm	Popliteal height (5th %F)	41 cm each chair
Seat dept	51 cm	Buttock popliteal (5th %F)	43 cm each chair
Seat Width	29 cm	Hip breadth (95th %F) Shoulder height (5th %F) - popliteal	40 cm each chair
Back rest	-	height (5th %F) - buttock popliteal depth (5th %F)	42 cm each chair

Figure 16. Redesign tables and chairs

5.4 Validation

The proposed layout improvement is in accordance with the Activity Relationship Chart (ARC) and Activity Relationship Diagram (ARD) to increase effectiveness and facilitate the movement of canteen visitors. It can be seen that in the proposed layout improvement the table for clean cutlery is close to the food stands and there is an additional table for clean cutlery so that it is on two sides of the food stands to increase effectiveness when taking cutlery, especially for visitors in the outer canteen and the upper canteen. Besides that, the clean cutlery table is also not close to the dirty cutlery table.

6. Conclusion

There are several problems that are often found in canteens, such as ineffective service time in the canteen, lack of accessibility in the canteen, small room capacity and the distance between furniture that is too close so that it interferes with movement and walking. The facilities in the canteen are not ergonomic so that it can harm the user's posture. Therefore, the researchers redesigned the canteen layout at the Faculty of Engineering, University of Indonesia considered an ergonomic approach from the consumer's point of view through redesigning the tables and chairs. Layout improvements itself are adjusted to the Activity Relationship Chart (ARC) and Activity Relationship Diagram (ARD) thus making several recommendations to increase the effectiveness of this canteen room, such as adding a few seats in the dining room, changing the layout of the food sales stands by combining kitchens in each stand to increase the convenience of the sellers. Moreover, the redesign canteen layout provides a distance of between one furniture and another in order to provide physical comfort for visitors.

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