Improvement and Design of a Kitchen Using DMADV Methodology

Néstor Carradero Torres
Master of Engineering in Manufacturing Engineering
Advisor: Carlos González, Ph.D.
Industrial Engineering and Systems Department
Polytechnic University of Puerto Rico

***Abstract* —** *This design project will focus on remodeling a kitchen for an elderly person. The kitchen that is going to be remodeled has a peninsula or G-shaped layout design. The new design that will be introduced aims to save time in the food preparation process with minimal effort. It also seeks to correct the areas that cause discomfort and further expand the spaces, discarding the areas saturated with unused cabinets to get a more comfortable workflow. To obtain the expected results, the preparation of a dish will be analyzed to study the movements and the execution time of each process by applying measurement methods to find waste. In addition, ergonomic evaluations will be carried out in the sink area due to discomfort during cleaning tasks. The DMADV (Define, Measure, Analyze, Design, Verify) methodology will be used as a tool to mitigate the problems encountered and implement the ideal kitchen design in order to save time, and energy and obtain the necessary comfort when performing tasks.*

Key Terms *— DMADV, Ergonomics, Kitchen Layout, Lean.*

INTRODUCTION

The evolution of the kitchen starts from the discovery of fire in the Stone Age up to today's kitchens. The functionalities of the kitchen at present have made the furniture a significant change compared to previous years. This leads to great innovation since art can be expressed in materials, textures, and colors. The correct design of a kitchen, in addition to complying with accessibility and comfort, involves satisfying the needs of the client. As a result, the kitchen has become an ideal place to work comfortably, increasing the functionality. Formulating ideas for practical and successful design makes the kitchen a pleasant workspace.

PROBLEM STATEMENT

A complete remodel will be carried out in the kitchen area of a house. The project will be running because the kitchen area has deteriorated with the passing of time. The house is in a flood zone and has suffered several floods affecting the bottom cabinets. Because the base of the cabinets is in bad condition, they are not used, contributing to the saturation of the spaces. In the areas of greatest use like the sink, the client suffers lower back discomfort due to the location and lack of movement. There is no linear path in the food preparation processes, forcing the client to make more movements than normal.

RESEARCH DESCRIPTION

This research has the goal to evaluate the inefficiencies of the kitchen area in terms of time, movement, and ergonomics. In addition, waterproof resistant materials for furniture will be taken into consideration in case of a flood. DMADV and Lean will be implemented to develop solutions and significantly improve results.

RESEARCH OBJECTIVE

This research has the objective to improve the process of food preparation, by measuring the current task to identify waste, improve the areas of discomfort by performing ergonomic evaluations, and analyze the design alternatives to choose the ideal. As a result, the mission is to have a more linear approach when performing tasks, saving time and energy.

RESEARCH CONTRIBUTIONS

The contribution of the project design is to improve the quality of life through the establishment

of a comfortable and accessible design for food preparation. The project will be carried out with an achievable budget cost.

LITERATURE REVIEW

The design allows to elaborate on different alternatives to improve a product, facilities, and business ideas among other applications. The goal is to make a product stand out with creativity. This is usually applied in engineering, architecture, marketing, and communication. These are some of the disciplines that need creativity, which must be complemented with good planning. To achieve the ideal design of a kitchen, it must be considered how to maximize it to meet the needs. This includes analyzing the different types of layouts and choosing the ideal one for the available space for remodeling. It is essential to implement the kitchen work triangle that is based on the distances between the stove, sink, and refrigerator. This method tells us how far the kitchen equipment is from each other, joining the distances and obtaining a triangle as a result. The method helps us minimize the back and forth, saving energy and time (See Figure 1).

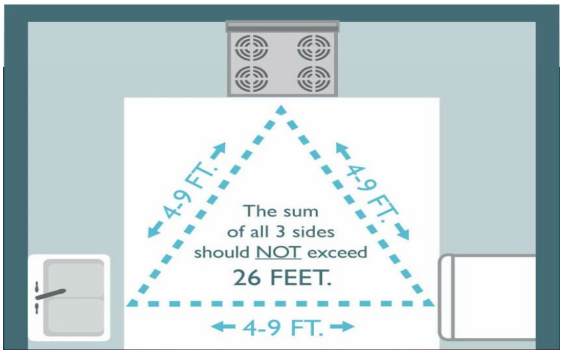

Figure 1
Kitchen Work Triangle [1]

The rule states that each side of the triangle must be no less than 4 feet and no more than 9 feet and the circumference of the triangle must be no less than 13 feet and no more than 26 feet. For optimal efficiency, distances from the kitchen work triangle should be kept to a minimum.

There are several types of kitchen design. These are designs that will be taken as a reference for the process of developing the ideal kitchen. The dimensions and open spaces of the place will be considered. The list of kitchen designs serves as a guide and starting point to choose what would be the best design for the project. Once the design is chosen, it will be modified and adjusted according to the characteristics of the place.

The Single Wall Layout is the most basic kitchen plan available. In the design, the kitchen appliances and cabinets are anchored against a wall. Generally, this alternative is used in small spaces [2].

- **Pros:** Save space efficiently, cost-effective design.
- **Cons:** Tend to have limited storage space.

Galley Kitchen Layout is common in old houses. This kitchen design features two parallel rows of cabinets and counters with a walkway running down the middle.

- **Pros:** Practical, efficient, and cost-effective kitchen design. Easy access to storage and countertops**.**
- **Cons:** Galley kitchens are associated with older home designs and typically don't offer views into living areas or space for a kitchen island.

U-Shaped Kitchen Design usually offers the most space. This includes three walls of cabinets and appliances joined by two corners obtaining a U-shaped form.

- **Pros:** Maximizes space with plenty of storage and food preparation areas.
- **Cons:** Not suitable for small houses due to the space they can occupy. It can be expensive due to the large number of materials for the type of design.

The L-Shaped Kitchen Layout features two perpendicular rows of cabinets and counters that meet at one corner. They offer extended spaces, lots of storage space, and an open feel making it one of the most used designs. L-shaped kitchens provide great traffic flow and workspace.

- **Pros:** Storage options, offer more counter space and open feel.

- **Cons:** Expensive to design and build. Require more finishing materials and custom cabinets for corner storage.

Island Kitchen Layout Design is one of the most popular and requested designs by homeowners. An island is a section of cabinets and counters that are not connected to a wall. The design can house additional appliances to serve as a food preparation area or provide a space to sit and eat. It can be easily incorporated in most L-shaped or U-shaped kitchen floor plans and requires a lot of floor space.

- **Pros:** Its design appearance is beautiful and offers additional storage.
- **Cons:** Island design can impede the flow of traffic and is not suitable for all kitchen designs.

Kitchen Ergonomics

Before the preparation of the design, materials, and appliances, there is the ergonomics of a kitchen. It is the key to having the results of a kitchen in which you can move comfortably, saving time and energy. Its purpose is to provide quality of life, allowing accessibility and organization to make the minimum possible effort and simultaneously fulfilling the tasks carried out in a kitchen. As a result, it protects health without the need to perform uncomfortable postures that can harm the human body.

There are several points to consider for good ergonomics in the kitchen, these are [3]:

- **Countertop Height:** The most common countertop height is 36 inches. If the person is shorter or taller than average, the height of the countertop must be adjusted. To calculate the proper working height, the height of the elbow must be measured. For this, the arm must be bent at the elbow at 90 degrees parallel to the ground and then the distance between the ground and the elbow is measured. The optimum working height should be the distance taken minus 4 to 6 inches.
- **Reaching Height:** The standard height between the countertop and upper cabinets is 18 inches. This is considered an ideal workspace. The minimum is 15 inches. The height can vary depending on the height of the user. An alternative to finding what would be the ideal level of the upper cabinets is to calculate when the level of the elbow reaches above the head. For this, it is important to consider workflow and minimize overhead reach for anything heavier than a cereal box. Upper cabinets should not be hung too high on the wall. It is important to have all utensils at the proper reaching height.
- **Kitchen Storage:** Frequently used kitchen items should be within easy reach. Stocking items at different levels in cabinets prevents unnecessary kneeling, bending, and stretching. This practice provides comfort when doing a task in the kitchen. The best way to distribute the items in the cabinets is as shown in Figure 2:

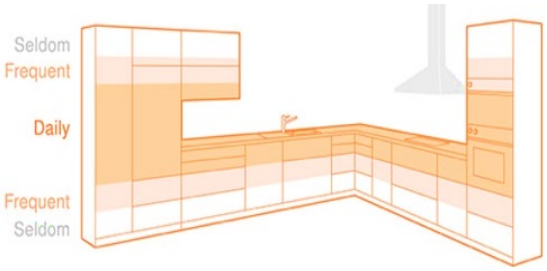

Figure 2
Distribution of the Items on the Cabinets [4]

Items of daily use should be placed near the countertop. Seldom-used items are placed in the top or bottom row. Frequently used items should be placed in between.

METHODOLOGY

The methodology that will be applied to the kitchen design project is DMADV. Its purpose is to build or completely redesign a process, service, or product instead of improving an existing one.

The steps of the DMADV methodology are as follows:

- **Define:** Identifies the purpose of the project, process, or service, and then establishes achievable and measurable goals to create a clear definition of the project. In this phase a Project Charter was used to define the problem.

- **Measure:** Customer needs are translated into measurable metrics. It is important to determine which metrics are critical and translate the client's requirements into clear statements of the project.

  The tools that were used to measure the problem are Value Stream Map (VSM) to determine waste and values in the process of preparing food on the current and new designs. This will help save time and energy by eliminating inefficiencies in each food preparation process.

  Another tool is the Spaghetti Diagram which is a visual representation that uses a continuous flow line that traces the path of an activity through a process. This will help determine the ideal configuration for kitchen equipment and preparation areas. The spaghetti diagram will be applied to the current kitchen and the new design.

  Finally, the ergonomic evaluations of the Moore Garg Strain Index to assess work-related musculoskeletal disorders of the distal upper extremities (hand, wrist, elbow) and Rapid Entire Body Assessment (REBA) to evaluate the risk of musculoskeletal disorders on the lower and upper parts of the body.
- **Analyze:** In this phase, the data collected from the previous phase is going to be analyzed to look for better ways to organize the project and discover the trouble points. Through this analysis, better design alternatives can be chosen.
- **Design:** In this stage, the best design alternative is selected, prioritizing the requirements established by the client. From the chosen alternative, a more detailed model will be created, and errors will be identified to make the necessary modifications.
- **Verify:** This last step verifies the design and compares it with the established criteria. Once the design has been compared with the specifications, it will be concluded whether it meets the client's expectations. Old vs new kitchen design will be compared to validate that there is a significant improvement.

RESULTS AND DISCUSSION

In this phase of the project, the DMADV methodology will be applied to develop the new design.

Define

A project charter is shown with information on the kitchen design which includes the project statement, project scope, and goal (See table 1).

Table 1
Project Charter

Project Charter: Improvement and Design of a Kitchen Using DMADV Methodology			
Project Lead: Nestor Carradero Torres		**Project Mentor**: Carlos Gonzalez, Ph.D.	
Project Statement	The project is focused on remodeling a kitchen. This remodeling seeks to solve disadvantages such as saturation in the spaces, inconveniences in the sink area in terms of ergonomics, and improve the kitchen configuration making the food preparation process more linear.		
Project Scope	Analyze waste in the food preparation process and implement a design that improves preparation time, accessibility, and ergonomics.		
Project Goal	Develop an accessible minimalist kitchen design that saves time and energy in food preparation, is ergonomically favorable, and is spacious for the customer.		
Safety	Safety gear like abrasion-resistant gloves, foot protection, and safety glasses will be used to perform the kitchen remodel.		
Time	**14 Nov 22 - 12 Feb 23**	**Cost**	Adjusted Cost.

Measure

In this phase, different measurements will be made in the kitchen. The measurements to be applied are Value Stream Map to identify waste in during phases of the process, Spaghetti Diagram to measure the motion in the workflow, and Moore Garg Strain Index to evaluate work-related musculoskeletal disorders on the upper extremities (hand, wrist, elbow). The data obtained from the different results

of the named measurements will give a clear idea of the critical points to improve.

Current Kitchen Value Stream Map

To develop the Value Stream Map (VSM), a particular dish was taken as a reference. The dish consists of stewed chicken with rice and beans. Specific measures were taken for the food so that four people can eat. These consist of three chicken breasts, a can of beans, and one and a half cup of rice. This task was conducted by a single person and the time was taken before and during each process (See Figure 3).

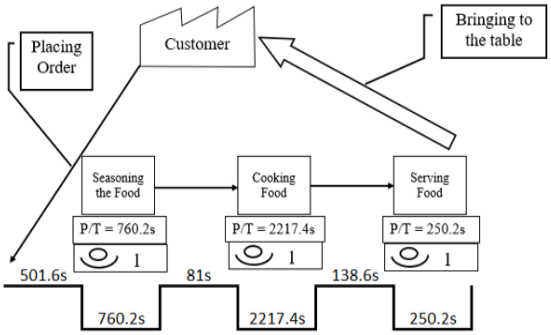

Figure 3
Current Kitchen Value Stream Map

The VSM shows the time it takes to have all the kitchen tools and condiments before seasoning the food, the time it takes to prepare the stove and put the pots with the seasoned food to cook, and the time it takes to collect the plates and cutlery before serving the food. The idea is to reduce waste before each process.

Current Kitchen Spaghetti Diagram

A Spaghetti diagram was made to detect unnecessary movement (See Figure 4). The diagram was created specifically for the dish that was prepared. This study gives us a clear idea of the movements that are conducted when preparing and cooking food in general. The steps and distance were measured using a pedometer [5].

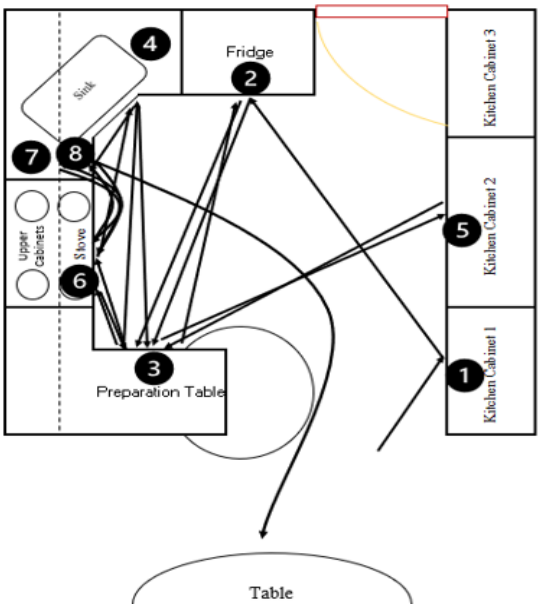

Figure 4
Current Kitchen Spaghetti Diagram

The measurements indicate 65.8 minutes of total time, 236 steps were performed with 528 feet of total distance. With the data obtained, it can be determined that there is room for improvement in terms of motion and kitchen configuration.

The numbers represent a component of the kitchen with its items. These are: 1 (Kitchen Cabinet 1 = Dry Food and Seasonings), 2 (Fridge = Cold Food), 3 (Preparation Table), 4 (Kitchen Utensils), 5 (Kitchen Cabinet 2 = Pots), 6 (Stove), 7 (Upper Cabinets = Dishes), 8 (Countertop for serving the food).

Moore Garg Strain Index Evaluation

The Moore-Garg Strain Index was performed to study the musculoskeletal disorders in the distal upper extremities (hand, wrist, elbow). The analysis was focused on the sink area while cleaning the dishes, utensils, and pots that were used to prepare the food. The strain index analysis uses six different criteria to evaluate risk factors which are: intensity of exertion, duration of exertion, efforts per minute, hand/ wrist posture, speed of work, and duration of task per day (hours) (See Figure 5) [6].

Moore-Garg Strain Index

Task	Analyst
	Date / /

Strain Index	Find rating for each risk factor and multiply them together.	SI < 3: Safe SI between 3 and 5: Uncertain SI between 5 and 7: Some Risk SI > 7: Hazardous			
Risk Factor	Rating Criterion	Observation	Ratings	Left	Right
Intensity of Exertion [Borg Scale values in brackets]	Light	Barely noticeable or relaxed effort [0-2]	1		
	Somewhat Hard	Noticeable or definite effort [3]	3		
	Hard	Obvious effort; Unchanged expression [4-5]	6		
	Very Hard	Substantial effort; Changed expression [6-7]	9		
	Near Maximal	Uses shoulder or trunk for force [8-10]	13		
Duration of Exertion (% of Cycle)	< 10%		0.5		
	10-29%		1.0		
	30-49%		1.5		
	50-79%		2.0		
	> 80%		3.0		
Efforts Per Minute	< 4		0.5		
	4 - 8		1.0		
	9 - 14		1.5		
	15 - 19		2.0		
	> 20		3.0		
Hand/ Wrist Posture	Very Good	Perfectly Neutral	1.0		
	Good	Near Neutral	1.0		
	Fair	Non-Neutral	1.5		
	Bad	Marked Deviation	2.0		
	Very Bad	Near Extreme	3.0		
Speed of Work	Very Slow	Extremely relaxed pace	1.0		
	Slow	Taking one's own time	1.0		
	Fair	Normal speed of motion	1.0		
	Fast	Rushed, but able to keep up	1.5		
	Very Fast	Rushed and barely/unable to keep up	2.0		
Duration of Task Per Day (hours)	<1		0.25		
	1 - 2		0.50		
	2 - 4		0.75		
	4 - 8		1.00		
	> 8		1.50		

Figure 5
Moore Garg Strain Index Evaluation Sheet [7]

Each risk factor evaluation has a rating that will be multiplied to obtain the total score and determine if the task is safe, uncertain, some risk, or hazardous.

Once the results of each risk factor have been obtained the Strain Index formula needs to apply which is SI Score = (Intensity of Exertion Multiplier) * (Duration of Exertion Multiplier) * (Exertions per Minute Multiplier) * (Posture Multiplier) * (Speed of Work Multiplier) * (Duration per Day Multiplier).

- If SI < 3.0: GREEN → No Risk
- If SI > 3.0 and < 7.0: YELLOW → It does not involve significant risk but should be analyzed in order to reduce workload.
- If SI > 7.0: RED → The task must be studied immediately since it presents a high risk of producing damage to the operator.

The point of evaluation will be focused on the left hand because it is the one that exerts the greatest effort most of the time. The evaluation of risk factors is defined as:

- **Intensity of Exertion** = An estimate of the strength required to perform the task one time.

  Since most of the items that were cleaned are lightweight, there were a few, such as pots, that were a bit heavy. The perceived effort falls in the category of "noticeable or definite effort" with a rating value of 3.

- **Duration of Exertion** = Is calculated by measuring the duration of all exertions during an observation period, then dividing the measured duration of exertion by the total observation time and multiplying by 100 (See Equation 1).

$$\%\ Duration\ of\ Exertion\ = 100\ x\ \frac{duration\ of\ all\ exertions}{total\ observation\ time} = 100\ x\ \frac{7.8min}{13.6min} = 57\% \quad (1)$$

The result falls between 50%-79% of the rating criterion with a rating value of 2.

- **Efforts per Minute** = are measured by counting the number of exertions that occur during an observation period, then dividing the number of exertions by the duration of the observation period, measured in minutes (See Equation 2).

$$Efforts\ per\ Minute\ = \frac{number\ of\ exertions}{total\ observation\ time\ (min)} = \frac{19}{13.6min} = 1.40 \quad (2)$$

The result is less than 4 (1.40 < 4). Therefore, the rating value is 0.5.

- **Hand/Wrist Posture** = is an estimate of the position of the hand or wrist relative to neutral position.

The hand/wrist posture during the process was good. There was no noticeable extension, flexion, or deviation. A slight wrist flexion was seen when cleaning the pots. Therefore, the perceived effort falls in the category of "near neutral" with a rating value of 1.

- **Speed of Work** = is an estimate of how fast the worker is working.

The perceived speed falls in "taking one's own time" with a "slow" rating criterion. Therefore, the rating value is 1.

- **Duration of Task per Day** = is the time measured for the task performed.

  The task duration is less than 1 hour (13.6min < 1). The rating value is 0.25.

The results are resumed in Table 2 to calculate the Strain Index.

Table 2
Strain Index Evaluation

Risk Factor	Rating Criterion	Observation	Left Hand Rating
Intensity of Exertion	Somewhat Hard	Noticeable or Definite Effort	3
Duration of Exertion (% of cycle)	50-79%	57% Duration of Exertion	2
Efforts per Minutes	<4	1.4 Efforts per Minute	0.5
Hand/Wrist Posture	Good	Near Neutral	1
Speed of Work	Slow	Taking one's own time	1
Duration of Task per Day	<1	Less than 1 hour	0.25

The Strain Index score formula is applied (See Equation 3).

$$SI\ Score = 3 \times 2 \times 0.5 \times 1 \times 1 \times 0.25 = 0.75 \quad (3)$$

0.75 < 3: Green = There is no risk in the task.

Although there is no risk in the task that was performed, there was discomfort in the lower back due to the lack of freedom in the lateral movements forcing to twist the torso. Therefore, the Rapid Entire Body Assessment (REBA) was applied to evaluate the risk of musculoskeletal disorders on the lower and upper parts of the body (See Figure 6).

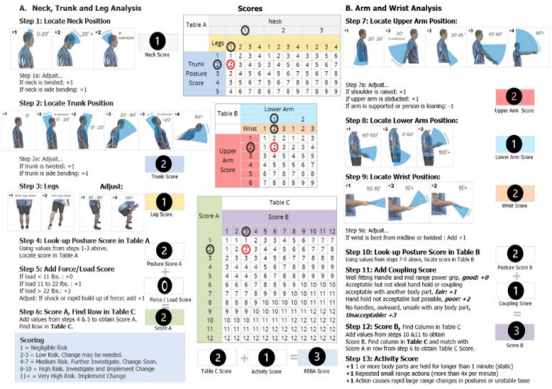

Figure 6
REBA Worksheet Assessment [8]

The result of the REBA score is based on 13 steps with their own score for the lower and upper body parts. The evaluation is divided into two categories: A. Neck, Trunk, and Leg Analysis, and B. Arm and wrist Analysis. Each category is linked to a table. See Table A and Table B to find the scores of each category respectively. Table C score depends on Score A and Score B, plus Activity score to obtain the result.

The scores for each step are based on the task performed and the executed position at that moment. The analysis of each step is:

A. Neck, Trunk, and Leg Analysis (Step 1-Step 6):

- **Step 1:** The Neck Position is from 0º-20º. Neck Score is 1.
- **Step 2:** The Trunk Position is 0º and twisted. Trunk Score is 2.
- **Step 3:** The Legs are down. Score is 1.
- **Step 4**: Posture Score in Table A using Step 1,2 and 3.
- **Step 5:** Force/Load Score is 0 since load < 11 lbs.
- **Step 6:** Score A = Posture Score A + Force/Load Score

B. Arms and Wrist Analysis (Step 7-Step 12):

- **Step 7:** The Upper Arm Position is from 20º-45º. Upper Arm Score is 2.
- **Step 8:** Lower Arm Position is from 60º-100º. Lower Arm Score is 1.
- **Step 9:** Wrist Position is from 15º-15º with twisted wrist in some moments. Wrist Score is 2.
- Step 10: Posture Score in Table B using Step 7,8 and 8.
- Step 11: Coupling Score is 1(fair).
- Step 12: Score B = Posture Score B + Coupling Score

The Table C Score is 2 and the Activity Score (Step 13) is 1 due to the twisted torso being held for more than 1 minute. The REBA Score is 3 (Low Risk. Change may be needed).

Analyze

Analyzing the Value Stream Map and the Spaghetti diagram it can be stated that there is waste,

specifically in motion. The seasoning and kitchen tools are distant from the area of preparation which is the most visited with the stove area. Each phase of the process lacks the tools needed in that specific area, making the client move from the process wasting time and energy. Not having an efficient method for material location and organization results in previous problems. The following suggestions are presented:

- Perform a 5s method to organize the kitchen tools, seasonings, and dry food in a way so that in each process the client has those items needed as close as possible, improving the walking time.
- Changing the kitchen layout to have a lineal approach in food preparation.

As for the ergonomics focused on the sink area, the client does not have the ability to make lateral movements, forcing the client to twist their torso for extended periods of time, causing fatigue and, therefore, discomfort in the lumbar area. This problem happens due to the corner sink design. The corner sink approach creates a more congested feel and also prevents others from being able to help (See Figure 7). The following suggestion are presented:

- Changing the kitchen layout so that the sink is against the wall. This allows more freedom in lateral movements, eliminating the torso twist to perform the dishwashing task.

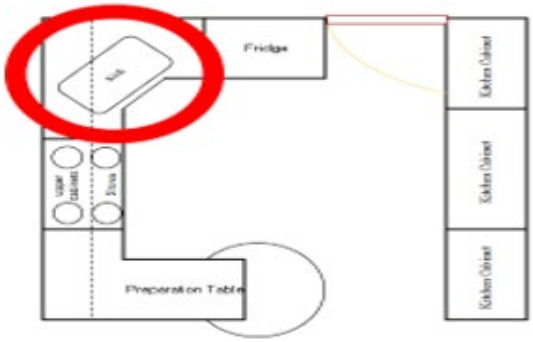

Figure 7
Corner Sink Design

Design

The size of the space where the remodeling will take place is 12'x10'. The current design of the kitchen is a G-shaped or Peninsula design which provides a lot of storage that is currently not being used. This takes up much more space and tends to inhibit traffic flow, making it a bit uncomfortable. There are many areas of improvement such as waste in terms of motion, lack of space in the sink area and not having a strategic location for seasoning and kitchen tools. The objective is to take as an alternative a minimalist design in terms of storage, freeing up space for comfort when traffic flow occurs. On the other hand, the new design must mitigate ergonomic problems and correct unnecessary movements and creating waste that, therefore, ends up spending more time and energy.

The design that fits the need is the Galley Kitchen Layout with a modification to the bottom of the wall including a preparation table closer to the stove (See Figure 8).

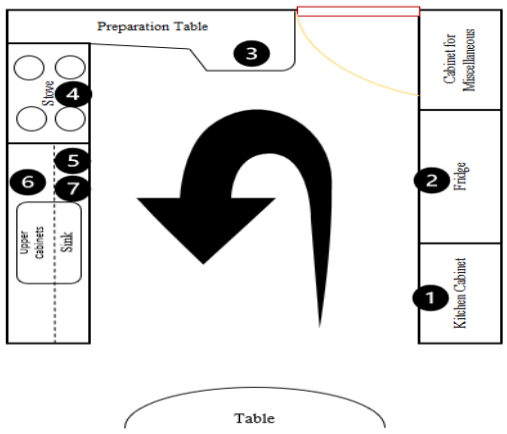

Figure 8
New Kitchen Design

The new design has new parameters in terms of motion for food preparation. There is a linear path for the processes, making it more accessible and comfortable avoiding constant back and forth. The kitchen tools and seasonings will be organized after applying the 5s method. Each number represents a component of the kitchen with its items. The expected results after applying 5s method are: 1 (Kitchen Cabinet = Dry Food), 2 (Fridge = Cold Food), 3 (Preparation Table), 4 (Stove), 5 (Bottom Cabinets = Kitchen Utensils and Pots), 6 (Upper Cabinets = Dishes and Seasonings), 7 (Countertop for serving the food).

Verify

In this phase, the measurements of the previous kitchen will be compared with the new one to validate that there is a significant improvement. The methods of VSM, Spaghetti Diagram and ergonomic evaluation will be applied again.

Value Stream Map Comparison

The Value Stream Map was performed in the new kitchen. The same menu was taken as a reference to obtain the measurements. The task was conducted also by a single person.

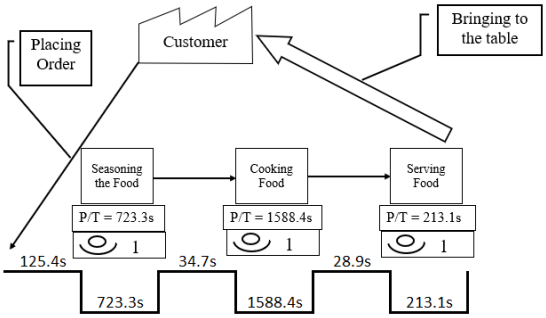

Figure 9
New Kitchen Value Stream Map

With the new kitchen, a significant improvement was found in the results compared to previous measurements. The results are resumed in Table 3.

Table 3
VSM comparison for Old Kitchen vs New Kitchen

Value Stream Map Results Comparison (Old vs New)		
	Old Kitchen	New Kitchen
Total Time	65.8 min	45.2 min
Total Value	53.8 min	42.1 min
Total Waste	12 min	3.2 min

Table 3 shows that it was possible to achieve a reduction in the total time in food preparation with a saving of 20.6 minutes. With the change of the stove and new kitchen layout, it was possible to achieve a reduction of the total value of 11.7 minutes. Finally, the total waste was reduced by 8.8 minutes.

Spaghetti Diagram Comparison

The Spaghetti Diagram was performed in the new kitchen during the dish preparation. Also, the same menu used before was taken as a reference.

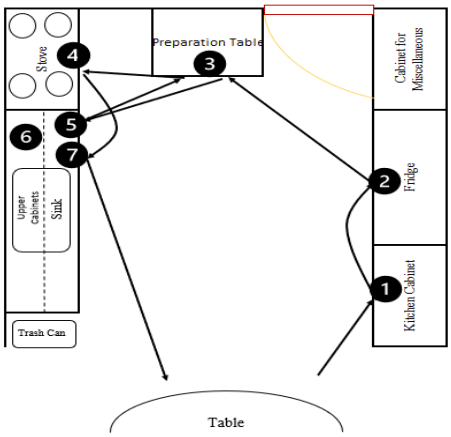

Figure 10
New Kitchen Spaghetti Diagram

As can be seen in Figure 10, the design of the new kitchen has a slight change in the preparation area compared to the original design. This is because in order to achieve the original design, the sink drainpipe had to be relocated and completely built. This would increase the costs for labor and materials, with which the small change in that area was chosen.

Despite the slight change in design, the objective of minimizing time and energy was achieved. Step and distance measurements were obtained with the use of a pedometer. The results are resume in Table 4.

Table 4
Spaghetti Diagram Comparison for Old vs New Kitchen

Spaghetti Diagram Results Comparison (Old vs New)		
	Old Kitchen	New Kitchen
Total Time	65.8 min	45.2 min
Total Steps	236 steps	82 steps
Total Distance	528 ft	158 ft

As shown in Table 4, there was a significant reduction in total time, steps, and distance traveled. With the new kitchen design and applying the 5's method (Sort, Set in order, Shine, Standardize, Sustain) there was a saving of 20.6 minutes, 154 steps, and 370 feet of distance. It should be noted that an additional trash can was added under the preparation table to avoid moving from the area.

Ergonomics Comparison

For this comparison, only REBA will be evaluated since no risk of injury was detected in the

results obtained from the hand, wrist, and elbow by applying the Moore Garg Strain Index. The evaluation will be in the new sink area and the same kitchen tools will be cleaned as in the previous evaluation. REBA evaluation results are shown in Figure 11.

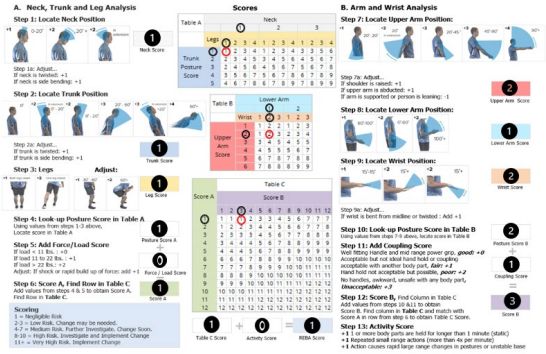

Figure 11
REBA Worksheet Assessment (New Sink Area) [8]

The changes in the evaluation are found in step 2a since there is no twisting of the waist thanks to the location of the sink on the wall. Another change is found in step 13 as the torso doesn't have the twisted static position it had before, so the score is 0. Therefore, as a result, a REBA score of 1(Negligible Risk) was obtained.

Kitchen Cost

The cost that was expected to be spent on the kitchen remodels was around $3,000. The total cost of the new kitchen including materials, stove, kitchen extractor, and labor is $2,154. There was a profit of $846 dollars. See the kitchen comparison in Figure 12.

Figure12
Before (Left) and After (Right)

Conclusion

The new kitchen design achieved the expected objectives thanks to the DMADV methodology. These goals include designing a kitchen that is cost-effective and as a result, is comfortable and easy to work with. It should be noted that the new design complies with the kitchen work triangle, obtaining a sum of the three sides of 18ft, which does not exceed the 26ft limit. This new design met expectations in saving time, energy and at the same time being comfortable to work.

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