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Abstract

This design project will be focused on the remodeling of 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, energy and obtain the necessary comfort when performing tasks.

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

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.

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, Spaghetti Diagram to measure the motion, Moore Garg Strain Index and REBA to determine musculoskeletal disorders.
- 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).

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 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.

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. The idea is to reduce waste before each process (See Figure 1).

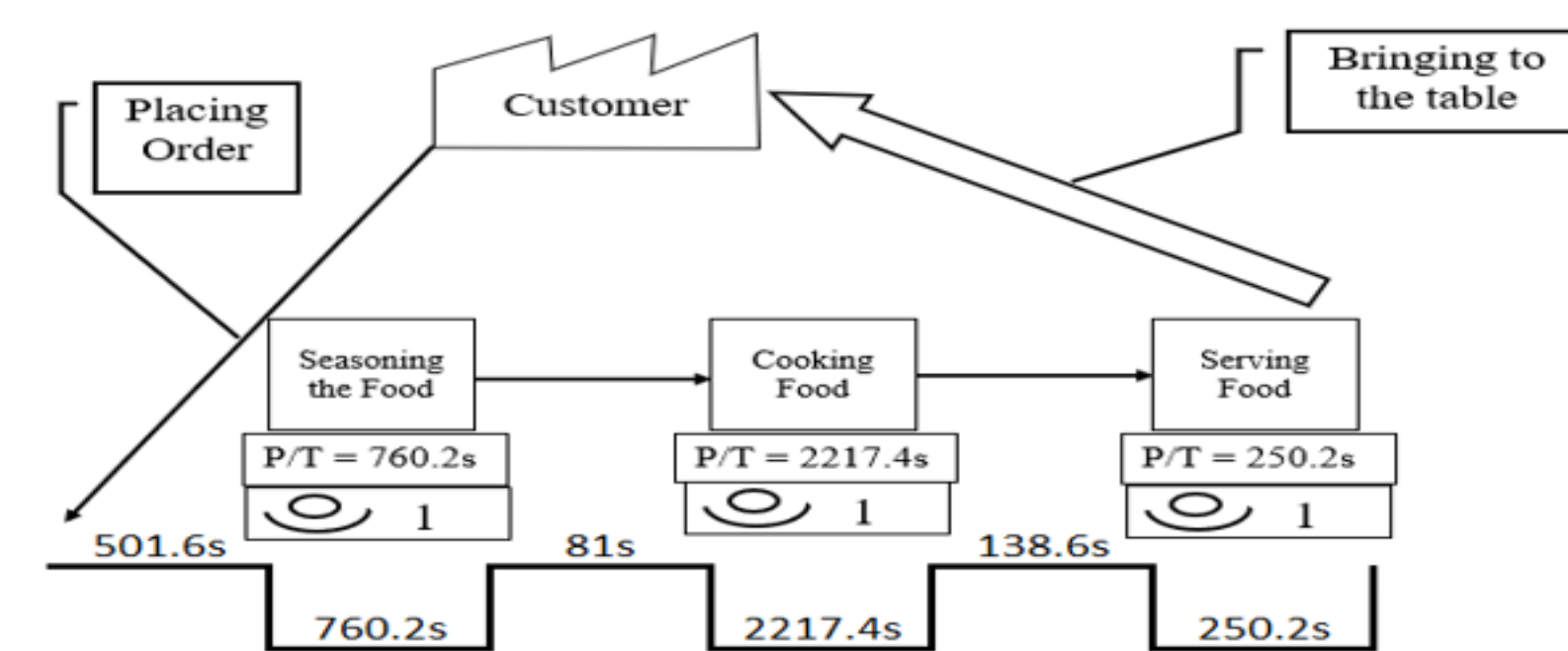


Figure 1
Current Kitchen Value Stream Map

The Spaghetti diagram was created specifically for the dish that was prepared (See Figure 2). 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].

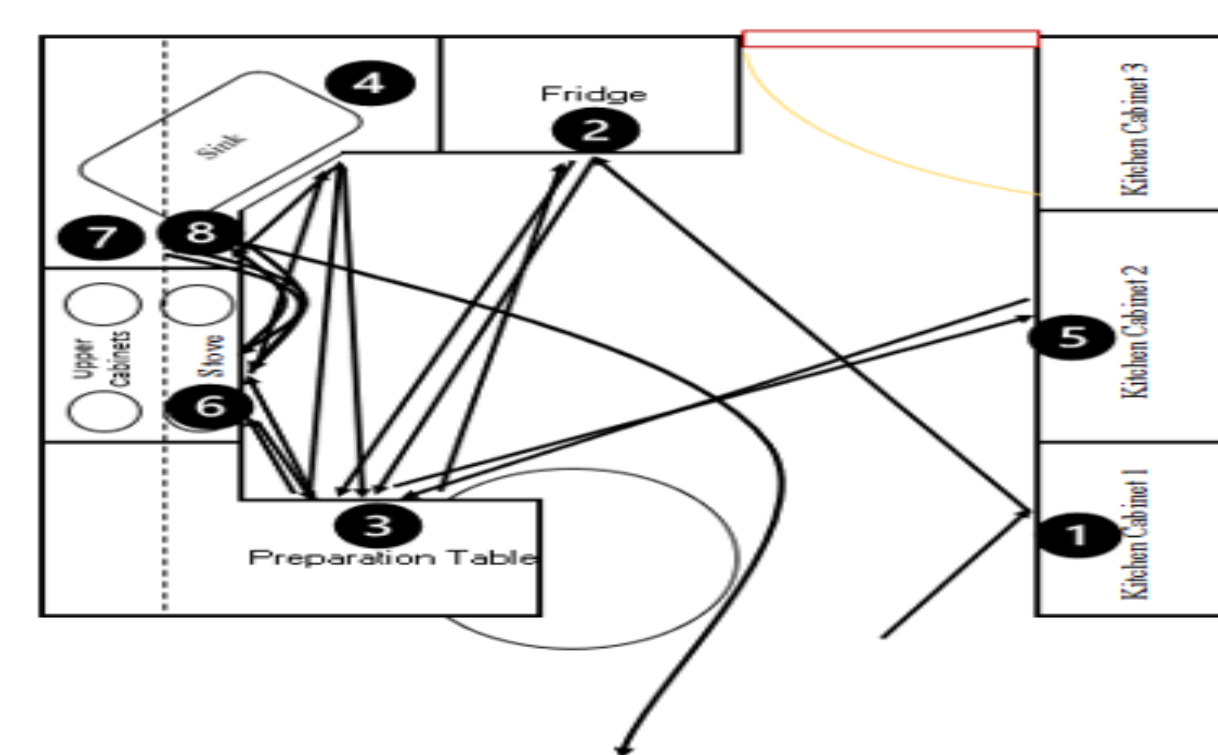


Figure 2
Current Kitchen Spaghetti Diagram

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).

Results and Discussion

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 Table 2) [6].

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

SI Score = $3 \times 2 \times 0.5 \times 1 \times 1 \times 0.25 = 0.75$, $0.75 < 3$: 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. The REBA Score is 3 (Low Risk) (Change may be needed) (See Figure 3).



Figure 3
REBA Worksheet Assessment [8]

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 prevents others from being able to help. The following suggestion is to change the kitchen layout so that the sink is against the wall.

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) (See Figure 4).

Results and Discussion

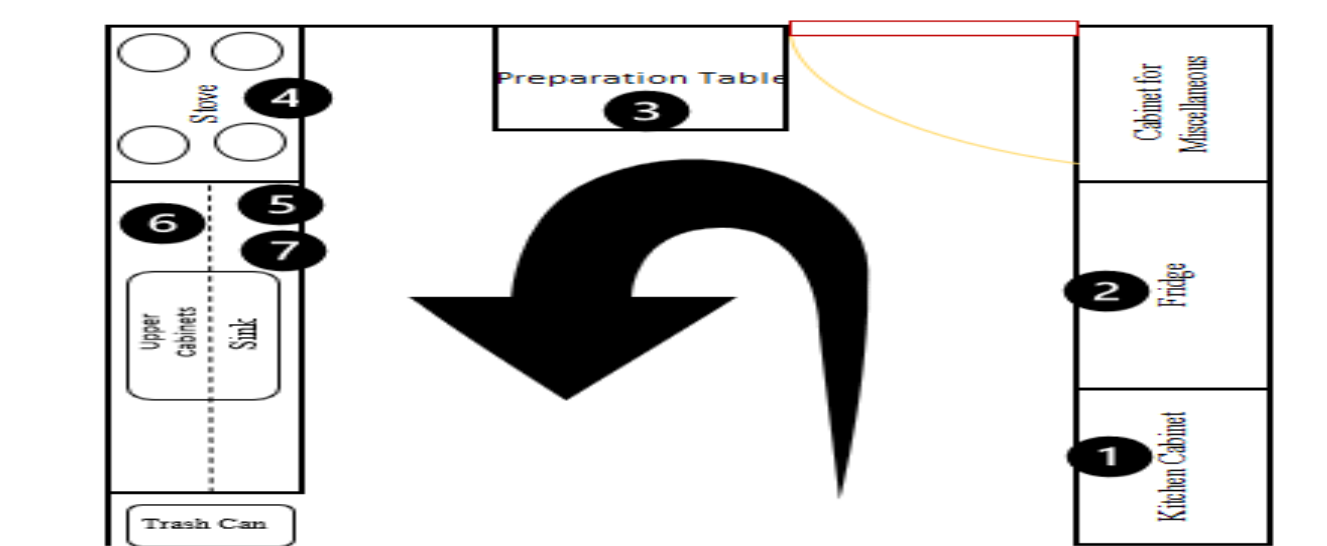


Figure 4
New Kitchen Design

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 (See Figure 5, 6, 7) (See Table 3, 4).

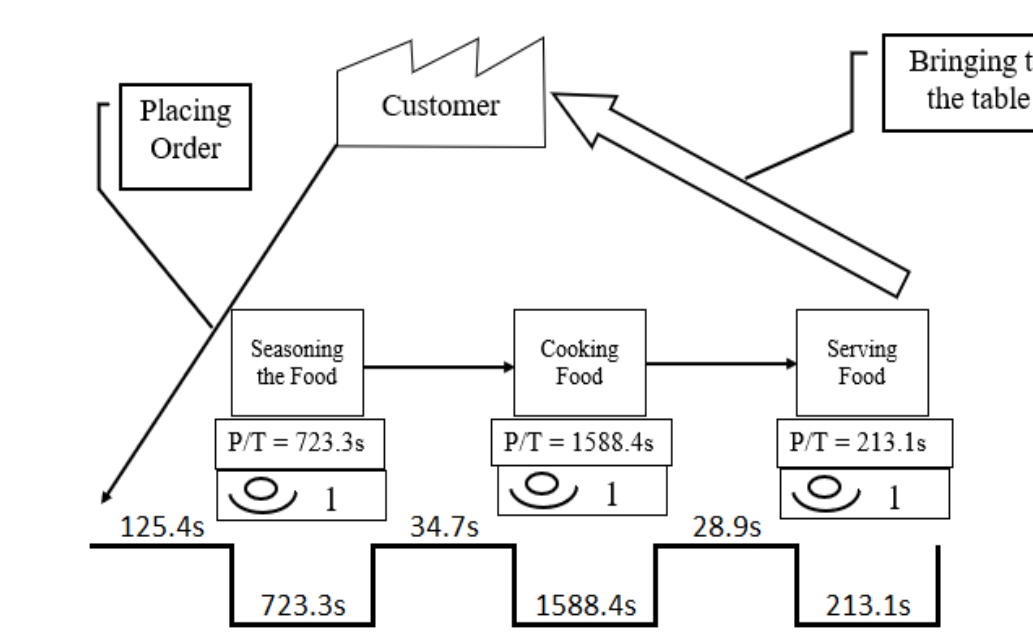


Figure 5
New Kitchen Value Stream Map

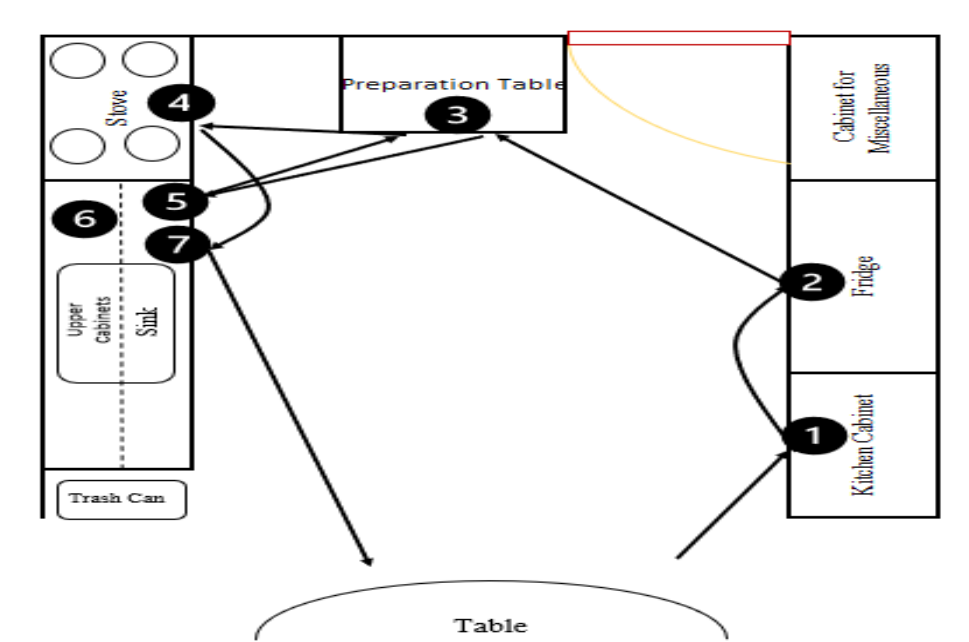


Figure 6
New Kitchen Spaghetti Diagram

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 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	108 ft

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 score of 1 (Negligible Risk) since there is no twist on the torso (Figure 7).

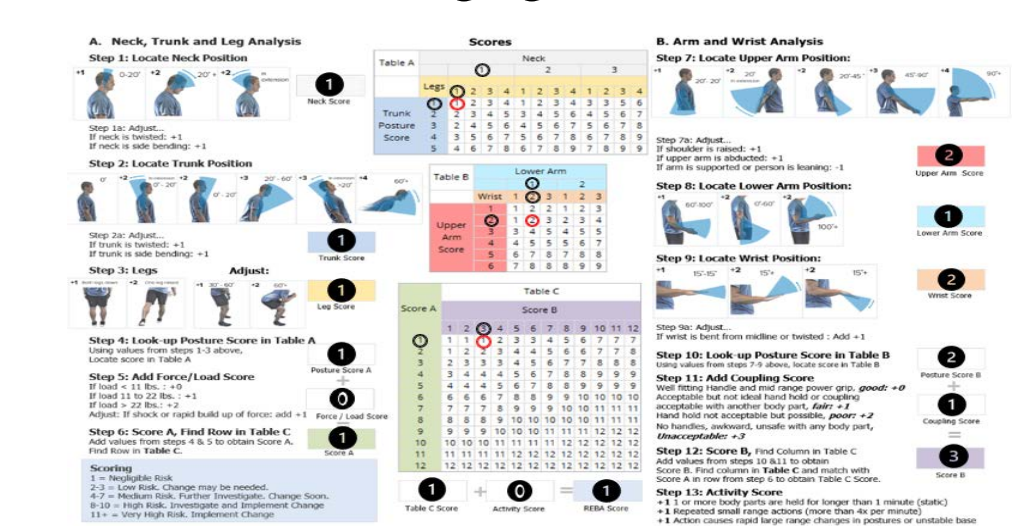


Figure 7
REBA Worksheet Assessment (New Sink Area) [8]

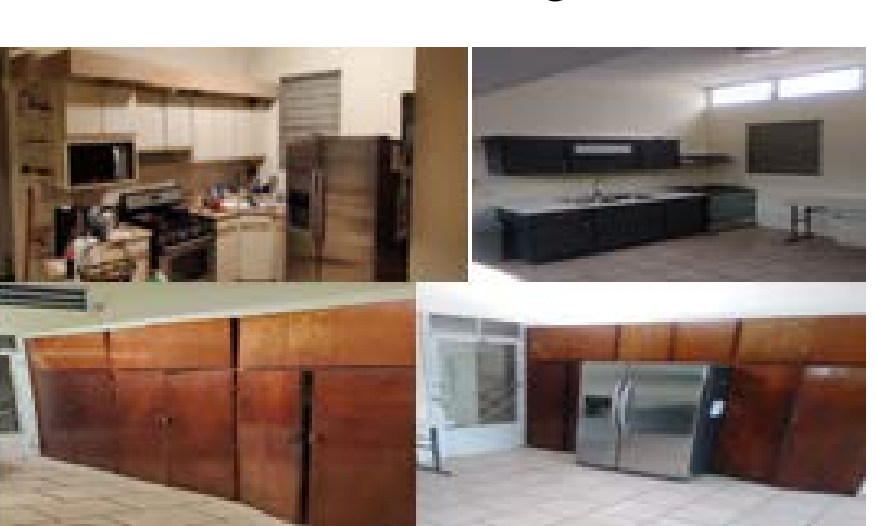


Figure 8
Before (Left) and After (Right)

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. The cost that was expected to be spent on the kitchen remodel 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.

References

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