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THE DISTANCE-WAGE METHOD FOR EVALUATING

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THE DISTANCE-WAGE METHOD FOR EVALUATING FOODSERVICE LAYOUTS

By

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ABSTRACT

THE DISTANCE-WAGE METHOD FOR EVALUATING FOODSERVICE LAYOUTS

By

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Foodservice employees have been estimated to spend 30% of their time walking. One goal of management is to minimize the time required for employees' walking because time spent in walking is not productive. The Distance-Wage Method is a proposed procedure to analyze layouts for the cost of relative travel distance. The purpose of this study was to evaluate the Distance-Wage Method by obtaining data on travel distance on two layout designs for Owen Hall Kitchen at Michigan State University. Results showed the difference in cost of travel time in the two foodservice designs. Over 50 years, the revised layout could save $190,746.61 compared to the current layout according to the Distance-Wage Method. The money saved on the travel of the five full time employees contributed 53.87% of the total travel dollars saved while 46.13% was contributed by that of the twenty-nine part time positions.

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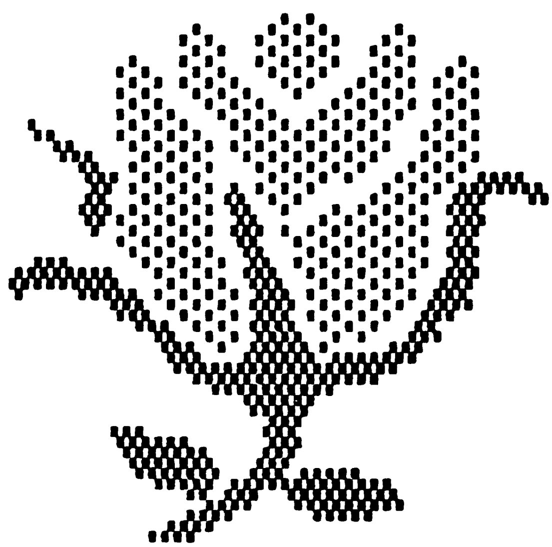

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INTRODUCTION

Labor costs have been estimated to total 35% of the income for the average foodservice establishment (VanEgmond-Pannell, 1985). As "student tastes become more sophisticated," university foodservice operators would like to spend more money on food and less on labor (Wolson, 1985).

A. Statement of the Problem

Labor cost, representing approximately 50% of direct foodservice costs, has always been a crucial point in planning and controlling a foodservice operation (VanEgmond-Pannell, 1985; Stokes, 1979). Dreis (1982) considered labor cost as the most difficult cost to control efficiently.

Both commercial and non-commercial foodservice managers often feel that their manpower has not been fully used, resulting in a waste of labor time. Kotschevar and Terrell (1985) indicated that labor appeared to be a major cost and a "worrisome problem" in foodservice. From examples such as managers doing dishes, cooks mopping floors and spending much of their time cleaning equipment, it is apparent that workers may be requested to take on tasks below their job description.

B. Definition of Terms

Terms used in this study are defined below:

1. Work Center

an area where the equipment used for related food production procedures is grouped. For example, store room, cooking area, and serving line may be considered to be work centers.

2. Walking

movements AMONG work centers (with or without a load) in the foodservice kitchen, instead of those movements WITHIN work centers. Only movements inside the kitchen production area were considered.

3. Distance-Wage Method

a procedure to analyze layouts for the cost of relative travel distance.

C. Undesirable Walking

In foodservice kitchens, Kahrl (1977) estimated that 30% of employees' time was spent walking. The time spent walking by employees has become increasingly important since walking has not been regarded as a task for which owners/operators want to pay. It has been desirable for managers to know "how long tasks actually took" (Feinberg, 1985). Besides, excessive travel could cause bodily fatigue and discomfort, as well as higher occurrance of accidents which result in a decrease of work efficiency (Kahrl, 1978).

D. Development of the Idea

Designing foodservice production areas for minimum effort and maximum efficiency has been essential (Lang, 1985; Prokosch, 1972). As wages continually rose, foodservice operators attempted to make available labor more effective to avoid going out of business (Dreis, 1982). Because employees were paid differently, more money could be saved by cutting the walking time of higher-paid workers rather than lower-paid workers.

Managers should avoid making skilled personnel at high wages do jobs (especially those require large amounts of walking) which can be done by persons with less skill at lower wages (Ketterer, 1982). If it were possible to shorten travel distances of some of the tasks and to allow highly-paid employees to walk less in performing their assignments, a significant saving would be expected after a long period of time (Powers, 1984). The concept of adding a wage factor to the evaluation of employee travel in a kitchen layout thus seemed to be a logical addition. For purposes of this paper, such evaluation of labor time would be called the **Distance-Wage Method**.

E. Differences from Other Methods

The Distance-Wage Method had three unique characteristics compared to current methods (discussed in Chapter 2):

1. wage factor

Cost for travel time among workers has usually differed relative to pay scale. The Distance-Wage Method introduced the wage concept into the evaluation of foodservice layouts.

2. focus on whole kitchen

The Distance-Wage Method was designed to evaluate the entire kitchen layout, rather than merely equipment arrangement within work centers.

3. new calculation procedure

A new calculation procedure was introduced in the Distance-Wage Method to obtain the cost of employees' walking.

F. Purpose

The purpose of this study was to evaluate the Distance-Wage Method by obtaining data on travel distance and costs for two layout designs of the kitchen of Owen Graduate Center at Michigan State University. The layout with the least employee travel time and hence the least labor cost would then be recommended for use. Objectives of the Distance-Wage Method were to improve productivity of the available labor, to get a larger output to input ratio of manpower, and to pay less money for employees' walking than in the past.

G. Scope of the Study

This study focused on the comparison between two kitchen layout designs, and determined the difference in employee travel time for the kitchen lifetime of 50 years estimated for the two layouts. The author of this study intended that the proposed evaluation method would be a useful tool for foodservice operators.

Avery (1973) suggested that researchers should follow the paths of the workers rather than the material flow when studying a kitchen. When the movements within a work center were followed, only a better arrangement of the equipment, which was used by a particular group of employees, could be derived. Ideas on efficiency about the whole kitchen, as used by all the workers, would be difficult to obtain from results of studies of movements within work centers only. Results more suitable for evaluation of entire layout designs would seem to be available if the movements among work centers were studied. Reducing travel time among work centers would not only improve kitchen layouts but would also reduce labor costs.

Ketterer (1982) reported that inadequate arrangement of work centers was the most costly error in the foodservice industry. Backtracking was a pattern of movement that employees travel in the reverse direction of from-origination-to-destination. Time spent in backtracking would be reduced if a better layout plan had initially been followed (Kotschevar and Terrell, 1985; Dukas, 1976). This study emphasized the concept that designers should make every effort to have higher-salaried production employees do fewer things which were not related to their special skills --briefly, to make them travel less. This would theoretically provide those employees with more "productive" time which would, in turn, allow them to perform other required tasks (Alber, 1974).

Of course, there are many other factors which could affect productivity and total labor budget, such as quantity of food moved, managerial techniques, architectural consideration, remodeling fees and the menu (Ketterer, 1982). How to find an optimum layout has been a problem of trial and error (Kazarian, 1979). Procedures presented in this study did not point to the "ideal" kitchen layout. Rather, the procedure used was just a comparison between two kitchen layout designs. What the study hopefully has contributed to the foodservice industry was a statement of how much less the manager had to pay for employees' walking if the revised layout, which required less travel cost, was installed.

LITERATURE REVIEW

Methods for evaluating foodservice layouts have been studied for a long time. Limitations of current evaluation methods include: only the arrangement of equipment WITHIN a work center or one part of the work center, rather than the whole kitchen, was considered; only straight-line-layout models were studied; subjective strategies were used to make "ratings"; and little attention was given to the effects made by different pay scales. Because of the limitations of current techniques, no one author has suggested a method which could lead to the "perfect" layout. For this reason, engineering and management literature, in addition to published material relating to the foodservice industry, were reviewed. This chapter will summarize the characteristics of existing methods for evaluating foodservice layout designs and give pros and cons of each.

A. Pilot Kitchen

One of the ways to evaluate layout proposals has been to build and operate a pilot kitchen. This has been the most direct way to learn about the advantages and disadvantages of a proposed layout. Building a pilot kitchen, either full scale or reduced size, to evaluate a layout has been considered enormously expensive and has seldom been recommended (Moore, 1962).

B. Food Flow Path

The Food Flow Path has been defined as the recorded sequence of the movements of food among the many work centers from receiving, through preparation, to service. A Food Flow Path with a minimum of backtracking, interruption, interference or congestion has been usually regarded as most efficient. For example, if the cooking area was placed in the Food Flow Path, then the vegetable preparation that usually occurred before cooking would be before the cooking area in the Food Flow Path. Normally, the Food Flow Path has been from receiving to storage, to preparation, to cooking, to handling, to service, and to dish-washing. The shortest path has usually been considered as the best. Food Flow Paths vary among kitchen layouts according to special needs of the foodservice operation (Kotschevar and Terrell, 1985; Prokosch, 1972).

C. Material Handling Costs

The layout of a foodservice kitchen should have been arranged to minimize the total cost of materials handling among work centers. If there were n work centers in the operation, the total materials handling cost (T) might be expressed as

Formula 1: Material Handling Cost
(References: Menipaz, 1984; Peters and Oliva, 1981).

$$\text{Total Materials Handling Cost (T)} = \sum_{i=1}^{n} \cdot \sum_{j=1}^{n} D_{ij} L_{ij} C$$

where D_{ij} = distance between work center i and j

L_{ij} = number of unit loads moved between work center i and j

C = cost of moving one load for one unit distance

when $i=j$, then $D_{ij}=0$. n = number of work centers.

The value of L_{ij} (number of loads between work center i and j) also could be expressed as the number of pounds of materials that had to be moved between work center i and j. It has been suggested that work centers involving the greatest quantities of materials should be located close together (Menipaz, 1984; Peters and Oliva, 1981).

D. Space Utilization

A good layout would make efficient use of the space available. Space includes vertical as well as horizontal dimensions. There are standards that indicate the space requirement of foodservice kitchens. Generally, a dormitory cafeteria that served 800 students per meal required 2800 square feet for the kitchen area while one that served 200 students per meal required 800 square feet (Kotschevar and Terrell, 1985). Too little space has caused interference when employees were performing their tasks. Too much space has resulted in excessive travel of workers, waste of investment, and difficulty of supervision (Prokosch, 1972; Moore, 1962).

E. Effectiveness

Another method of evaluating foodservice layouts has been to determine their effectiveness through enumerating forward movements (desirable) versus backtracking (undesirable) because backtracking tended to increase the total travel distance. The greater the effectiveness or frequency of forward movements, the better the layout. Assume that the operation was from the left to the right (as below) and the order of the movements were ACDBEADABCE. Movements that proceed to the right were called FORWARDs while those proceed to the left were called BACKWARDs. The effectiveness of the layout might be calculated as 70% according to the method of Kotschevar and Terrell (1985; Figure 1).

```
+-------+-------+-------+-------+-------+
|       |       |       |       |       |
|   A   |   B   |   C   |   D   |   E   |
|       |       |       |       |       |
+-------+-------+-------+-------+-------+

Forwards:  AC, CD, BE, AD, AB, BC, CE = 7
Backwards: DB, EA, DA                 = 3
```

$$\text{Effectiveness} = \frac{7}{7+3} = \frac{7}{10} \text{ or } 70\%$$

A, B, C, D and E were work centers, and the order of the movements were ACDBEADABCE. (Reference: Kotschevar and Terrell, 1985.)

Figure 1. Calculation of Effectiveness (Distance Ignored).

If the distances traveled among the work centers adjacent to one another were all equal to 1 foot and were taken into consideration, the effectiveness would become 59.09% according to the method of Kazarian (1979; Table 1).

Table 1. Calculation of Effectiveness (Distance Considered).

FORWARD							BACKWARD						
Movements	No.	x	Distance				Movements	No.	x	Distance			
CD, AB, BC	3	x	1	=	3			0	x	1	=	0	
AC, CE	2	x	2	=	4		DB	1	x	2	=	2	
BE, AD	2	x	3	=	6		DA	1	x	3	=	3	
	0	x	4	=	0		EA	1	x	4	=	4	
	7				13			3				9	

$$\text{Effectiveness} = \frac{13}{13+9} = \frac{13}{22} \text{ or } 59.09\%$$

A, B, C, D and E were work centers, and the order of the movements were ACDBEADABCE. (Reference: Kazarian, 1979.)

F. Flexibility

Needs of space would vary and demands of meals served would increase sometimes. The chance of change and expansion should always be considered so that changes would be made at a minimum of cost or disturbance of the operation process. No standardized measuring procedures for flexibility were available in the literature. Thus, flexibility should be considered as one of the characteristics of a good layout design (Amrine et al., 1982; Prokosch, 1972).

G. Weighted Factors

In the Weighted Factor Comparison Method, numerical values or weights were assigned proportionally to each previously discussed factor in this thesis, such as cost, flow and flexibility, based on their degrees of importance. Each layout design to be considered would be given a relative rating according to its performance. A score was obtained by multiplying the weight by the rating against each factor. The sum of the scores was called an overall weighted score (OWS), and might be used in evaluating foodservice layouts. Better layouts usually gave greater overall weighted scores. In Table 2, the OWS of Layout B was greater than that of Layout A (Menipaz, 1984; Tompkins and White, 1984).

Table 2. Overall Weighted Score (OWS).

		Layout A		Layout B	
Factor	Weight	Rating	Score	Rating	Score
1. Cost	7	1	7	3	21
2. Flow	4	3	12	2	8
3. Effectiveness	3	2	6	1	3
4. Flexibility	1	1	1	1	1
		OWS = 26		OWS = 33	

There were two steps in calculating OWS:
(1) Weight x Rating = Score,
(2) the sum of the Scores was OWS.
The better layout gave greater OWS.
(References: Menipaz, 1984; Tompkins and White, 1984.)

H. Concept of Work Sequence

Foodservice workers may be required to travel among several work centers to complete an assigned task. For example, a cook could be required to travel among the cooking area, preparation area, refrigerator, storage room, and dish room to prepare one recipe. By observing the order of work centers used to complete a given task, a sequence of work centers may be recorded. This recorded information was called a **Work Sequence** (Table 3). The **Work Sequence** provided the order of work centers used in performing a task, which might serve as a tool of data-collecting in evaluating foodservice layouts (Mayer, 1982; Kazarian, 1979; Moore, 1962; Ireson, 1954).

Table 3. Examples of Work Sequences.

Worker	Work Sequence
P	DAEBCEACBADCEAEAC
Q	CACBECABAEBCEBCABEB
R	DCBDEABCAEBA

A, B, C, D and E indicated different work centers. The WORK SEQUENCE recorded the order of work centers used to perform a task. (References: Mayer, 1982; Kazarian, 1979; Moore, 1962; Ireson, 1954.)

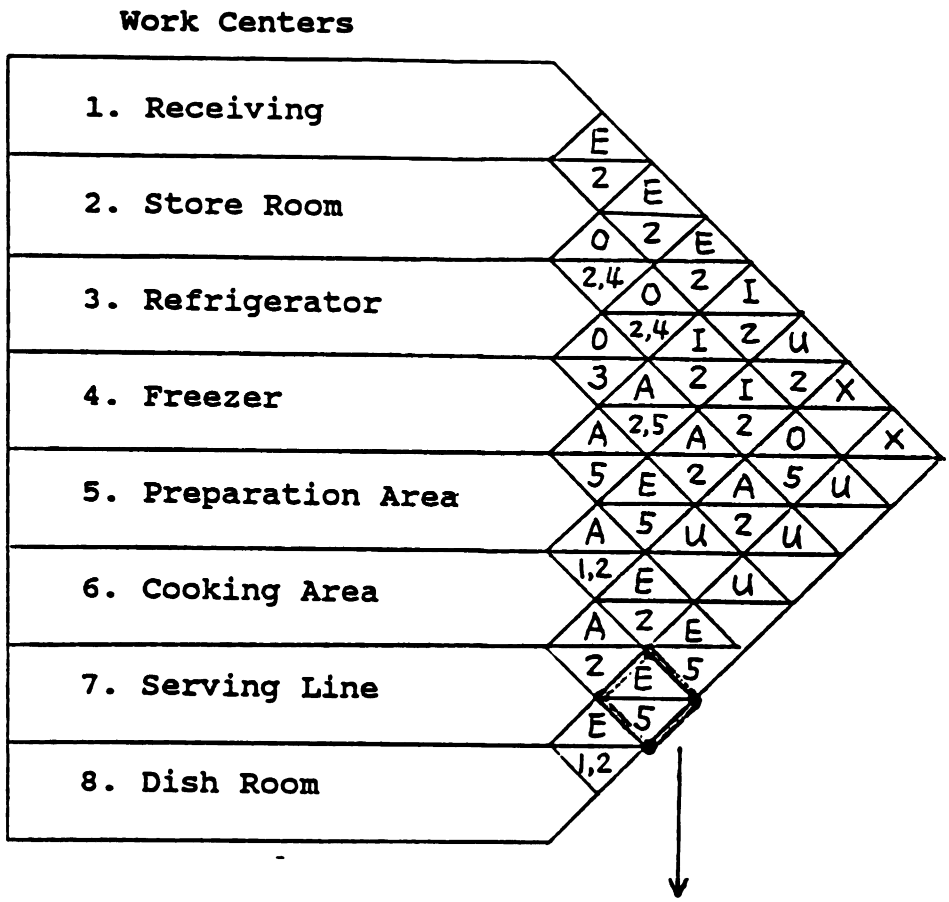
I. Concept of Movement Frequency

From the **Work Sequence** in Table 3, data indicated that there were more interactions between some pairs of work centers, and at the same time, no or relatively few movements between others. Doubtless that work centers with the most frequent movements should be put adjacent to each other, and those with no interaction should be kept far away as possible in order to avoid excessive travel.

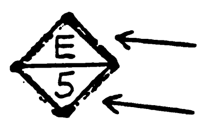
Prokosch (1972) suggested that a **Relationship Chart** be used to report the relationships among work centers. In the **Relationship Chart** (Figure 2), the importance of closeness desired between each pair of work centers was rated and supported with reasons (Dilworth, 1986; Kotschevar and Terrell, 1985; Schroeder, 1985; Greene, 1984; Riggs, 1981; Kazarian, 1979; Lawson, 1978; Muther, 1976; Avery, 1974; Moore, 1971; Lee and Moore, 1967).

Because relationship ratings were arbitrarily assigned on the basis of past experience, such data have been considered somewhat subjective even though they may be the concensus of the judgments of several persons. No standard concerning the grading of the relationships was available.

The number of movements between work centers may be shown in a **Frequency-Typed Cross Travel Chart** (Figure 3; Lawson, 1978). The **Frequency-Typed Cross Travel Chart** may be defined as a square chart which has the same number of columns and rows depending on the number of work centers being studied. For example, if there were five work centers A, B, C, D and E in the kitchen, there would be five columns and five rows in the chart. The order of the designations of rows must be kept exactly the same as that of columns; that is, if the order ABCDE was used in the column, the same order ABCDE must be used in the row.



the relationship between the cooking area and the dish room:



Importance of Closeness

A Absolutely necessary
E Especially important
I Important
O Ordinary closeness OK
U Unimportant
X Undesirable

Reason for Closeness*

1 Use same equipment
2 Flow of materials
3 Saving of energy
4 Ease of supervision
5 Convenience

*Others may be added.

In the RELATIONSHIP CHART, the importance of closeness desired between each pair of work centers was rated and supported with reasons. (Reference: Prokosch, 1972.)

Figure 2. Relationship Chart.

From

To: ROWS \ COLUMNS	A	B	C	D	E	
A		1		1	3	5
B			1		1	2
C	2	1		1		4
D	1					1
E	2		2			4
	5	2	3	2	4	16

A, B, C, D and E were work centers. The FREQUENCY-TYPED CROSS TRAVEL CHART (FREQUENCY CHART) gave a summary of the number and the direction of movements among work centers required for Worker P's task, and might be derived from the Work Sequence (Table 3). In column B and row A, "1" meant there was one movement from work center B to A. (References: Kazarian, 1979; Lawson, 1978.)

Figure 3. Frequency-Typed Cross Travel Chart (Frequency Chart)

Since no movement would be recorded from a work center to the work center itself, a diagonal should be drawn from the upper left to the lower right of the **Frequency-Typed Cross Travel Chart.** The letter above the chart was used to point out which work center a movement originated FROM while the letter at the left side of the chart was used to indicate the work center to which a movement was headed TO (toward). Some authors have added an extra column at the right side and an extra row at the bottom to indicate totals (Dilworth, 1986; Kotschevar and Terrell, 1985; Schroeder, 1985; Greene, 1984; Buffa, 1983; Fearon, 1983; Riggs, 1981; Chase and Aquilano, 1977; Gottlieb and Couch, 1960). **Frequency-Typed Cross Travel Charts** have given the summary of the number and direction of movements among work centers required for a task or set of tasks, and could be derived from the **Work Sequence** (Kazarian, 1979).

For purposes of this study, the **Frequency-Typed Cross Travel Chart** was called a **Frequency Chart.**

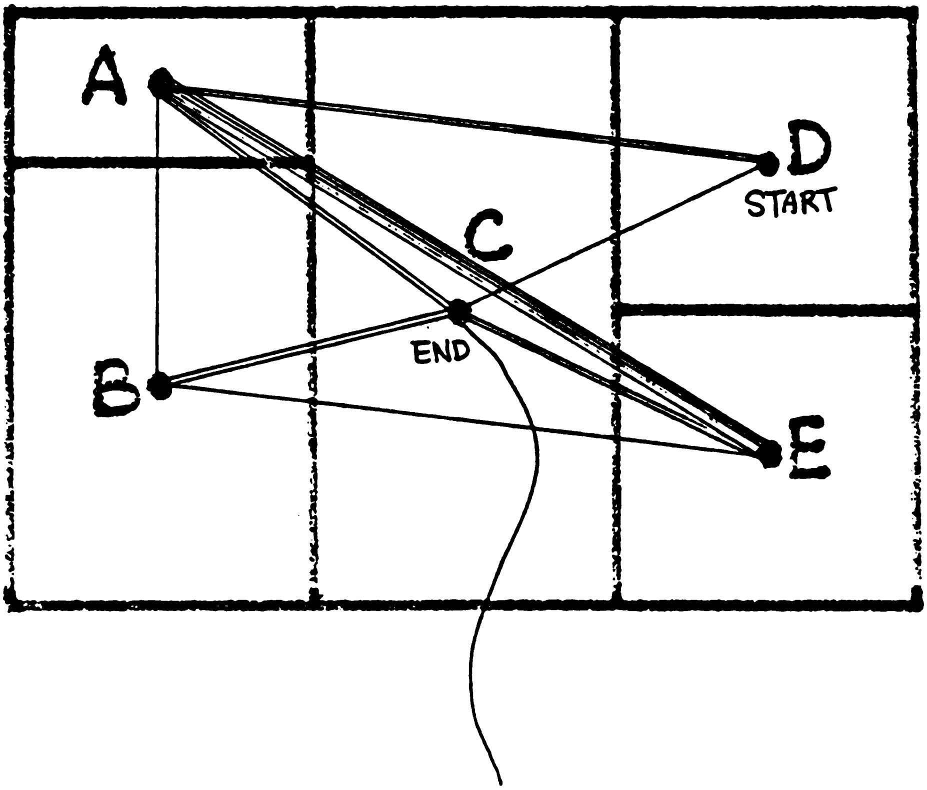
J. Concept of Travel Distance

Heyel and Nance (1984) stressed that transportation has been a "major waste" of the worker in a process. In foodservice, excessive travel not only has caused fatigue and danger and, waste of time, but also has been unfavorable to the food when microbiological characteristics of the food were considered (Kahrl, 1978). Travel distance has naturally become one of the critical points in evaluating foodservice layouts.

Kotschevar and Terrell (1985) reported the distance which a kitchen worker traveled in the operation process with a **String Chart** (Figure 4). A blueprint on which a pin was located at every work center was required. The procedure included the following steps. Fasten a string at the point where the task started, then move the string along the path this worker traveled. Take off the string at the end of the process and measure the length. The travel distance of the worker for finishing this particular task was obtained by dividing the length of the string by the scale of the blueprint. (If the scale was 1/4 inch to 1 foot, each inch of string represented a 4-foot actual distance.)

Movements in a straight line among work centers were not possible at all times because employees could not "walk through" equipment such as an oven or a steam-jacketed kettle. So the **String Chart** did not seem feasible to all situations in evaluating the layouts of the whole kitchen. More pins were needed to locate at the points where employees turned.

The distances between pairs of work centers have generally not been the same because the sizes and shapes of work centers varied among layouts. Riggs (1981) constructed a **From-To Chart** (same format as the **Frequency Chart** previously mentioned) to record the distance between each pair of work centers (Figure 5). The difference between



A, B, C, D and E were work centers. The STRING CHART introduced the concept of the travel distance of worker P (Table 3) by moving a string on a blueprint along the path he worker traveled. The thin lines indicated the string.
(Reference: Kotschevar and Terrell, 1985.)

Figure 4. String Chart.

From

To (ROWS) \ From (COLUMNS)	A	B	C	D	E
A		40	70	90	130
B	40		50	110	90
C	70	50		60	60
D	90	110	60		40
E	130	90	60	40	

A, B, C, D and E were work centers. The FROM-TO CHART (DISTANCE CHART) was used to record the distance between each pair of work centers. In column B and row A, "40" meant there were 40 feet between work center B and A. (Reference: Riggs, 1981.)

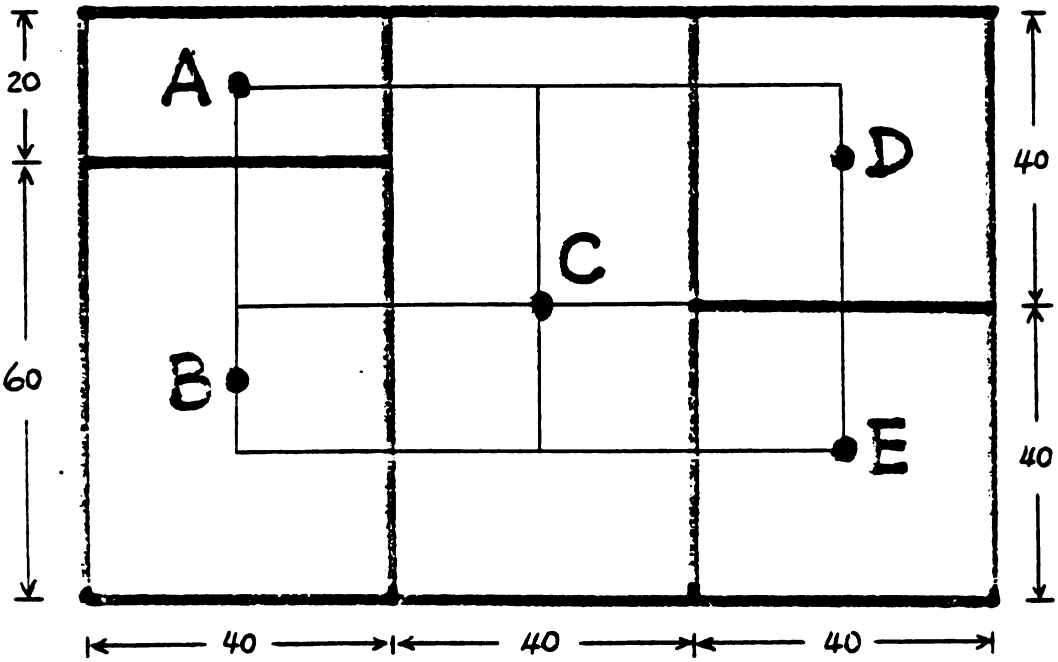
Figure 5. From-To Chart (Distance Chart).

From-To Charts and **Frequency Charts** was that distances were put into "cells" of **From-To Charts** and frequencies were put into the cells of **Frequency Charts**. Note that the distances shown in the **From-To Chart** were for the particular work center arrangement (Figure 6) and would not be the same for other arrangements (Greene, 1984; Amrine et al., 1982; Kazarian, 1979). The diagonal divided the chart into two symmetrized parts since the distance from A to B was the same as that from B to A. To avoid causing any confusion, the **From-To Chart** was called a **Distance Chart** in this study because FROM and TO were used in the **Frequency Chart** as well.

Kazarian (1979) further combined a **Frequency Chart** and a **Distance Chart** into a **Travel Chart** to indicate the total travel distance to perform a task in a particular foodservice layout. The **Travel Chart** (Figure 7) was constructed by multiplying each cell in the **Frequency Chart** by the same cell in the **Distance Chart** and putting the result in this **Travel Chart** (Avery, 1974). Cameron (1952) claimed that **Travel Charts** "could be used to present a dramatic and easily understood picture to top management." Lundy (1955) also asserted that **Travel Charts** were very helpful when planning engineering layouts.

K. Concept of Wages

Obviously, the travel performed by a $15 per hour cook costs more than the same travel performed by a $4 per hour



A, B, C, D and E were work centers, and the thin lines showed the paths of the movements. (unit:feet)

Figure 6. The Layout for the Distance Chart in Figure 5.

From

To: ROWS \ COLUMNS	A	B	C	D	E	
A		40		90	390	520
B			50		90	140
C	140	50		60		250
D	90					90
E	260		60			320
	490	90	110	150	480	1320

A, B, C, D and E were work centers. The TRAVEL CHART indicated the total travel distance for a worker to perform a given task, and was constructed by multiplying each cell in the Frequency Chart (Figure 3) by the same cell in the Distance Chart (Figure 5). In the lower right corner, "1320" meant the total travel distance for worker P (Table 3) to perform his task was 1320 feet. (Reference: Kazarian, 1979.)

Figure 7. Travel Chart.

potwasher. Needless to say, such differences in wages should be taken into consideration in evaluating foodservice layouts. Most of the methods previously mentioned failed to take into account the effect of wages in dollars among various levels of foodservice employees.

Because employees were paid differently, management did not pay the same amount of money for every worker to travel a given distance. Avery (1974) used an **Importance Factor** to advocate this difference in the kitchen of Missouri State Cancer Hospital. The performance of thirteen individuals was studied, including four cooks, one baker, one pot washer, one dish washer and six tray girls. Avery took the wage of the lowest paid worker in the kitchen of the hospital (tray girl) as the basis for his calculations. That is, the lowest paid worker in the kitchen would be given a factor of one, and according to their wage rates, the **Importance Factors** of the other workers would go up proportionately. The daily wage and the **Importance Factor** of any worker X were as below.

Formula 2: Calculation of Daily Wage According to the Method of Avery (1974)

$$\text{Daily Wage of Worker X} = \frac{\text{Yearly Salary of Worker X}}{\text{Total Days Worked by Worker X}}$$

Formula 3: Calculation of Importance Factor According to the Method of Avery (1974)

$$\text{Importance Factor} = \frac{\text{Daily Wage of Worker X}}{\text{Daily Wage of a Tray Girl}}$$

Thus, the interactions of the worker with an **Importance Factor** of 2 should receive twice as much consideration as those of the worker with an **Importance Factor** of 1 in evaluating different layouts. For example, if Worker P with an **Importance Factor** of 3 took 100 trips of 40 feet between A and D, Worker Q with an **Importance Factor** of 2 took 100 trips of 32 feet between C and D, and Worker R with an **Importance Factor** of 1 made 200 trips of 17 feet between B and D according to the layout ACBD below, the total weighted travel distance of these three workers would be 21,800 feet according to the method of Avery (1974, 1973; Figure 8).

If a rearrangement of the work centers was made and D was placed at the left side of A (Figure 9) where Worker P traveled 10 feet between A and D, Worker Q traveled 18 feet between C and D, and Worker R now had to travel 33 feet between B and D according to the second layout, the total weighted travel distance would become 13,200 feet (Figure 9; Avery, 1974, 1973).

```
+- 6'-+-- 10' --+------- 20' -------+---- 14' ----+

+-----+---------+-------------------+-------------+
|     |         |                   |             |
|  A  |    C    |         B         |      D      |
|     |         |                   |             |
+-----+---------+-------------------+-------------+

   +-- 8'--+----- 15' ----+------ 17' -----+
```

IF = Importance Factor

Worker P: AD	100 trips x 40 feet x 3 IF =	12000 feet
Worker Q: CD	100 trips x 32 feet x 2 IF =	6400 feet
Worker R: BD	200 trips x 17 feet x 1 IF =	3400 feet
	Total =	21800 feet

A, B, C and D were work centers. The numbers (in feet) above the Figure indicated the sizes of work centers while the numbers (in feet) below the Figure showed the distances between work centers, and were measured between centroids of the work centers. (Reference: Avery, 1974, 1973.)

Figure 8. Weighted Travel Distance on Layout ACBD.

```
+----- 14'----+- 6'-+-- 10' --+------  20' -------+

+------------+-----+---------+-----------------+
|            |     |         |                 |
|     D      |  A  |    C    |        B        |
|            |     |         |                 |
+------------+-----+---------+-----------------+

      +-- 10' --+-- 8'--+---- 15' -----+
```

IF = Importance Factor

Worker P: AD	**100 trips x 10 feet x 3 IF =**	**3000 feet**
Worker Q: CD	**100 trips x 18 feet x 2 IF =**	**3600 feet**
Worker R: BD	**200 trips x 33 feet x 1 IF =**	**6600 feet**
	Total =	**13200 feet**

A, B, C and D were work centers. The numbers (in feet) above the Figure indicated the sizes of work centers while the numbers (in feet) below the Figure showed the distances between work centers, and were measured between centroids of the work centers. (Reference: Avery, 1974, 1973.)

Figure 9. Weighted Travel Distance on Layout DACB.

Weighted travel distance in Figure 8 was 21800 feet and in Figure 9, 13200 feet. The difference between the travel distance in Figures 8 and 9 was 8600 feet. This difference would mean a saving of "the equivalent of 8600 feet of travel overall" for the arrangement in Figure 9 (Avery, 1973).

The **Importance Factor** model as described by Avery left a criterion open to question that no clear explanation about the **unit** of "equivalent of travel" could be found. Since 8600 feet was not the actually saved distance, it was impossible to imply that the **unit** meant "a saving of travel in feet." Also, there was no way to relate this unit to the wages in dollars.

L. Summary

Building a **Pilot Kitchen** has probably been the most definitive way to determine the advantages and disadvantages of a proposed foodservice layout design. The **Food Flow Path** was defined as a recorded sequence of the movements of food among the many work centers from receiving to service. A Food Flow Path with a minimum of backtracking, interruption, interference or congestion has usually been regarded as most efficient. A layout of a foodservice kitchen should be arranged to minimize the **Material Handling Cost** among work centers. Effective layouts have utilized both cubic space and floor area available. The **Effectiveness** of a layout was obtained by emphasizing the desirability of forward movements or the undesirability of backtracking, and might be used as an indicator in evaluating layout alternatives. Being assigned numerical weights to factors based on their degrees of importance, the **Weighted Factor Comparison Method** was a tool in comparing different foodservice layouts.

The **Work Sequence**, which recorded the order of work centers used to perform a task, has served as a starting-point for data-collecting in evaluating foodservice layouts. The **Relationship Chart** has been used to show the importance of closeness desired between each pair of work centers and, simultaneously, to provide the reasons for the decisions on proximity. The data collected in the Relationship Chart lacked objectivity because relationship ratings were given on the basis of past experience and no standard concerning the grading was available. The **Frequency Chart** has given a summary of the number and the direction of movements among work centers required for a task, and could be derived from the Work Sequence.

The **String Chart** was used to introduce the concept of the travel distance of the worker by moving a string on a blueprint along the path a worker might travel. Since straight-line travels, which moved only along a straight line between work centers, were not available at all times, the String Chart did not seem feasible to all situations in evaluating the layouts of the whole kitchen. The **Distance Chart** used the same format as the Frequency Chart and was designed to record the distance between each pair of work centers.

The **Travel Chart** was constructed by multiplying each cell in the Frequency Chart by the same cell in the Distance Chart. The Travel Chart indicated the total travel distance for a worker to perform a given task in a particular foodservice layout, and would be an integral part of the Distance-Wage Method proposed in this study.

Except for the **Importance Factor**, methods reviewed in Chapter 2 failed to take into consideration the effect of different wage levels among foodservice employees. The **Importance Factor** model tried to introduce the concept of wages in evaluating foodservice layouts by giving every worker in the kitchen a relative factor on the basis of the salary of the lowest paid employee. Every worker's travel distance was multiplied by his Importance Factor and a weighted travel distance was obtained. The sum of all travel was calculated by adding up the weighted travel distances of all the workers. This total may only be treated as an indicator in comparing different kitchen layouts. The smaller the value, the better the layout. The Importance Factor model did not give an actual connection between the travel distance and wage factor.

Thus a clearer model was needed by the foodservice industry which combined concepts of: **Work Sequence**, **Frequency Chart**, **Distance Chart**, **Travel Chart**, and **Wage** factor together. This thesis will suggest such a model, the model was called the **Distance-Wage Method**.

METHODS

The cafeteria in Owen Graduate Center of Michigan State University was used as the test site for this study.

A. Conceptual Model

At the time of this study, excluding the manager, full and part time supervisors and cashiers, Owen Cafeteria operated with five full time positions. The full time positions consisted of: three cooks, one salad person and one stockperson. Part time positions at Owen Cafeteria consisted of: six foodservice positions for breakfast (6:00 a.m. to 11:15 a.m.), nine for lunch (10:15 a.m. to 4:15 p.m.), nine for dinner (4:00 p.m. to 8:00 p.m.) and five for the night period after dinner (7:30 p.m. to 1:30 a.m.). Each of these thirty-four positions was observed during three replications (3 x 34 = 102), resulting in 102 observations for the current layout design. No travel training for Owen employees was given in preparation for this study. The observations took seven weeks and 92 different workers were included. The author of this study intended that the Distance-Wage Method would be applicable to any set of two or more foodservice layout designs being considered regardless of foodservice market segment.

B. Two Layout Plans

Figure 10 was the current layout of Owen Kitchen and Figure 11 was the layout of the same facility revised by the author. The revised layout design was conceptual; no real changes were made. The size and content of each work center were kept as close to the current area in Figure 11 as possible; only arrangement of work centers had been revised. Three changes were made in the revised layout:

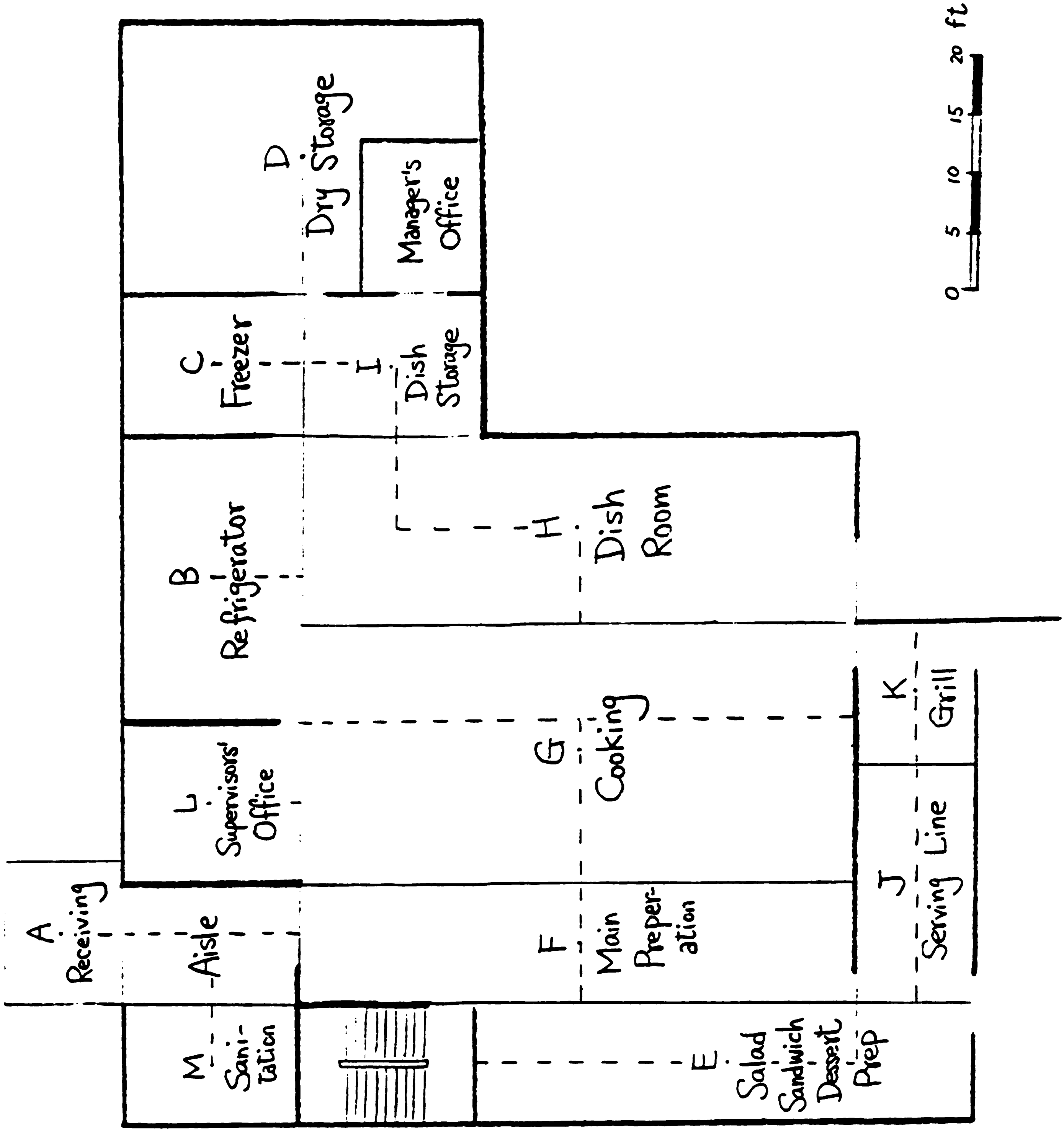
1. eliminated the aisle between the receiving area and the kitchen, and rearranged the supervisors' office, receiving, refrigerator, freezer and sanitation areas (**REASON:** to shorten the travel distance between receiving and storage areas);

2. rearranged the cooking and the main preparation areas (**REASON:** to shorten the travel distance, especially of the cooks, according to the food flow path); and

3. made an aisle between the cooking area and the serving line so that the employees could travel "through" these two areas directly (**REASON:** indirect travel, which made the employees travel extra distance, was found between these two areas, which caused danger and fatigue).

Figure 10. The Current Layout of Owen Hall Kitchen, MSU.

Each capital letter stood for one work center, and 13 work centers have been designated for Owen kitchen. Dotted lines showed the aisles within work centers.



A
Receiving
Aisle
M
Sani-
tation
L
Supervisors'
Office
B
Refrigerator
C
Freezer
D
Dry Storage
Manager's
Office
I
Dish
Storage
H
Dish
Room
G
Cooking
F
Main
Preper-
ation
E
Salad
Sandwich
Dessert
Prep
J
Serving Line
K
Grill
0
5
10
15
20 ft

Figure 10.

Figure 11. The Revised Layout of Owen Hall Kitchen, MSU.

Three changes were made:

(1) eliminated the aisle between receiving area and kitchen, and rearranged supervisors' office, receiving, refrigerator, freezer and sanitation areas.

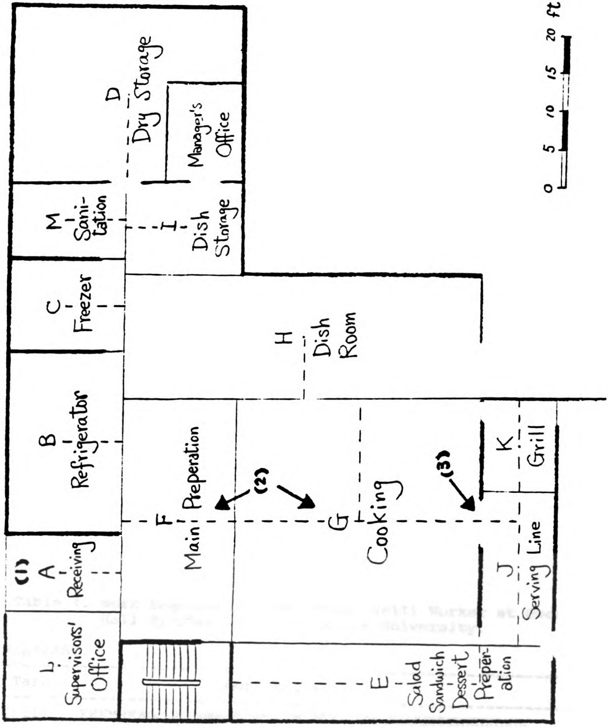
REASON: to shorten the distance between receiving and storage areas.

(2) rearranged cooking and main preparation areas.

REASON: to shorten the travel distance, especially of the cooks, according to the food flow path.

(3) made an aisle between cooking area and serving line so that the employees could travel "through" these two areas directly.

REASON: indirect travel was found between two areas, which caused danger and fatigue.



A Receiving
B Refrigerator
C Freezer
D Dry Storage
E Salad Sandwich Dessert Preperation
F Main Preperation
G Cooking
H Dish Room
I Dish Storage
J Serving Line
K Grill
L Supervisors' Office
M Sanitation
Manager's Office
(1)
(2)
(3)
0 5 10 15 20 ft

Figure 11.

C. Gathering Data

Each of the thirty-four foodservice employee positions at Owen Hall Kitchen was studied. A **Work Sequence** (movements among work centers), a **Frequency Chart**, a **Modified Frequency Chart**, and a **Modified Distance Chart** for performing each task were completed after each replication. The same procedure was repeated three times. Work sequences and charts are explained in detail below. For constructing of these charts, time was saved by use of a code letter to record each work center (versus descriptive words).

D. Work Sequences

A **Work Sequence** was defined as the order in which work centers were used to complete a task (Chapter 2). Only movements AMONG (versus WITHIN) work centers were recorded. In Table 4, for breakfast, the grill worker moved from work center K to E, then back to K, went to M later, and so on. Each capital letter stood for a work center.

Table 4. Work Sequence for Breakfast Grill Worker at Owen Hall Kitchen, Michigan State University.

BREAKFAST:

Task	Work Sequence
Grill	KEKMHKBGCGKIKDKGKJKHKGKJKJKJKGKGKDKHKBKMKHKDKBC DHKMKHKEKHMKLE

Capital letters indicated work centers. The Work Sequence recorded the order of work centers used by the breakfast grill worker to perform his task. (Reference: Kazarian, 1979.)

E. Frequency Chart, Modified Frequency Chart

Frequency Charts (Figure 12) were derived from the **Work Sequences**. A **Frequency Chart** may be defined as a summary of the quantity and direction of movements among work centers required for a task or set of tasks. The number of work centers on a layout has been used to determine the number of columns and rows of a **Frequency Chart**. Because there were 13 work centers in Owen Kitchen, the **Frequency Chart** was constructed to have 13 columns and 13 rows. Since no movement would be recorded from a work center to the work center itself, a diagonal was drawn through the square chart from the upper left to the lower right (Figure 12). The letter above the chart pointed out which work center a movement originated FROM while the letter at the left side of the chart indicated which work center the movement would go TO.

In Figure 12, the movements of the breakfast grill position were enumerated. For example, in column G and row K, "5" meant there were five movements from work center G to K. The **Frequency Chart** has been rewritten as a **Modified Frequency Chart** in Figure 13. Figure 13 showed the movements (without direction) as well as the relationship between each pair of work centers.

Work centers with most frequent movements should be placed as close to each other as possible in order to avoid excessive travel. In column G and row K of Figure 13, "9" meant there were 9 movements between work center G and K,

From (COLUMNS) / **To** (ROWS)

ROWS	A	B	C	D	E	F	G	H	I	J	K	L	M	Total
A														
B											3			
C		1					1							
D			1								3			
E											2	1		
F														
G		1	1								4			
H				1							5		1	
I											1			
J											4			
K		1		3	2		5	6	1	4			3	
L											1			
M								1			3			
Total		3	2	4	2		6	7	1	4	26	1	4	60

Breakfast- Grill

Capital letters indicated work centers. The FREQUENCY CHART gave a summary of the quantity and direction of movements among work centers required for a task or set of tasks. In column G and row K, "5" meant there were five movements from work center G to K (Kazarian, 1979).

Figure 12. Frequency Chart.

COLUMNS

ROWS

	A	B	C	D	E	F	G	H	I	J	K	L	M	Total
A														
B														
C		1												
D			1											
E														
F														
G		1	2											
H				1										
I														
J														
K		4		6	4		9	11	2	8				
L					1						1			
M								2			6			
Total		6	3	7	5		9	13	2	8	7			60

Breakfast- Grill

Capital letters indicated work centers. A MODIFIED FREQUENCY CHART showed the movements (without direction) and the relationship between each pair of work centers. In column G and row K, "9" meant there were nine movements BETWEEN work center G and K.

Figure 13. Modified Frequency Chart.

which was the sum of the movements from G to K and from K to G (5+4=9; Figure 14).

```
+-----------------+   +---------------+   +---------------+
|    Movements    |   |   Movements   |   |   Movements   |
|     between     | = |               | + |               |
|     G and K     |   | from G to K   |   | from K to G   |
+-----------------+   +---------------+   +---------------+
```

Both G and K were work centers.

Figure 14. Counting Movements Between Two Work Centers.

F. Distance Chart, Modified Distance Chart

The **Distance Chart** indicated the distance when moving from one work center to another. The **Distance Chart** was constructed in the same way as the **Frequency Chart** but distances between work centers were put into the squares rather than quantity of trips between work centers.

In column G and row K of Figure 15, "45.5" meant 45.5 feet was needed to travel from G to K. The distances were the same from G to K and from K to G, so the distance between G and K was also 45.5 feet. The **Distance Chart** could also be concentrated to half-sized (Figure 16) because the two sections in Figure 15 were symmetrical along the diagonal. **Distance Charts** were the same for all tasks if the arrangement of the kitchen remained unchanged. So only one **Distance Chart** (or **Modified Distance Chart**) per layout design was necessary.

From

To \ COLUMNS / ROWS	A	B	C	D	E	F	G	H	I	J	K	L	M
A		57.5	75.5	85.5	67	52.5	58.5	77.5	75.5	88	104	38.5	23.5
B	57.5		33	43	84.5	62	46	43	33	85.5	69.5	34	56
C	75.5	33		25	102.5	80	64	61	15	103.5	87.5	52	74
D	85.5	43	25		112.5	90	74	71	25	113.5	97.5	62	84
E	67	84.5	102.5	112.5		39.5	55.5	79.5	102.5	31	47	65.5	65.5
F	52.5	62	80	90	39.5		16	82	80	43.5	59.5	43	51
G	58.5	46	64	74	55.5	16		66	64	59.5	45.5	41	57
H	77.5	43	61	71	79.5	82	66		61	58.5	42.5	54	76
I	75.5	33	15	25	102.5	80	64	61		103.5	87.5	52	74
J	88	85.5	103.5	113.5	31	43.5	59.5	58.5	103.5		16	86.5	86.5
K	104	69.5	87.5	97.5	47	59.5	45.5	42.5	87.5	16		80.5	102.5
L	38.5	34	52	62	65.5	43	41	54	52	86.5	80.5		37
M	23.5	56	74	84	65.5	51	57	76	74	86.5	102.5	37	

Capital letters indicated work centers. The DISTANCE CHART indicated the distance when moving from one work center to another in the current layout of Owen kitchen. Values in two sides of the diagonal were symmetrical. In column G and row K, "45.5" meant 45.5 feet was required to travel from work center G to K. (Kazarian, 1979).

Figure 15. Distance Chart.

COLUMNS

ROWS	A	B	C	D	E	F	G	H	I	J	K	L	M
A													
B	57.5												
C	75.5	33											
D	85.5	43	25										
E	67	84.5	102.5	112.5									
F	52.5	62	80	90	39.5								
G	58.5	46	64	74	55.5	16							
H	77.5	43	61	71	79.5	82	66						
I	75.5	33	15	25	102.5	80	64	61					
J	88	85.5	103.5	113.5	31	43.5	59.5	58.5	103.5				
K	104	69.5	87.5	97.5	47	59.5	45.5	42.5	87.5	16			
L	38.5	34	52	62	65.5	43	41	54	52	86.5	80.5		
M	23.5	56	74	84	65.5	51	57	76	74	86.5	102.5	37	

Capital letters indicated work centers. The MODIFIED DISTANCE CHART was derived from the distance chart in which the data were paired. The modified distance chart provided a summary of the distance between each pair of work centers. In column G and row K, "45.5" meant 45.5 feet was required to travel between work center G to K.

Figure 16. Modified Distance Chart.

G. Travel Chart, Modified Travel Chart

By multiplying each value in the **Frequency Chart** by the symmetrical entry in the **Distance Chart** and putting the result in the appropriate "cell", the travel chart was constucted (Figure 17).

```
+-----------------+   +----------------+   +----------------+
|                 |   |                |   |                |
| Frequency Chart | x | Distance Chart | = |  Travel Chart  |
|                 |   |                |   |                |
+-----------------+   +----------------+   +----------------+
```

Figure 17. Derivation of Travel Chart.

The sum of the values shown in the lower right hand of the **Travel Chart** (Figure 18) was the total travel distance for the breakfast grill position (3447.0 feet). Again, a **Modified Travel Chart** (Figures 19 and 20) could be obtained without running the previous step for the simplification of calculation.

```
+-----------------+   +----------------+   +----------------+
|     Modified    |   |    Modified    |   |    Modified    |
|                 | x |                | = |                |
| Frequency Chart |   | Distance Chart |   |  Travel Chart  |
+-----------------+   +----------------+   +----------------+
```

Figure 19. Derivation of Modified Travel Chart.

H. Calculation

Because the study was focused on the comparison between two kitchen layouts, the **Work Sequences** of all the positions at Owen kitchen were used for the two layout

From

To \ From	A	B	C	D	E	F	G	H	I	J	K	L	M	Total
A														
B											208.5			
C		33					64							
D			25								292.5			
E											94	65.5		
F														
G		46	64								182			
H				71							212.5		76	
I											87.5			
J											16			
K		69.5		292.5	94		227.5	255	87.5	64			307.5	
L											80.5			
M								76			307.5			
Total														3447

Breakfast- Grill

Capital letters indicated work centers. The TRAVEL CHART stated the total travel distance for performing each task. The travel chart was the multiplication of the frequency chart and the distance chart. The value shown in the lower right corner of Travel Chart (3447 feet) was the total travel distance of the breakfast grill position for one meal (Kazarian, 1979).

Figure 18. Travel Chart.

COLUMNS

ROWS

	A	B	C	D	E	F	G	H	I	J	K	L	M	Total
A														
B														
C		33												
D			25											
E														
F														
G		46	128											
H				71										
I														
J														
K		278		585	188		409.5	467.5	175	128				
L					65.5						80.5			
M								152			615			
Total														3447

Breakfast- Grill

Capital letters indicated work centers. The MODIFIED TRAVEL CHART was derived from the travel chart (Figure 18) for the simplification of calculation. The modified travel chart was the multiplication of the modified frequency chart and the modified distance chart.

Figure 20. Modified Travel Chart.

designs (Figures 10 and 11). A comparison of the charts between the two layouts was summarized in Table 5.

Table 5. Comparison of Charts Between Two Layouts.

Work Sequence	: same
Frequency Chart	: same
Modified Frequency Chart	: same
Distance Chart	: different
Modified Distance Chart	: different
Travel Chart	: different
Modified Travel Chart	: different

A wage table of the workers at Owen kitchen (Table 6) was obtained from the Accounting Office of Owen Hall. If the average walking speed of workers at Owen kitchen was S feet/minute and he/she was paid W dollars per hour, then the money needed to pay for the walking of this particular worker per day would be

Formula 4: Travel Cost for Individual Worker per Day

$$L \text{ feet} \times \frac{1 \text{ min}}{S \text{ ft}} \times \frac{1 \text{ hr}}{60 \text{ min}} \times \frac{\$W}{1 \text{ hr}} = \frac{\$LW}{60S} = \$ \text{ paid for his/her walking}$$

where L = total distance traveled by the employee

W = wage of the employee

S = average walking speed of Owen employees.

There were 34 different positions at Owen kitchen per day, so the total money paid for their walking would be

Table 6. Wage Table at Owen Hall Kitchen, MSU.

	Positions	Wages/hr[a]
Full-Time Employees	Cook A	$9.46
	Cook B	$7.94
	Cook C	$8.23
	Stockperson	$8.87
	Salad person	$7.21
Student Employees	Student cooks	$4.19
	General shifts	$3.85

[a]Source: Accounting Office of Owen Hall, Michigan State University.

Formula 5: Total Travel Cost per Day

$$\frac{L_1 \times W_1}{60S} + \frac{L_2 \times W_2}{60S} + \ldots + \frac{L_{34} \times W_{34}}{60S}$$

$$= \sum_{i=1}^{34} \left(\frac{L_i \times W_i}{60S}\right) = \frac{1}{60S} \times \sum_{i=1}^{34} (L_i \times W_i).$$

where L_i = distance traveled by worker i

W_i = wage of worker i

S = average walking speed of Owen employees.

Owen Cafeteria has been open 7 days a week, 11 weeks per term and 4 terms per years. From discussion with the Food Service Manager of Owen Cafeteria, 50 years was estimated as the expected life of the facility. The total travel cost needed for performing tasks for 50 years under the current layout could be calculated as follows.

Formula 6: Total Travel Cost for Lifetime of Owen Kitchen

$$\frac{7 \text{ days}}{1 \text{ wk}} \times \frac{11 \text{ wks}}{1 \text{ term}} \times \frac{4 \text{ terms}}{1 \text{ yr}} \times \frac{50 \text{ yrs}}{\text{life}} \times \frac{1}{60S} \sum_{i=1}^{34} (L_i W_i)$$

$$= \frac{770}{3S} \sum_{i=1}^{34} (L_i W_i)$$

where L_i = distance traveled by worker i

W_i = wage of worker i

S = average walking speed of Owen employees.

With the same logic, the total travel cost for 50 years under the revised layout could also be calculated. Then, a comparison of the travel costs between these two layouts could be made and the possible money saved on employees' walking would be obtained.

Formula 7: Travel Cost Saved on the Revised Layout

$$\$\text{ Saved} = \frac{770}{3S}\left(\sum_{i=1}^{34} L_i W_i\right) - \frac{770}{3S}\left(\sum_{i=1}^{34} L'_i W_i\right) = \frac{770}{3S}\sum_{i=1}^{34}[(L_i - L'_i)W_i]$$

where L_i = distance traveled by worker i on the current layout

L'_i = distance traveled by worker i on the revised layout

$L_i - L'_i$ = decreased travel distance if the revised layout was used.

W_i = wage of worker i

S = average walking speed of Owen employees.

I. Summary

Thirty-four employee positions at Owen Kitchen, Michigan State University, were observed during three replications of the study. Figures 10 and 11 were the current and revised layout designs of Owen Kitchen. A Work Sequence, a Frequency Chart, a Modified Frequency Chart, and a Modified Distance Chart to perform each task were completed after each replication. The Modified Travel Chart was constructed by multiplying Modified Frequency Chart by Modified Distance Chart. Travel cost for individual worker per day was then obtained by combining total travel distance, wage and average walking speed. The sum of all the individual travel cost indicated the money paid for employees' walking every day, or the total travel cost per day. By multiplying the total travel cost per day by 50 years operation time, the total travel cost for lifetime of Owen Kitchen on the current layout was calculated. The lifetime travel cost on the revised layout could be also obtained with the same logic. Thus a comparison between the two layout designs against travel dollars could be made.

RESULTS AND DISCUSSION

At the time of this study, excluding the manager, full and part time supervisors and cashiers, Owen Cafeteria employed five full time and twenty-nine part time positions. Each of the thirty-four positions was observed during three replications of this study. This effort resulted in 102 observations for the current layout design. The observations took seven weeks (approximately 170 working hours) and included ninety-two different employees.

A. Data Collection and Manipulation

Since there were 102 observations in this study, 102 **Modified Frequency Charts** were prepared after data collection. Again, these charts indicated very clearly the movement between each pair of work centers. A **Modified Distance Chart** also could be completed for either the current layout (Figure 16) or the revised layout (Figure 21). As long as the layout was kept the same, the Modified Distance Chart would not change. For each position at Owen Kitchen, a comparison table between two layouts was prepared by combining the Modified Frequency Chart and the Modified Distance Chart.

COLUMNS

ROWS

	A	B	C	D	E	F	G	H	I	J	K	L
A												
B	32											
C	50	33										
D	70	53	35									
E	57.5	74.5	92.5	112.5								
F	22	25	43	63	49.5							
G	45.5	48.5	66.5	86.5	48	23.5						
H	62	45	51	71	74.5	40	31.5					
I	60	43	25	25	102.5	53	81.5	61				
J	72.5	75.5	93.5	97.5	31	50.5	27	58.5	103.5			
K	76.5	71.5	77.5	113.5	47	54.5	31	42.5	87.5	16		
L	27	44	62	82	51.5	34	57.5	74	72	72.5	88.5	
M	61	44	26	24	103.5	54	77.5	62	16	104.5	88.5	73

Capital letters indicated work centers. In column G and row K, "31" meant 31 feet would be required to travel between work center G and K if the revised layout (Figure 11) was used. movements from work center G to K.

Figure 21. Modified Distance Chart of Revised Layout of Owen Hall Kitchen, Michigan State University.

In Table 7, Column P indicated the movement between each pair of work centers, Column Q indicated the frequencies and, Columns R and S showed the travel distance of the breakfast grill person, who was doing short orders from 6:30 a.m. to 10:15 a.m., according to the current layout while Columns T and U showed similar information for the revised layout. The last row of Table 7 showed that the breakfast grill worker traveled 3347.0 feet while performing his task on the current layout and 3320.0 feet on the revised layout. Thus, 127.0 feet of required travel distance would be decreased (improved) for this task if the revised layout would have been used. Values with minus signs in the last column of Table 7 indicated when longer travel distances would be required for the revised layout.

B. Model Approach

For the observation of each worker, an individual comparison table was constructed as shown in Table 7. Using the data from all possible Table 7's, a Summary Table of Distance Decreased may be constructed, and the mean and standard deviation of decreased distances were also calculated (Table 8). For example, the average improved travel distance of the three observations of the breakfast grill persons was 108.5 feet.

Table 7. Comparison Table for Breakfast Grill Worker (1 Meal).

Move	Freq	Current Layout		Revised Layout		Improved
		Distance	Subtotal	Distance	Subtotal	Current-Revised
P	Q	R	S	T	U	V
AB	0	57.5	.0	32.0	.0	.0
AC	0	75.5	.0	50.0	.0	.0
AD	0	85.5	.0	70.0	.0	.0
AE	0	67.0	.0	57.5	.0	.0
AF	0	52.5	.0	22.0	.0	.0
AG	0	58.5	.0	45.5	.0	.0
AH	0	77.5	.0	62.0	.0	.0
AI	0	75.5	.0	60.0	.0	.0
AJ	0	88.0	.0	72.5	.0	.0
AK	0	104.0	.0	76.5	.0	.0
AL	0	38.5	.0	27.0	.0	.0
AM	0	23.5	.0	61.0	.0	.0
BC	1	33.0	33.0	33.0	33.0	.0
BD	0	43.0	.0	53.0	.0	.0
BE	0	84.5	.0	74.5	.0	.0
BF	0	62.0	.0	25.0	.0	.0
BG	1	46.0	46.0	48.5	48.5	-2.5
BH	0	43.0	.0	45.0	.0	.0
BI	0	33.0	.0	43.0	.0	.0
BJ	0	85.5	.0	75.5	.0	.0
BK	4	69.5	278.0	71.5	286.0	-8.0
BL	0	34.0	.0	44.0	.0	.0
BM	0	56.0	.0	44.0	.0	.0
CD	1	25.0	25.0	35.0	35.0	-10.0
CE	0	102.5	.0	92.5	.0	.0
CF	0	80.0	.0	43.0	.0	.0
CG	2	64.0	128.0	66.5	133.0	-5.0
CH	0	61.0	.0	51.0	.0	.0
CI	0	15.0	.0	25.0	.0	.0
CJ	0	103.5	.0	93.5	.0	.0
CK	0	87.5	.0	77.5	.0	.0
CL	0	52.0	.0	62.0	.0	.0
CM	0	74.0	.0	26.0	.0	.0
DE	0	112.5	.0	112.5	.0	.0
DF	0	90.0	.0	63.0	.0	.0
DG	0	74.0	.0	86.5	.0	.0
DH	1	71.0	71.0	71.0	71.0	.0
DI	0	25.0	.0	25.0	.0	.0
DJ	0	113.5	.0	97.5	.0	.0
DK	6	97.5	585.0	113.5	681.0	-96.0
DL	0	62.0	.0	82.0	.0	.0
DM	0	84.0	.0	24.0	.0	.0
EF	0	39.5	.0	49.5	.0	.0
EG	0	55.5	.0	48.0	.0	.0
EH	0	79.5	.0	74.5	.0	.0
EI	0	102.5	.0	102.5	.0	.0
EJ	0	31.0	.0	31.0	.0	.0
EK	4	47.0	188.0	47.0	188.0	.0
EL	1	65.5	65.5	51.5	51.5	14.0

Table 7 (cont'd.)

Move	Freq	Current Layout		Revised Layout		Improved
		Distance	Subtotal	Distance	Subtotal	Current-Revised
P	Q	R	S	T	U	V
EM	0	65.5	.0	103.5	.0	.0
FG	0	16.0	.0	23.5	.0	.0
FH	0	82.0	.0	40.0	.0	.0
FI	0	80.0	.0	53.0	.0	.0
FJ	0	43.5	.0	50.5	.0	.0
FK	0	59.5	.0	54.5	.0	.0
FL	0	43.0	.0	34.0	.0	.0
FM	0	51.0	.0	54.0	.0	.0
GH	0	66.0	.0	31.5	.0	.0
GI	0	64.0	.0	81.5	.0	.0
GJ	0	59.5	.0	27.0	.0	.0
GK	9	45.5	409.5	31.0	279.0	130.5
GL	0	41.0	.0	57.5	.0	.0
GM	0	57.0	.0	77.5	.0	.0
HI	0	61.0	.0	61.0	.0	.0
HJ	0	58.5	.0	58.5	.0	.0
HK	11	42.5	467.5	42.5	467.5	.0
HL	0	54.0	.0	74.0	.0	.0
HM	2	76.0	152.0	62.0	124.0	28.0
IJ	0	103.5	.0	103.5	.0	.0
IK	2	87.5	175.0	87.5	175.0	.0
IL	0	52.0	.0	72.0	.0	.0
IM	0	74.0	.0	16.0	.0	.0
JK	8	16.0	128.0	16.0	128.0	.0
JL	0	86.5	.0	72.5	.0	.0
JM	0	86.5	.0	104.5	.0	.0
KL	1	80.5	80.5	88.5	88.5	-8.0
KM	6	102.5	615.0	88.5	531.0	84.0
LM	0	37.0	.0	73.0	.0	.0
	60		3,447.0		3,320.0	127.0

Column P = Movement between each pair of work centers where capital letters A to M indicated work centers at Oven Kitchen.
Column Q = Frequency of movements between each pair of work centers.
Column R = Distance (feet) between each pair of work centers based on the current layout.
Column S = Required travel distance (feet) between each pair of work centers based on the current layout.
= Column Q x Column R.
Column T = Distance (feet) between each pair of work centers based on the revised layout.
Column U = Required travel distance (feet) between each pair of work centers based on the revised layout.
= Column Q x Column T.
Column V = Decreased travel distance (feet) between each pair of work centers if the revised layout, rather than the current layout, was used.
= Column S - Column U.
Values in the last row indicated the sums of the columns.

Table 8. Summary of Distance Decreased on Revised Layout.

	Position	Replications (a) 1st	2nd	3rd	(b) AVE	(c) STD
F	Cook A	2,937.0	2,849.5	2,971.0	2,919.2	51.2
F	Cook B	3,974.5	3,454.5	3,521.5	3,650.2	231.0
F	Cook C	2,949.5	2,464.5	2,311.5	2,575.2	272.0
F	Stockperson	662.0	626.0	711.0	666.3	34.8
F	Salad Person	-3.0	-37.0	77.5	12.5	48.0
B	Grill	127.0	104.5	94.0	108.5	13.8
B	Line Serve	1,001.0	928.0	1,030.0	986.3	42.9
B	Dish Room	231.0	223.0	229.0	227.7	3.4
B	Pot & Pan	106.0	114.0	118.0	112.7	5.0
B	Dessert Prep	141.0	136.0	137.5	138.2	2.1
B	Student Cook	509.5	547.0	515.0	523.8	16.5
L	Salad Serve	-241.0	-204.0	-236.0	-227.0	16.4
L	Utility	-6.0	14.5	-3.5	1.7	9.1
L	Grill	1,395.5	1,365.5	1,426.5	1,395.8	24.9
L	Truck	2,045.0	2,454.0	2,410.0	2,303.0	183.3
L	Line Serve	189.5	148.0	176.0	171.2	17.3
L	Dish Room	341.0	368.5	323.0	344.2	18.7
L	Area	353.0	305.0	336.0	331.3	19.9
L	Pot & Pan	95.5	126.0	143.0	121.5	19.7
L	Student Cook	1,713.5	1,596.0	1,722.5	1,677.3	57.6
D	Salad Serve	319.5	349.5	320.5	329.8	13.9
D	Utility	517.0	492.0	536.0	515.0	18.0
D	Grill	1,250.5	1,270.0	1,229.5	1,250.0	16.5
D	Truck	2,770.5	2,584.5	2,834.5	2,729.8	106.0
D	Line Serve	477.0	558.0	439.0	491.3	49.6
D	Dish Room	460.0	479.0	525.0	488.0	27.3
D	Pot & Pan	76.0	90.0	76.0	80.7	6.6
D	Salad Prep	119.0	104.0	116.0	113.0	6.5
D	Student Cook	1,403.5	1,212.5	1,217.5	1,277.8	88.9
N	Grill	851.5	705.0	872.5	809.7	74.5
N	Pizza	1,049.0	1,047.5	1,109.0	1,068.5	28.6
N	Sanitation	224.0	334.0	370.0	309.3	62.1
N	Extra	332.0	487.0	351.0	390.0	69.0
N	Sandwich Prep	255.5	271.5	255.5	260.8	7.5

(unit:feet)

F = Full Time
B = Breakfast
L = Lunch
D = Dinner
N = Night

(a) One replication = one day for full time employees or one shift for part time workers.
(b) AVE = average of the three replications.
(c) STD = standard deviation of the three replications.

According to Formula 7 presented in Chapter 3, the money saved on employees' walking, if the revised layout was selected, would be

Formula 7: Travel Cost Saved on the Revised Layout for 50 Years

$$\frac{770}{3S} \sum_{i=1}^{34} [(L_i - L'_i) W_i]$$

where $L_i - L'_i$ = Decreased travel distance using the revised layout (feet)

W_i = Wage (dollars/hour)

S = Average walking speed of Owen employees (feet/minute).

In Table 9, the sum of $(L_i - L'_i) \times W_i$ equaled 155,545.2 (feet-dollars/hour). By observation, the average walking speed of Owen employees was 209.3 feet per minute (Table 10). So, the possible money saved on Owen employees' transportation when performing their tasks using the revised layout design (Figure 11) turned out to be $190,746.61 for 50 years.

The average wage for the five full time employees of Owen Kitchen at Michigan State University in this study was $8.34 per hour while $3.89 per hour was the average wage for the twenty-nine part time positions. Full time employees were paid $4.45 per hour or 115.58% higher than part time workers at Owen Kitchen.

Note that in Table 9, when the revised layout was used, the total travel distance saved for the full time

Table 9. Combination of Wage and Distance Decreased.

	Position	W Wage (a)	$L_i - L'_i$ Improved (b)	$(L_i - L'_i)W$ \$ x feet (c)
F	Cook A	9.46	2,919.2	27,615.6
F	Cook B	7.94	3,650.2	28,982.6
F	Cook C	8.23	2,575.2	21,193.9
F	Stockperson	8.87	666.3	5,910.1
F	Salad Person	7.21	12.5	90.1
			9,823.4	83,792.3
B	Grill	3.85	108.5	417.7
B	Line Serve	3.85	986.3	3,797.3
B	Dish Room	3.85	227.7	876.6
B	Pot & Pan	3.85	112.7	433.9
B	Dessert Prep	3.85	138.2	532.1
B	Student Cook	4.19	523.8	2,194.7
L	Salad Serve	3.85	-227.0	-874.0
L	Utility	3.85	1.7	6.5
L	Grill	3.85	1,395.8	5,373.8
L	Truck	3.85	2,303.0	8,866.6
L	Line Serve	3.85	171.2	659.1
L	Dish Room	3.85	344.2	1,325.2
L	Area	3.85	331.3	1,275.5
L	Pot & Pan	3.85	121.5	467.8
L	Student Cook	4.19	1,677.3	7,027.9
D	Salad Serve	3.85	329.8	1,269.7
D	Utility	3.85	515.0	1,982.8
D	Grill	3.85	1,250.0	4,812.5
D	Truck	3.85	2,729.8	10,509.7
D	Line Serve	3.85	491.3	1,891.5
D	Dish Room	3.85	488.0	1,878.8
D	Pot & Pan	3.85	80.7	310.7
D	Salad Prep	3.85	113.0	435.1
D	Student Cook	4.19	1,277.8	5,354.0
N	Grill	3.85	809.7	3,117.3
N	Pizza	3.85	1,068.5	4,113.7
N	Sanitation	3.85	309.3	1,190.8
N	Extra	3.85	390.0	1,501.5
N	Sandwich Prep	3.85	260.8	1,004.1
			18,329.9	71,752.9
		Total =	28,153.3 feet	155,545.2 feet-dollars/hour

F = Full Time
B = Breakfast
L = Lunch
D = Dinner
N = Night

Column a = Wage (dollars/hour) of each employees.
Column b = Decreased travel distance (feet) of each employee if the revised layout, rather than the current layout, was used.
Column c = Column a x Column b.

Table 10. Average Walking Speed of Owen Hall Employees

	Position	Replications 1st	2nd (feet/minute)	3rd
F	Cook A	207.0	213.0	206.0
F	Cook B	216.0	218.0	208.0
F	Cook C	200.0	202.0	210.0
F	Stockperson	198.0	194.0	203.0
F	Salad Person	203.0	209.0	207.0
B	Grill	219.0	218.0	211.0
B	Line Serve	209.0	219.0	210.0
B	Dish Room	204.0	210.0	206.0
B	Pot & Pan	214.0	207.0	204.0
B	Dessert Prep	212.0	206.0	213.0
B	Student Cook	208.0	208.0	211.0
L	Salad Serve	207.0	214.0	202.0
L	Utility	211.0	215.0	216.0
L	Grill	216.0	202.0	207.0
L	Truck	201.0	213.0	212.0
L	Line Serve	214.0	205.0	207.0
L	Dish Room	207.0	209.0	204.0
L	Area	217.0	210.0	210.0
L	Pot & Pan	204.0	206.0	201.0
L	Student Cook	213.0	219.0	215.0
D	Salad Serve	213.0	208.0	207.0
D	Utility	207.0	210.0	213.0
D	Grill	220.0	213.0	214.0
D	Truck	214.0	215.0	209.0
D	Line Serve	216.0	218.0	205.0
D	Dish Room	204.0	203.0	204.0
D	Pot & Pan	208.0	208.0	203.0
D	Salad Prep	209.0	211.0	207.0
D	Student Cook	209.0	214.0	215.0
N	Grill	210.0	204.0	218.0
N	Pizza	212.0	206.0	207.0
N	Sanitation	203.0	206.0	199.0
N	Extra	224.0	203.0	213.0
N	Sandwich Prep	209.0	209.0	205.0

Average = 209.3 feet/minute
Standard Deviation = 5.5

F = Full Time
B = Breakfast
L = Lunch
D = Dinner
N = Night

One replication = one day for full time employees or one shift for part time workers.

workers was 9,823.4 feet, and 18,329.9 feet for the part time workers. The subtotal of $(L_i - L'_i)Wi$ for the five full time employees was 83,792.3 (feet-dollars/hours), and 71,752.9 for the twenty-nine part time positions.

Formula 8: Contribution to the Saved Travel Cost

$$\frac{770}{3S}\sum_{i=1}^{34}[(L_i - L'_i)W_i]$$

$$= \frac{770}{3S}\sum_{i=1}^{5}[(L_i - L'_i)W_i] + \frac{770}{3S}\sum_{i=6}^{34}[(L_i - L'_i)W_i]$$

$$= \frac{770}{3S}(\$83,792.3) + \frac{770}{3S}(\$71,752.9)$$

$$= \$102,755.32 + \$87,991.29$$

$$= \$190,746.61$$

where i = Full time worker when i = 1-5

i = Part time worker when i = 6-34

$L_i - L'_i$ = Decreased travel distance using the revised layout (feet)

W_i = Wage (dollars/hour)

S = Average walking speed of Owen employees

= 209.3 feet/minute.

For 50 years, according to Formula 8, the money saved on full time employees' walking was \$102,755.32, out of \$190,746.61, if the revised layout was used. The money saved on the travel of the five, out of thirty-four, full time employees contributed 53.87% of the total travel dollars saved. On the other hand, the travel cost of the twenty-nine part time positions decreased $87,991.29 when the revised layout was used, representing only 46.13% of the total saved travel cost. This implied that trying to reduce the travel time of full time workers (higher-paid) could be more valuable in cutting costs.

C. Discussion

In evaluating foodservice layouts, minimizing labor costs has been an indicator of good layout designs. Wages are paid to the people, not to the food. The pattern of movement of the employees, rather than that of the food, should be followed if a study of a foodservice kitchen was planned from the standpoint of minimizing labor costs. Excessive travel while performing the task has usually been undesirable but could be minimized by careful planning. Combination of these two criticisms made a more effective evaluating method than either of them.

Obviously, there were many other factors which could affected the total labor budget, such as quantity of food moved, architectural considerations, and remodeling fees. Expenses of the remodeling project would not necessarily be covered by $190,746.61 but, rather than the amount of remodeling fees, evaluation among different layout proposals BEFORE construction was the focus of this study.

The author of this study intended that the **Distance-Wage Method** could be used to determine which layout should be chosen to minimize the travel distance, especially of high-salaried personnel because effects made by the travel of higher-paid workers were greater than those made by the travel of lower-paid ones.

If the travel distance could be shortened, the production time (hence labor cost) would be decreased, effort and fatigue of employees would be minimized, and the supervision of employees would be simplified (Kahrl, 1977). Employees would be able to perform the same tasks with less time and effort, and managers would spend less money for transportation by employees. Over the lifetime of the foodservice production kitchen, a reasonably large amount of labor money could be saved!

SUMMARY AND CONCLUSIONS

The **Distance-Wage Method** is a mathematical procedure to analyze foodservice layouts for the cost of relative travel distance. The Distance-Wage Method had three unique characteristics compared to other methods discussed in Chapter 2: (1) wage factor, (2) focus on whole kitchen, and (3) new calculation procedure.

The purpose of this study was to evaluate the **Distance-Wage Method** by obtaining data on travel time and costs for two layouts of Owen Kitchen at Michigan State University. The layout with the least employee travel cost according to the Distance-Wage Method would be recommended for use from the standpoint of reducing costs.

Because indirect travel, which made the employees travel extra distance, was found in the current Owen Kitchen, three changes were suggested in the revised layout. A **Modified Frequency Chart** and a **Modified Distance Chart** for performing each task were completed after observation, and the same procedure was repeated three times.

In this study, the full time employees at Owen Kitchen (with average wage of $8.34/hour) were paid $4.45 per hour or 115.58% more than the part time workers (with average wage of $3.89/hour). According to the data gathered from this study, $190,746.61 would be expected to be saved on transportation by Owen employees when performing their tasks if the revised layout would be used for 50 years. Fifty-four percent ($102,755.32) of the total saved dollars was contributed by the decreased travel cost of the five full time workers while forty-six percent ($87,991.29) was contributed by that of the twenty-nine part time positions.

This did not necessarily mean that the revised layout should be selected now because of other concerns, such as quantity of food moved, managerial techniques, architectural considerations, remodeling fees, and the menu itself. However, results of this study suggested that management should try hard to shorten the travel distance of higher-paid employees to reduce labor costs.

Recommendations for Further Research

Quantity of food moved could make a difference in material handling costs when evaluating layout designs. As previously mentioned, it would be very difficult to record the weight of the food or materials each foodservice employee carried during each walking period. Further studies therefore would be needed to try to take weight into consideration in evaluating layout proposals.

For a particular case such as Owen Hall Kitchen, it took the author himself seven weeks (approximately 170 working hours) for data collection using the Distance-Wage Method. The observation procedure would probably be regarded as tiring. However, since the workers in each part time position at Owen Hall Kitchen were changed frequently, observations of different workers performing a given task would have to be made. More observers would be very helpful and work sampling might be done by using video equipment whenever possible.

Since the Distance-Wage Method required a lot of mathematic calculations, use of computer technology to save time and obtain accurate results is recommended. Different travel routes could vary the walking distance to perform a task. Management should conduct training programs to teach employees the best and the shortest way to travel and perform their tasks. Engineers and architects should be consulted before a new layout design is built to stay within the limits of building codes.

Results of this study were, of course, limited by the number of observations made. In addition, the lack of standardization of work sequences made the analysis process difficult. This was the reason that the identical work sequence was used in the comparison between two kitchen layouts.

Although the using of the Distance-Wage Method was demonstrated in the kitchen of a university dormitory cafeteria, there would be no reason why the Method should not be of value for other foodservice layout designs. The contribution of the Distance-Wage Method was to serve as a starting point for related studies and, to provide the foodservice industry with an evaluation process among different layout proposals. Further research, such as computer applications in the evaluation process of foodservice layouts and effects made by employee training programs, would be needed to expand the area of this study, and to develop a reliable evaluation model which could really select the ideal foodservice layout design.

REFERENCES

Alber, Carl H. 1974. **Food and Beverage Cost Planning and Control procedures.** The Educational Institute of the American Hotel and Motel Association, East Lansing, Michigan.

Amrine, Harold T., Ritchey, John A. and Hulley, Oliver S. 1982. **Manufacturing Organization and Management.** Prentice-Hall, Inc., Englewood Cliffs, NJ.

Avery, Arthur C. 1974. Development and evaluation of hospital kitchen rehabilitation layout design system. **Food Service Trends.** Cahners Books, Boston, Mass.

Avery, Arthur C. 1973. Equipment arrangement for greater worker productivity. **Increasing Productivity in Foodservice.** Cahners Books, Boston, Mass.

Bloom, Thomas A. 1981. Careers in the 1980's for the foodservice and lodging industries. **Introduction to Hotel and Restaurant Management.** Kendall/Hunt Publishing Company, Dubuque, Iowa.

Brimeyer, James L. and Sink, D. Scott. 1981. Productivity measurement and improvement: a participative approach. A report of **Productivity Management Conference.** Oklahoma Center for Continuing Education, Oklahoma.

Buffa, Elwood S. 1983. **Modern Production/Operations Management.** John Wiley & Sons, New York.

Cameron, D. C. 1952. Travel charts-a tool for analyzing material movement problems. **Modern Materials Handling** (January, 1952): 37-40.

Chase, Richard B. and Aquilano, Nicolas J. 1977. **Production and Operations Management.** Richard D. Irwin, Inc., Homewood, IL.

Dilworth, James B. 1986. **Production and Operations Management: Manufacturing and Nonmanufacturing.** Random House, Inc., New York.

Dreis, Timothy E. 1982. **A Survivor's Guide to Effective Restaurant Pricing Strategy.** Chain Store Publishing Company, New York.

Dukas, Peter. 1976. **Planning Profits in the Food and Lodging Industry.** Cahners Publishing Company, Boston, Mass.

Evans, James R., Anderson, David R., Sweeney, Dennis J., and Williams, Thomas A. 1984. **Applied Production and Operations Management.** West Publishing Company, St. Paul, MN.

Fearon, Harold E, et al. 1983. **Fundamentals of Production/ Operations Management.** West Publishing Co., St. Paul, MN.

Feinberg, Mortimer R. 1985. Time to adjust your internal clock. **Restaurant Business** 84/5: 96.

Gottlieb, Regina and Couch, Mary A. 1960. Using the cross chart in planning kitchen layouts. **Journal of the American Dietetic Association** 36/6: 585-592.

Greene, James H. 1984. **Operations Management:Productivity and Profit.** Reston Publishing Co., Inc., Reston, VA.

Heyel, Carl and Nance, H. W. 1984. **The Foreman/Supervisor's Handbook.** Van Nostrand Reinhold Company Inc., New York.

Ireson, William Grant. 1954. **Factory Planning and Plant Layout.** Prentice-Hall, Inc., New York.

Kahrl, William. 1978. **Food Service Equipment.** Lebhar-Friedman Books, New York.

Kahrl, William L. 1977. **Advanced Modern Food and Beverage Service.** Prentice-Hall, Inc., Englewood Cliffs, N.J.

Kazarian, Edward A. 1979. **Work Analysis and Design for Hotels, Restaurants and Institutions.** Avi Publishing Company, Westport, Conn.

Ketterer, Manfred. 1982. **How to Manage a Successful Catering Business.** Hayden Book Company, Rochelle Park, N.J.

Kotschevar, Lendal H. and Terrell, Margaret E. 1985. **Foodservice Planning: Layout and Equipment.** John Wiley & Sons, New York.

Lang, Joan. 1985. Kitchen design. **Restaurant Business** 84/4: 135-146, 148-151.

Lawson, Fred. 1978. **Principles of Catering Design.** The Artitectural Press, London.

Lee, Robert C. and Moore, James M. 1967. CORELAP-COmputerized RElationship LAyout Planning. **Industrial Engineering** 18/3: 195-200.

Lundy, James L. 1955. A reply to prof. Wayland P. Smith's article: travel charting-first air for plant layout. **Journal of Industrial Engineering** (May, 1955): 9, 29.

Mayer, Raymond R. 1982. **Production and Operations Management.** McGraw-Hill Book Company, New York.

Menipaz, Ehud. 1984. **Essentials of Production and Operations Management.** Prentice-Hall, Inc., Englewood Cliffs, NJ.

Moore, James M. 1971. Computer program evaluates plant layout alternatives. **Industrial Engineering** 3/8: 19-25.

Moore, James M. 1962. **Plant Layout and Design.** The Macmillan Company, New York.

Muther, Richard. 1976. **Systematic Layout Planning.** Cahners Book, Boston, Mass.

Peters, Michael and Oliva, Terence. 1981. **Operations and Production Management.** Prindle, Weber & Schmidt, Boston.

Powers, Thomas F. and Powers, Jo Marie. 1984. **Food Service Operations: Planning and Control.** John Wiley & Sons, New York.

Prokosch, S. Cecelia. 1972. **Guide to Foodservice Management.** Cahners Books, Boston, Mass.

Riggs, James L. 1981. **Production Systems:Planning, Analysis and Control.** John Wiley & Sons, New York.

Schroeder, Roger G. 1985. **Operations Management: Decision Making in the Operations Function.** McGraw-Hill Book Company, New York.

Splaver, Bernard R. 1982. **Successful Catering.** CBI Publishing Company, Boston, Mass.

Stokes, Judy Ford. 1985. **Cost Effective Quality Food Service: An Institutional Guide.** Aspen Systems Corporation, Germantown, Maryland.

Tompkins, James A. and White, John A. 1984. **Facilities Planning.** John Wiley & sons, New York.

Van Dress, Michael G. 1982. **The Foodservice Industry: Structure, Organization, and Use of Food, Equipment, and Supplies.** U.S. Department of Agriculture, Washington, D.C.

VanEgmond-Pannell, Dorothy. 1985. **School Foodservice.** Avi Publishing Company, Westport, Conn.

Wolson, Shelly. 1985. Operators are increasing on-campus choices. **Restaurants & Institutions** 95/2: 164-166, 195.

Zaccarelli, Brother Herman E. 1983. **The Future of Food Service Management.** Purdue University, West Lafayette, Indiana.