No. 5

USING COMPUTER SIMULATION TO SOLVE SCHOOL FOODSERVICE PROBLEMS

A PUBLICATION FOR CHILD NUTRITION PROFESSIONALS FROM THE NATIONAL FOOD SERVICE MANAGEMENT INSTITUTE

OVERVIEW

Congress mandated the National Food Service Management Institute (NFSMI) to conduct applied research to improve the quality and cost effectiveness of Child Nutrition Programs (CNPs). Among the research activities that have relevance to CNPs is the use of analytical techniques involving current technology to solve day-to-day operational problems. Engineering and other professions have used these methods for several decades.

This study was initiated to determine the feasibility of using computer simulation techniques to answer questions associated with customer service in CNPs. Results suggested that simulation does have relevance in solving CNP operational problems although the exacting procedures of computer simulation methodology present many challenges.

RESEARCH

Computer simulation has been used in foodservice management since the 1960s, but it has not been applied to the CNP arena. Simulation is a process that uses a computer to design a model of a real system. We use computer models to learn something about a real life situation that cannot be altered directly, either because the system does not yet exist or it is too difficult to change just for experimental purposes. Simulation models can help explain, understand, or improve a system. The purpose of simulation modeling is to help the decision maker solve a problem.

OBJECTIVES

The purpose of this NFSMI research project was to explore applications for computer simulation in school foodservice operations. The specific objectives of this study were to:

- find out the impact of changing foodservice assistants' responsibilities for serving meals from a serving line on the time it takes elementary students to be served; and
- examine the effect of altering class arrival times into the cafeteria on the total time for a student to move through the serving line.

METHOD

RESEARCH SITE

To build a computer simulation model, we needed to document times associated with service procedures in an actual school cafeteria. One district school foodservice director from a small school district agreed to allow data collection for the research study. Children in grades four through six attended this elementary school. The menu consisted of choices of entrees, vegetables, and fruit items each day. The foodservice staff placed at least one menu item on the compartment tray and the students picked up the other food items. We videotaped the lunch period and recorded the time required for students to receive a compartment tray; pick up food items, such as milk; and be processed by a cashier.

Two days during the data collection period only one foodservice assistant served hot food to the students. Two employees were on the serving line the other seven days. All observations were videotaped for frequency of food pan changes, time between food pan changes, and time to serve teachers for the seven days when two foodservice assistants were on the serving line. The school manager provided estimates of the number of students released at one time into the cafeteria for use in the computer model.

SIMULATION MODEL

We worked with a consultant from Systems Modeling Corporation to build the simulation model using ARENA software (*Figure 1*). After the model was functionally complete, the model was verified and validated. Verification seeks to show that the computer program does as expected and intended, thus providing a correct logical representation of the cafeteria system being modeled. Validation establishes that model behavior accurately represents that of the real-world system being simulated.

ANIMATION OF THE SIMULATION MODEL

The simulation model can be run using graphics. *Figure 2* illustrates the model at one point during the simulation run. "Students in" was the count of students that have entered the cafeteria. "Hot Q" was the number of students waiting in line to receive a food tray. Here, one student was receiving a tray and four were waiting in the queue. "Cold Q" was the number of students waiting to pick up cold food items. The capacity of the cold food section was five; three students were moving through this station, thus, there were no students in the queue. "Cash Q" was the number of students waiting for the cashier. One student was being served by the cashier and one was waiting in line. "Students out" was the count of students processed through the serving line.

STAFFING SCENARIO

In the original data, two foodservice assistants served on the cafeteria line. When viewing the videotapes, we observed many delays due to stopping of the line to replace food pans. A research question was posed: *If there could be no changes in the arrival time of students into the cafeteria and staffing of the serving line, what could be done to speed the movement of students through the serving line?*

We proposed a simulation model which used one of the two foodservice assistants scheduled to work on the serving line as a kitchen runner. The responsibilities of this position would be to anticipate food pan exchanges, retrieve food from the kitchen, and thus reduce service delays due to food outages. Total time for students to go through the serving line and the number of students standing in line to receive a tray were calculated for:

- original arrival times with two foodservice assistants; and
- original arrival times with one foodservice assistant and a kitchen runner.

The average total time for a student to go through the serving line in the scenario with two foodservice assistants serving was 4 minutes 31 seconds. This average represented the time beginning when the class arrived in the cafeteria, a student received a compartment tray, picked up cold items and milk, and was processed by the cashier. The time ranged from 2 minutes 23 seconds to over 9 minutes for a student to go through the line.

COMPUTER SIMULATION SHOWED THAT THE USE OF A RUNNER TO STOCK THE CAFETERIA LINES COULD SAVE TIME AND INCREASE THE EFFICIENCY OF THE SERVING LINE. TOTAL STUDENT TIME THROUGH THE SERVING LINE DECREASED AN AVERAGE OF 2 MINUTES 33 SECONDS, OR 56 PERCENT.

When the simulation model altered the staffing pattern to use one foodservice assistant on the line and a kitchen runner, the average time decreased to 1 minute 58 seconds for a student to move through the cafeteria line. This time ranged from 1 minute 48 seconds to 2 minutes 17 seconds, and most children could obtain a lunch tray before the next class arrived in the cafeteria. *Figure 3* depicts the number of children waiting to receive their lunch tray taken from one replication. Each peak represents a class entering the cafeteria. When the line falls back to zero, indicated by the white space between the peaks, all children received a tray before another class entered the cafeteria. The solid areas between the peaks signified that children had not been served their lunch trays when the next class arrived. Clearly most of the children could obtain a lunch tray before the next class arrived in the cafeteria. In this example, there was only one instance where over 30 children were in line to receive a lunch tray. Computer simulation showed that the use of a runner to stock the cafeteria lines could save time and increase the efficiency of the serving line. Total student time through the serving line decreased an average of 2 minutes 33 seconds, or 56 percent.

ARRIVAL TIME SCENARIO

In the second scenario, we asked the following research question: *What effect does the sequencing of class arrival times have on the movement of students through the serving line?* The foodservice director had not indicated that scheduling was a problem in this school; however, the release of classes for mealtime is a point of frustration for many school foodservice directors. Too many students scheduled into the cafeteria at once create long lines and a decrease in the students' ability to eat and enjoy their meals. Longer lunch periods, a solution to the first situation, create havoc in academic scheduling for the school day. Ideal solutions are difficult to detect, but computer simulation represented an approach to use in analyzing alternatives. We wanted to test whether computer simulation could be used to analyze the flow of students into the cafeteria. Simulation allowed us to test scenarios without involving school administrators to alter meal schedules, and potentially disrupt lunch periods without knowing the end results.

We made several modifications in the arrival time of classes into the cafeteria. The simulation model was developed with one foodservice assistant serving on the cafeteria line and the second assistant as the kitchen runner. Total time for students to go through the serving line and the number of students in line to receive a tray were calculated.

In the original data for the elementary school, classes were being released into the cafeteria at various times. This time ranged from 1 minute to 7 minutes between arrival times of classes into the cafeteria. The number of students in each class ranged from 9 to 26. We ran the simulation model using several common arrival times: blocks of ten classes every 30 minutes; one class every 4 minutes; and two classes every 8 minutes.

As depicted in *Table 1* the average time for a student to go through the cafeteria line ranged from 1 minute 43 seconds to over 12 minutes. The arrival time of blocks of ten classes every 30 minutes scenario showed that students spent the longest time standing in line and moving through the serving line. Upon examination of the data from one replication, the minimum amount of time for a student to go through the line was 30 seconds. The maximum length of time in this replication was 27 minutes 52 seconds; thus, some students were in line almost 28 minutes. If students had 30 minutes in which to eat, it is doubtful whether some students would have time to eat their meals.

The scenario with arrival times of one class every 4 minutes moved students through the serving line in the least amount of time. When one replication was examined, the data ranged from 15 seconds to 3 minutes 42 seconds. The longest time any student had to wait in line in this replication was less than 4 minutes. A disadvantage is that this scenario lengthened the lunch period to two hours.

The scenario of two classes arriving every 8 minutes also extended the lunch period to two hours. However, the difference between this scenario and the one previously discussed is that two classes are arriving at the same time. Data from one replication showed that the maximum amount of time for a student to move through the cafeteria line was 6 minutes 27 seconds. A student possibly could be in line for over 6 minutes compared with less than 4 minutes in the previous scenario.

FIGURE 1

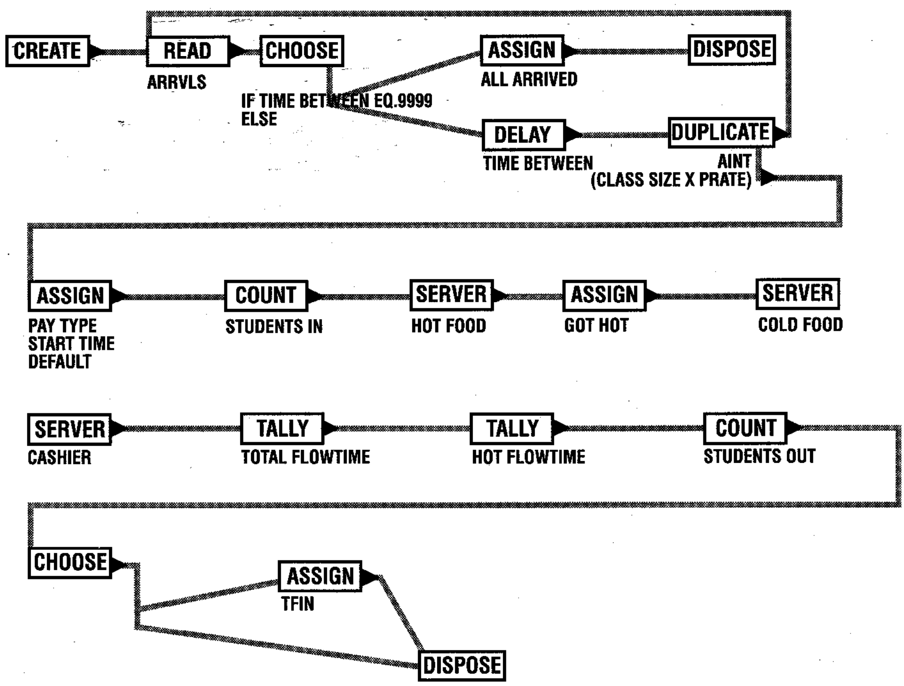

Figure 1. *Simulation Model*

FIGURE 2

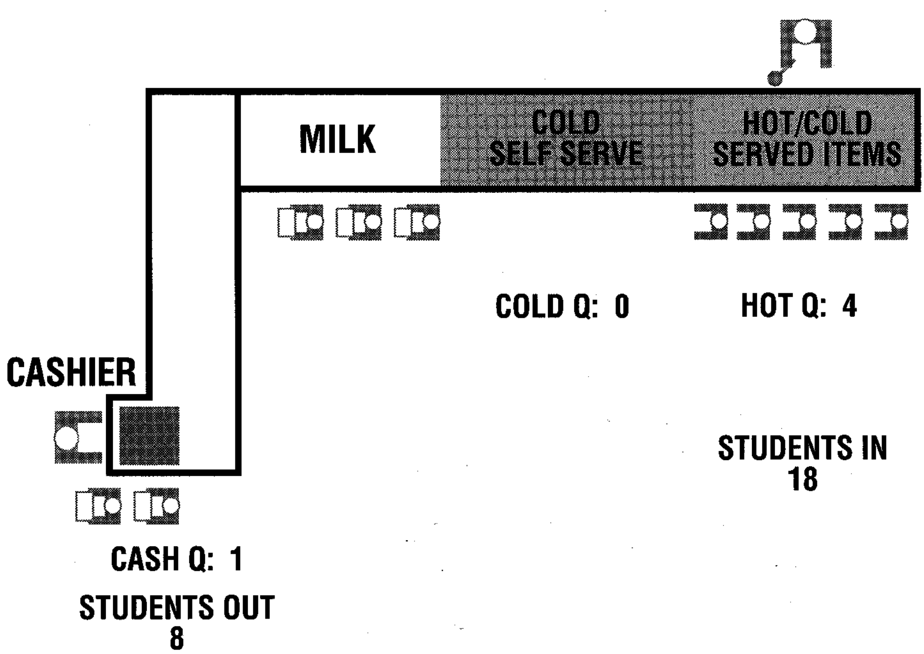

Figure 2. *Animated Simulation Model*

TABLE 1

AVERAGE TIME FOR A STUDENT TO MOVE THROUGH THE SERVING LINE FOR VARIOUS ARRIVAL RATES INTO THE CAFETERIA[a]

CLASS ARRIVAL RATE	AVERAGE TIME
Original data[b]	1 minute 58 seconds
Ten classes every 30 minutes[c]	12 minutes 49 seconds
One class every four minutes[c]	1 minute 43 seconds
Two classes every eight minutes[c]	2 minutes 55 seconds

[a] 95% Confidence level

[b] N = 60 replications

[c] N = 20 replications

NUMBER OF STUDENTS IN LINE

In the original data, most students could receive a lunch tray before the next class arrived in the cafeteria. Data from one replication showed the maximum number of students in line any time was 32.

When blocks of ten classes arrived in the cafeteria every 30 minutes, the number of students who had to stand in line to receive a lunch tray greatly increased. Data from one replication showed that as many as 202 students were in line to receive a lunch tray. All students did receive a tray before the next group of classes arrived; however, their time to eat was limited.

In the scenario of one class arriving every four minutes, all students in each class received lunch trays before the next class of students entered the cafeteria (*Figure 4*). When we examined the data from one replication, the maximum number of students waiting in line to receive a tray was 23. This closely corresponded to the number of students in each class.

All the students in the scenario of two classes arriving in the cafeteria every eight minutes also received their trays before the next block of classes reached the cafeteria (*Figure 5*). However, the number of students who had to

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stand in line to receive a lunch tray was greater. Data from one replication suggested that up to 43 students were standing in line to receive a tray.

We concluded that computer simulation is a viable alternative to generate strategies for evaluating meal schedules without physically moving students and disrupting the academic day. Only one of our scenarios slightly improved (15 seconds) the average time each student took to move through the serving line. If this improvement extended to at least 120 students, 30 minutes of time would be saved (120 x 15 seconds ÷ 60 = 30 minutes). This might make a difference in lunch time efficiency and student satisfaction. The benefit of computer simulation was that it allowed us to see the ebb and flow of student movement, determine the the minimum and maximum amount of time for a student to move through the serving line, and contrast average time through the line with total waiting time. This would be virtually impossible to do by simple observation.

PRACTICAL USE OF THIS INFORMATION

Other segments of the foodservice industry have used computer simulation very successfully. The purpose of this study was to explore applications for computer simulation in school foodservice operations. Through simulation, we developed scenarios to improve the efficiency of one type of service system that exists in school foodservice: a single line cafeteria serving a limited choice menu to elementary students. Use of this technology can provide information on alternate solutions to operational problems in school foodservice. NFSMI research scientists used simulation to show that altering staffing patterns and arrival times of classes into the cafeteria can greatly affect the time it takes students to go through the serving line. Specific conclusions include:

- Staffing patterns for serving lines should include a position for a runner to help the flow of food.
- Decisions regarding the arrival times of students into the cafeteria should be a careful balance between the amount of time students have to wait on the serving line and the total length of the meal period.

FIGURE 3

Figure 3. [a]

Number of children waiting to receive a lunch tray from the foodservice assistant and kitchen runner scenario

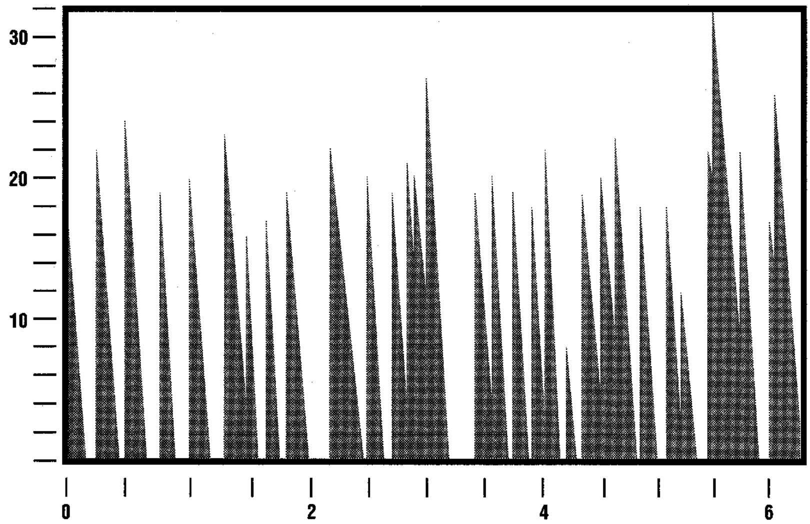


FIGURE 4

Figure 4. [a]

Number of children waiting to receive a lunch tray when one class was released every four minutes

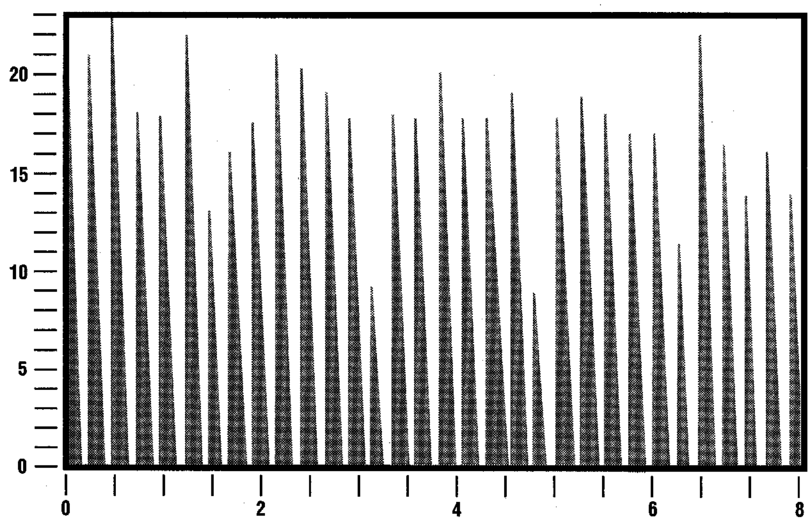
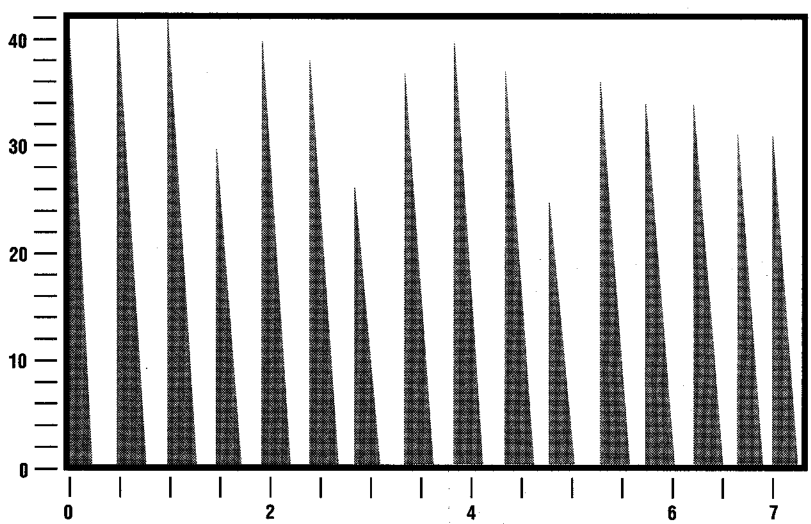


FIGURE 5

Figure 5. [a]

Number of children waiting to receive a lunch tray when two classes were released every eight minutes



[a] Each peak represents a class entering the cafeteria. When the line falls back to zero, indicated by the white space between the peaks, all children received a tray before the next class arrived. The solid areas between the peaks signified that all children had not received their lunch trays when the next class arrived.

FOR MORE INFORMATION

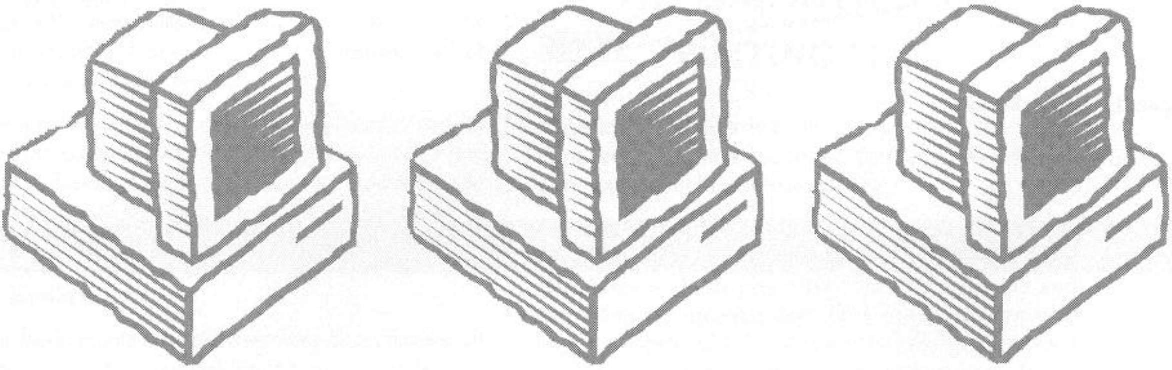
RESOURCES:

Nettles, M.F. (1995). *Use of computer simulation in school food service*, NFSMI-R21-95. University, MS: National Food Service Management Institute.

NFSMI. Champions of change: child nutrition personnel, TT102595, University, MS: author.

NFSMI. Go for the gold with customer service, ET9-94, University, MS: author.

NFSMI. Participation: The key to healthy food practices, TT30994, University, MS: author.



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