MICHIGAN STATE UNIVERSITY
COLLEGE OF HOME ECONOMICS
EAST LANSING, MICHIGAN

AN APPROACH TO SCHEDULING BY COMPUTER

By

Clara Louise Augustine
1014 North Fairview
Lansing, Michigan 48912

Address after August 20, 1966:

206 West Park Road
Iowa City, Iowa 52240

This study was carried out as a problem for partial fulfillment of the requirements for the Master of Science Degree in the Department of Institution Administration, College of Home Economics, Michigan State University, East Lansing. Mrs. Augustine, then a computer consultant in the College of Home Economics, did the research under the direction of Dr. Grace A. Miller and Dr. Frances M. Magrabi. Mrs. Augustine now resides in Iowa City, Iowa.

AN APPROACH TO SCHEDULING BY COMPUTER

General increases in the size and functions of many types of food service operations have added to the complexity of fitting the time and talents of available workers to a designated number of required operational tasks. In many cases, the development of economically operable work schedules is demanding a disproportionate amount of administrative time for completion of this very necessary but routine task.

In relation to hospital service, Casbergue (1) reported that the population growth and increasing demand for hospital care have outstripped the ability of hospitals to provide acceptable service. Fewer highly trained personnel are available to meet heavier and heavier demands. He stated that the time and energy of the dwindling number of skilled professionals must be conserved so they will be free to do the jobs for which they were trained and which only they are capable of performing. Routine tasks must be automated as much as possible.

Donaldson (2) stated that there are many possible applications of data processing and computer programming in the planning and operation of a dietary department which could greatly reduce the amount of time and money used for completion of routine tasks. In food service, areas that look promising for computer based automation include cost accounting, purchasing forecasts, recipe calculation, inventory control, nutritional analysis, and scheduling employees and work loads. (1)

Similarly, the accelerated growth in high school, college, and university enrollments has added to the complexity of developing schedules which permit all individuals to use their time optimally. Administrators and faculty need to use their time for instruction, professional counseling, guidance, and research and evaluation rather than for the detailed and routine task of scheduling classes for students, teachers, and physical facilities.

In discussing flexible scheduling of classes in secondary schools, Trump (3) pointed out that mechanical aids could simplify the process and help avoid conflicts, and alleviate some other operational problems that arise. He emphasized that, in planning, the concepts of schedule-making come first and the machines that facilitate the process come second.

Research in automating educational scheduling has centered around the problem of assigning students to a manually prepared master class schedule. (4) Recently, the master class schedule has been generated by computer with the inputs being student course demands, teacher preferences, administrative stipulations, and the physical plant facilities available. A computer program manipulates these data to generate a master class schedule as free of conflicts as possible, then prints out the student class schedules, teacher schedules, class lists, and other requested information.

THE PROJECT

A particular case which illustrates the concepts of schedule-making was the recurring problem which confronted the professor and graduate assistant responsible for the course HMC[1] 362,

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[1]Department of Home Management and Child Development, College of Home Economics

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Child Study, at Michigan State University. Requirements for the course included scheduling five different 50-minute observation experiences in the Child Development Laboratory for each student enrolled. The activities of pre-school children to be observed were eating, mental development, physical-motor development, social development, and emotional development. These experiences had to be scheduled within a five-week period during free time for the students (times other than class or work) and had to fit into the Child Development Laboratory school days. The professor specified the times of the day during which the different types of observation experiences could be scheduled. In Winter Term 1966, thirty hours of out-of-class teacher time were required for manual development of an operable observation schedule for the 141 students enrolled in the course.

This problem provided a case study which involved principles basic to a variety of personnel scheduling problems and which conceivably could be applied to similar problems in food service management. The total project included analyzing the traditional scheduling procedure, gathering and coding the data, developing and writing the program, and writing directions for using the program. Two modest goals were set: 1) to simulate the manual scheduling procedure used for the course HMC 362, Child Study, and 2) to reduce the clerical tasks to a minimum. Completion of the project resulted in the successful development of procedures for coding the data and a computer program with directions for its use.[2]

[2]The program and description for use are on deposit in the Computer Library, Computer Center, Michigan State University, East Lansing, Michigan.

DESIGN OF THE PROJECT

There were four essential steps in the development of this automated scheduling procedure. The first step was to analyze the manual scheduling procedure, the time and space requirements for each of the five types of observations, and the kinds of data needed. Secondly, data formats were developed. The third step was to formulate procedures for coding and assembling the data. As a final step, the program was written and tested.

The Scheduling Specifications. The overall requirements for the five types of activities to be observed were the length of time for each observation, the time lapse between observations, the time of day for the observation, and the sequence of the activities to be observed. Each student observation had to be scheduled for a 50-minute free period of the student; each student could be assigned only one type of observation experience in any given week; and since there were twenty observation spaces in the laboratory units, this was the maximum number of students that could be scheduled to observe the children during the same time period on any given day of a given week.

Furthermore, each type of observation had certain additional requirements that had to be satisfied. For example, eating observations had to be scheduled for 11:30 a.m. to 12:20 p.m.; they could be scheduled for any day of the school week during any one of the five weeks; and approximately one-fifth of the students were to observe this activity each week. For students who were not free during this time period any day of the school week, this observation experience had to be scheduled during the fifth week and special arrangements made with instructors or employers so these students could be free to complete this course requirement.

For the four other types of observations the following restrictions were imposed. For any given student, each of the four remaining observation experiences had to be scheduled for the same time of the day and the same day of the week but in four different weeks. Observations for mental development and emotional development could be scheduled in any one of the five weeks; the social development observation could be scheduled in weeks one through four only; and the physical-motor development observation could be scheduled in the first and second weeks only. The reason for these latter two restrictions was to provide observation experience in these areas before theoretical material on these topics was presented in lecture.

<u>The Data Specifications</u>. Examination of the University class periods and the Child Development Laboratory units school schedules revealed that there were a maximum of twenty-three time periods each week for student observations. Twenty-three 1-column fields were used for coding data for the time periods for each week and five 1-column fields were used for the five observation weeks in both the student data array and the Child Development Laboratory data array.

Each student hand-coded his own weekly class schedule, his first and second time period preferences for all observations except eating, and his university student identification number in assigned numbered lines on IBM 555 mark sense sheets. After the coding was spot checked for accuracy, data cards were mechanically punched from the mark sense sheets by the IBM 1230 Scanner. One data card was sufficient for each set of student data.

The school schedules and laboratory unit identification for each of the twenty observation spaces were coded in specified columns on 80-column forms and data cards were punched from them. One data card for each observation space for each week was punched.

Since the number of enrollees in this particular course and the number of observation spaces may vary from term to term, the computer program was designed to accomodate a maximum of 180 sets of student data and 100 sets of Child Development Laboratory data. The finished program also had to be sufficiently flexible to accomodate different sets of student data and observation space data in subsequent university terms.

The code for the two data arrays consisted of a 1 if a student or an observation space in a laboratory unit was available for scheduling at a given time period and a 0 if not available. In the student array, the five fields designating the weeks were all marked 1. Each observation space in the Child Development Laboratory units had to be coded for each week. A 1 was coded into the field representing a particular week and a 0 was recorded in each of the other four fields.

The Program. Using the scheduling specifications and the formats of the input data arrays, Program HMC362 was written to schedule the students for their required observations in the Child Development Laboratory. Program HMC362 is comprised of four parts, a main program and three subroutines. The main program reads in data and stores the arrays in memory, calls three subroutines which schedule the students for their five required observations and prints out an observation schedule for each student and the observation space array after the schedules are completed. It converts the coded day, time, and week for each scheduled observation to the actual day, time, and week.

The first subroutine schedules all students for their eating observation, changing the week used for this observation from one student to the next. The second subroutine schedules all students for their mental development observation, again rotating the weeks, using each student's first time period preference if possible. If this time period cannot be used, the second time preference is substituted. If neither time preference is available, or if the student did not choose a time period or if his mark sense sheet was coded incorrectly, the computer is instructed to find a time period available to schedule the observation. The time period used for each student's mental development observation is also used for the three remaining observations in the open weeks.

Each student's observation schedule is completed by the third subroutine in the following order: 1) physical-motor development observation, 2) social development observation, and 3) emotional development observation. Provisions are made in the program to schedule the physical-motor development observation during the first or second week and for the social development observation to be scheduled in or before the fourth week.

For each student observation to be scheduled, the product of the time period and week codes for an observation space and the codes for the same time period and week for a student must equal one. The program instructs the computer to scan the two arrays until the code product of the four selected elements equals one. This means that the observation space and the student are both available for an observation at a given time period within a given week. After an observation is scheduled, the program instructs the computer to replace the 1 in the designated week for that student by a 0 and the 1 in the time period for the specific observation space by a 0. By this method, a student cannot be scheduled again in this particular week and the particular observation space at this time period is unavailable.

RESULTS

Program HMC362 is a 3600 Fortran computer program to schedule the required observation experiences in the Child Development Laboratory units at Michigan State University for students enrolled in the course HMC 362, Child Study. It was written and pretested during Winter Term 1966, using the class and work schedules of the 141 students already enrolled in the course and the observation space data of the Child Development Laboratory units for that term. After a series of tests, all students were scheduled for their eating observations. One hundred twenty-six of the 141 students were scheduled for their four other observations during their first or second time period preferences. The program instructed the computer to schedule these four observations for each of the fifteen remaining students during a free time period in his class-work schedule. Twelve students were so scheduled, leaving three students to be assigned manually. The five types of observations all met the scheduling specifications.

The computer program was first used to schedule student observations for Spring Term 1966. All 88 enrollees were scheduled for their eating observations, and all but four students were scheduled for the remaining observations in their first time period preference. The program instructed the computer to schedule the four observations for each of these students in a free time period in his class-work schedule. One student was so assigned, leaving three students to be manually scheduled by the professor. The program results were thoroughly checked, and all student observation schedules satisfied the requirements.

By automating this scheduling process, clerical time was reduced by an estimated 50 percent. As in the manual scheduling operation, it was necessary to collect and organize the data, but the time used for the actual scheduling procedure was virtually eliminated. Computer time used in the pretest was approximately 1½ minutes to schedule 693 student observations, and slightly over 1 minute was required to schedule 428 observations in Spring Term 1966.

IMPLICATIONS

It is believed that the four procedural steps used in this project are basic to the development of all automated scheduling programs. The first step, analysis of the problem, is the responsibility of the administrator or teacher. He must be thoroughly familiar with every detail of his scheduling operation and be able to communicate precisely the scheduling specifications, data available, and the nature of the results needed to a computer consultant or to the person who writes the computer scheduling program. Although this analysis may take considerable time and thought, it is imperative that every detail regarding the scheduling specifications and the data be evaluated before the program is written. Omission of significant details at the beginning of program development will reduce program efficiency, limit results, and increase the expense of developing a successful program.

The computer consultant or programmer specifies data formats, helps formulate procedures for coding and assembling data, gets the program written and tested, and prepares directions for its use. The administrator or teacher is responsible for interpreting and evaluating the programmed results.

Once the initial investments of professional time and expense to computerize routine scheduling tasks have been made, the major advantages are optimum solutions for recurring scheduling problems and release of professionals from routine tasks so their time and talents may be channeled to more productive purposes.

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