ON DESIGNING AND IMPLEMENTING A DENTAL PRACTICE MANAGEMENT GAME

Susumu Morito
Arnold Reisman
Hamilton Emmons
Juan Rivaud

Case Western Reserve University
Cleveland, Ohio 44106

ABSTRACT

This paper describes the structure of an interactive dental practice management game, with special emphasis on its design and computer implementation. The game covers a wide spectrum of management decisions in setting up and in running a dental practice. The decisions considered include practice location, the form of practice, staffing mix and salaries, and the purchasing or leasing of equipment. The game also covers major daily, monthly, and yearly decisions, including forecasting patient load, economic analysis, and scheduling of patients, workers, and operatories.

As three levels of decisions (daily, monthly, yearly) are considered, the game has a multi-level structure. The program system is modularized based on this time level, and also from a functional point of view. The game is designed so that it can be used both as an educational tool and as a planning tool. The game incorporates a random mechanism to reflect random aspects of real-world. The program is written in interactive FORTRAN and is implemented at several dental schools.

1. Introduction

This paper describes a computerized dental practice management game to teach various management skills to dental students as well as to dental practitioners, with special emphasis on its design and computer implementation.

Dental practices are growing increasingly complex as their sizes increase and as the diversity of worker types becomes greater. Thus, the efficient and effective management of dental practices is becoming more and more critical. To teach a full range of management skills to dental students, most dental schools offer practice management courses of the traditional lecture type. The student, however, has difficulty in finding practical applications of concepts offered and especially gaining experience in managerial problem solving.

To cope with this situation, a new computerized tool has been developed to teach dental practice management. The tool is named the CWRU/Kellogg Dental Practice Management Game, after its developers (Case Western Reserve University, Department of Operations Research in collaboration with the Dental School) and the W.K. Kellogg Foundation, which supported the work.

2. Structure of the Game

The computer program for this management game as a whole is designed in a modular form, which enables the player to use it to pursue different objectives. Thus, if he wants to forecast his patient load, or if he wants a procedure for determining a rational fee structure, he can consult the computer on these items without going through the whole game. On the other hand, the game is also an educational tool which provides a dental student or dentist with a simulated practice in the computer and enables him to evaluate the impact of his decisions on the performance of his practice immediately, thereby giving him invaluable experience. Figure 1 shows the overall structure of the game. First, we shall briefly describe these parts.

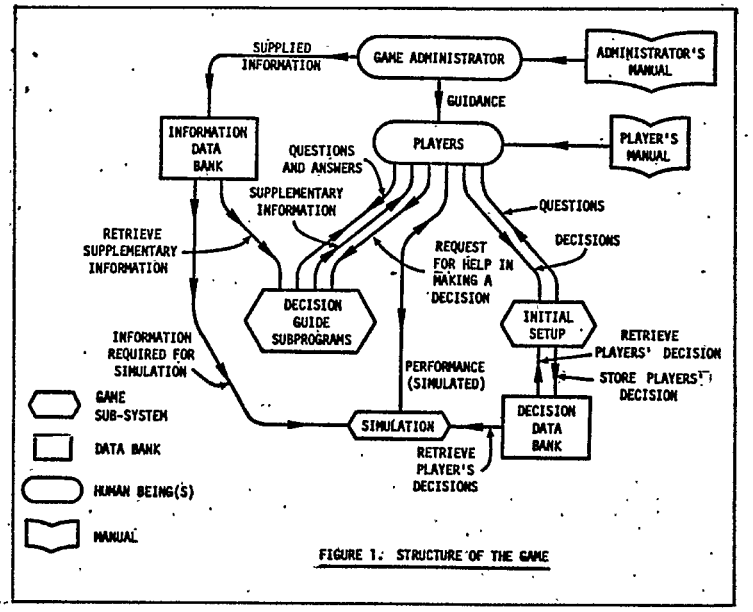

FIGURE 1: STRUCTURE OF THE GAME

The management game is divided into three basic parts or subsystems from both the conceptual and the programming points of view. These are: (1) initial setup, (2) simulation, (3) decision guide subprograms.

(1) Initial setup. This part of the game asks the player a sequence of questions and accepts the player's decisions. It allows the player to decide the kind of practice he wants to set up. The sequence of questions is determined by the previous decisions, by the game administrator's inputs, and by the fixed structure of the game. The areas covered in the game are listed in the next section (Table 1) with the overall flowchart (Figure 2). The setup phase usually does not give the player any help in his decision-making.

(2) Simulation. This non-interactive part of the game produces and gives the player the simulated results of his decisions, as well as statistical and financial information. Included here are the following:

1) Patient generation. Based on the player's decisions and performance, such as location, fee, busyness, and scheduling efficiency, the program generates patients to be scheduled.

2) Task scheduling and the evaluation of player's schedule. Given a player's patient schedule, the model simulates detailed task scheduling and obtains various performance measures such as waiting time, worker utilization, etc.

3) Extrapolation. Based on a player's daily performance over one or a few days of detailed simulation, the model calculates his estimated monthly performance. Similarly, annual results are computed from monthly performance.

4) Monthly and yearly report production.

5) Heuristic patient scheduling. To evaluate how good the player's schedule is, one or more schedules are produced by the computer for the same set of potential patients given to a player.

6) Performance evaluation. A subroutine evaluates the player's overall performance in terms of profit, worker utilization, etc.

(3) Decision guide subprograms. Each of these subprograms leads the player in a step-wise fashion to logical, reasonable and good (but not necessarily the best) decision. Its use is initiated by a player's request (when allowed by the fixed structure of the game and by the game administrator's inputs) for help in making one particular decision. The decision guide then sends the player a sequence of questions which are, in general, more detailed in nature than the original question. It will guide the player to a sound decision and will show him how the logical decision-making process should proceed. Results obtained using the decision guide are neither used for calculations in the simulation nor are they binding for subsequent decisions in the game. They only suggest a logical decision-making process, and whether the suggestion is followed or not is up to the player.

A good deal of information must be stored and available to the computer. This is organized in two main blocks.

1) Decision data bank. Here are stored all decisions made by players in the initial setup.

2) Information data bank. This block of storage contains data necessary for the simulation and also for the decision guide subprograms. Examples of this data are frequency and average fees for a set of dental procedures, costs of equipment and supplies, etc. All this information can be modified or updated by the administrator, if necessary.

Also supporting the game are three kinds of manuals: one for the player, one for the game administrator, and one for the computer programmer.

1) Player's Manual [1]. This volume contains background information about the game and dental practice management in general. Players should read a copy before they start the game and refer to it while playing. It will assist decision-making and provide relevant information about various aspects of dental practice management.

2) Administrator's Manual [2]. This manual describes the options available to an administrator in charge of the game operation. The two most important responsibilities of the game administrator: i) the player's registration and file control, and ii) the updating of the information data bank of the game, are explained in detail.

3) Programmer's Manual [3]. The details of the computer program for the game are described. This manual will be used by persons who want to modify the program. Flowcharts showing detailed program logic, lists of major program variables, etc., are included.

3. Levels and Areas of Decision-Making

In order to allow a player flexibility to change his strategy at realistic time intervals, we consider three levels of decisions, i.e., daily, monthly, and yearly. The game decisions were realistically allocated among the various levels. For example, a dentist would not normally consider changing the location or the type of his practice more than once a year. Thus, these decision items are classified as "yearly" decisions. Of course, a yearly decision does not mean that the player should change his decision every year, but it means that reviewing the decision item once a year is enough. Table 1 summarizes areas covered in the game with their levels. Figure 2 shows the overall flow of the game.

Table 1. Areas and Levels of Decisions

Decision area	Examples	Level*	Included in current version?**
Type of practice	private, group, military, public health	I,Y	Y (private, group)
Start a new practice or buy an existing one		I,Y	N
location: geographic preference	north, south, east, west	I,Y	Y
location: setting	urban, suburban, rural	I,Y	Y
location: lease vs. buy building		I,Y	N
Space requirement	square feet	I,Y	Y
Practice emphasis	generalist, specialist	I,Y	N
Financial arrangements		I,Y,M	Y
Number of operatories		I,Y,M	Y (up to 5)
personnel: type & number		I,M	Y (DR,EFDA,DH,DA)
personnel: salary		I,M	Y
equipment & supplies: type & number		I,Y,M	Y
equipment & supplies: buy or lease		I,Y,M	Y
Fee Schedule		I,M	Y
Working hours & days		I,M	Y
Billing methods		I,Y,M	N
Scheduling		D	Y

*Levels: I - Initialization, Y - Yearly decision, M - Monthly decision, D - Daily decision

**Y - Included in the current version, N - Not included in the current version

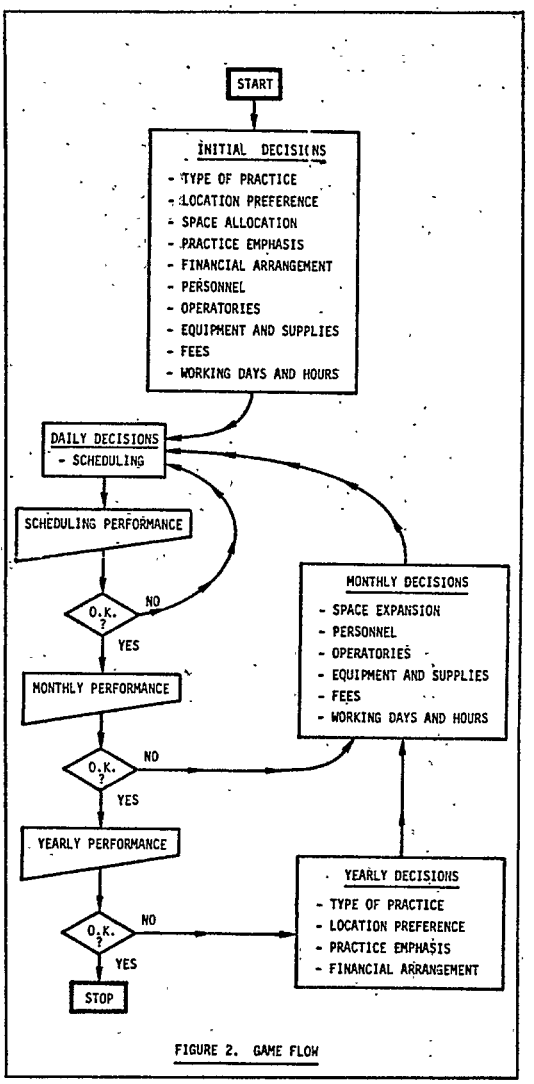

FIGURE 2. GAME FLOW

We now describe how the game proceeds. The details can be found in the Player's Manual [1].

3.1 Setting up the practice

After giving the player's identification and answering some other preliminary questions, the computer asks various questions regarding the practice the player wants to set up. As illustrated in Figure 3, self-explanatory questions will be printed. (If the player wants to speed up his play, he can take the option of simplified questions in which case the computer just prints "TYPE OF PRACTICE?" instead of a complete self-explanatory question as in Figure 3. Much time will be saved if the simplified option is taken.) The player simply types the answer (underlined in the figure).

FIGURE 3

```
1. WHAT TYPE OF PRACTICE WILL YOU ENTER?
YOU HAVE TWO CHOICES.
   1 SOLO PRACTICE (STARTING A NEW PRACTICE)
   2 GROUP PRACTICE (HERE WE WILL ASSUME THAT YOU HAVE
     THE POWER TO MAKE DECISIONS FOR THE GROUP)
PLEASE HIT AN APPROPRIATE NUMBER.
? 1

2. IN WHICH GEOGRAPHIC AREA DO YOU WANT TO
PRACTICE?
   1 NEW ENGLAND      5 CENTRAL
   2 MIDDLE EAST      6 NORTHWEST
   3 SOUTHEAST        7 FAR WEST
   4 SOUTHWEST
REFER TO THE MANUAL FOR THE DEFINITION OF AREAS.
? 2

   HOW MANY MONTHS HAVE YOU PRACTICED DENTISTRY IN THIS AREA?
? 0

3. WHAT IS THE POPULATION AND POPULATION/DENTIST
RATIO IN YOUR CHOSEN AREA ? PLEASE REFER TO THE
MANUAL ABOUT SAMPLE CITIES.  IF YOU HAVE POPULATION
600000, AND P/D RATIO = 5000, PLEASE PUNCH 600000,5000
? 500000,4000
```

In order to make major strategic decisions, a good estimate of patient load and an appropriate financial analysis are essential. As mentioned earlier, the player may have access to the decision guide subprogram in order to make logical decisions. Currently, the game is provided with two decision guide subprograms for forecasting patient load and for fee determination. If the player wants to go through the decision guide for forecasting, the computer will ask a series of questions which guide him to a reasonable forecast of patient load. The basic methodology is described elsewhere [4].

Another major decision guide is designed for fee determination. (For further details see [5].) The basic idea of the method is to estimate the desired annual gross revenue, (i.e., overhead costs plus take-home income plus taxes) and total annual working hours, and then to find the hourly revenue necessary to attain the goal. Combining this hourly revenue, the time required to perform a procedure and its laboratory cost, the player obtains the fee for a procedure.

3.2 Daily scheduling

Patient scheduling decisions are the only daily ones considered. Here a player is given a list of patients to be scheduled within his practice hours. The patient list indicates information about patients and their procedures such as procedure name, fee, material cost, and task time information. A player's responsibility then is to assign an appointment time to each patient so that workers and operatories are utilized efficiently and effectively. Considering task time information as well as worker and operatory availability, the player can make a reasonable schedule.

To make the game realistic, emergencies and patient no-shows can be included. Given a player's schedule, the computer simulates his schedule and gives his performance as in Figure 4.

FIGURE 4

```
TOTAL NUMBER OF PATIENTS TREATED - 10

AVE. WAITING TIME IN WAITING ROOM  15.2  MINUTES
AVE. WAITING TIME IN CHAIR          7.4  MINUTES

CLINIC HOURS                NORMAL              OVERTIME
  BEFORE LUNCH BREAK   2 HOURS (10-12)          60 MIN.
    (ACTUAL LUNCH BREAK WAS   0 MIN.)
  AFTER LUNCH BREAK    4 HOURS (13-17)           0 MIN.

OVERTIME INFORMATION (THE FOLLOWING OVERTIME WORK WAS PERFORMED.)
  LUNCH TIME
    OPERATORY  1      60 MIN.
    OPERATORY  2       4 MIN.
  AFTER NORMAL HOURS
    OPERATORY  1      NONE
    OPERATORY  2      NONE

PRODUCTIVE HOURS AND UTILIZATION
             NUMBER  AVE. PRODUCTIVE HR.  AVE. UTILIZATION
  DENTISTS      1       2 HR. 50 MIN.          0.405
  ETDA'S        1       3 HR. 50 MIN.          0.548
  ASSISTANTS    2       3 HR. 40 MIN.          0.524
  HYGIENISTS    1       0 HR. 40 MIN.          0.095

  OPERATORIES   2       4 HR.  5 MIN.          0.583

**********
```

3.3 Monthly and yearly financial report

Based on the results of daily scheduling (only a few days are necessary), the rest of the month will be simulated, and the estimated monthly financial report (Figure 5) is given. After seeing these results, the player is given a chance to change some of his earlier decisions. After changing earlier decisions (if necessary) the new month starts. In each new month the player is asked to schedule patients for at least one day.

FIGURE 5

FINANCIAL REPORT
MONTH 12 YEAR 1

	MONTHLY REPORT	CUM. REPORT FOR CURRENT YEAR	CUM. REPORT FROM START OF PRACTICE
TOTAL REVENUE	$ 8116	$ 108815	$ 108815
EXPENSES:			
SALARIES	$ 2100	$ 25200	$ 25200
FIXED COSTS	$ 1839	$ 22068	$ 22068
VAR. COSTS	$ 852	$ 11448	$ 11448
MAT. COSTS	$ 1016	$ 13392	$ 13392
OVERTIME	$ 180	$ 3828	$ 3828
TOTAL	$ 5987	$ 75936	$ 75936
EARNINGS			
BEFORE TAXES	$ 2129	$ 32879	$ 32879

In order to save time, you are given several options to skip occasional months of simulated practice. Even as you skip over the month, the computer estimates its performance. Included in the twelfth monthly financial report is a summarizing annual report. At the end of each year of simulated practice, the player may review his annual performance and will be given a chance to change any previous decisions.

4. Information Data Bank

The information data bank stores all data necessary to play the game. For example, cost of equipment and monthly rent will be needed to estimate a monthly financial report. Also a frequency distribution of various procedures as well as each procedure's time and worker requirement will be required to generate patients of a simulated practice and to figure out the player's scheduling performance. All this information is fixed and kept in two major files by the game administrator making it inaccessible to players. These files are the procedure data bank and the cost data bank. The former contains all relevant information for procedures such as frequency, average fee, time and worker requirement, etc., whereas the latter contains basic cost parameters. The information contained is the result of extensive research and surveys conducted at the time of the game development. Still, some of the parameters such as average fees, costs of dental supplies, insurance, etc., are constantly changing and need to be updated periodically. Therefore, the supplementary program is provided which allows the game administrator to modify the information data bank. For more detail regarding data modification, refer to the Administrator's Manual [2].

5. Design Considerations

In this section, we will list major design considerations which led us to the final version of the game. These considerations are the results of finding out what users want and what the current technology (i.e., computer hardware and programming) could offer.

5.1 Language selection and transferability

As the objective of developing the game was to provide a new teaching tool for various dental schools, the transferability of the game program was one of the prime concerns. Language selection is clearly a key factor in determining a program's adaptability to many different computers. Three types of languages were originally considered:

1) Simulation language (such as GPSS, SIMSCRIPT, SIMULA)
2) Scientific language (such as FORTRAN, ALGOL, BASIC)
3) Business-oriented language (such as COBOL, RPG)

Even though models were basic to the game, a simulation language was not selected, primarily because of poor transferability (not many computers support simulation languages), but also because of: 1) limited I/O (especially file I/O) capabilities, 2) general lack of knowledge in these simulation languages, 3) lack of capability in the time-sharing mode. A business-oriented language did not seem promising either, despite the fact that there would be a reasonable amount of report-type outputs. This was because we expected rather complicated simulation models (e.g., a simulation model to evaluate the player's schedule) in the game program. Though it might be possible to use more than one language for different functions, this would add to the complexity and thus reduce transferability. This led us to a scientific language. Considering their popularity, two languages remained from which one had to be picked, namely FORTRAN and BASIC. Our final choice was FORTRAN, though it did not seem much superior to the other. Here are some of the reasons why FORTRAN was chosen: 1) FORTRAN, being more established, if we stuck to the standard set of instructions (that is, if we tried to avoid machine-dependent features), not many problems were expected; 2) more and more machines support interactive FORTRAN, 3) almost everywhere someone can be found who can handle a program written in FORTRAN.

The game has been transplanted and is in the process of being transplanted to over a dozen dental schools. So far, we have not encountered any school which could not implement the game due to the use of interactive FORTRAN.

Another important factor governing the portability of a program is its size. With this in mind, the game is modularized so that, if the whole program does not fit into the main core, it can be put into an overlay structure.

5.2 Interactive mode or batch mode

One of the important initial decisions was whether to choose interactive or batch operating mode. We investigated and compared both modes from several points of view: 1) effectiveness as an educational tool, 2) ease of access, 3) computer cost, 4) transferability of the program, 5) programming effort. The decision was made to use the interactive mode, mainly for the first two reasons above. As we observed later, educational effectiveness and accessibility were much enhanced with the game accessible from any telephone for immediate use. Note that the players are dentists and dental students who want to play the game right at their practice or dental school, without making a trip to a computing center. Nowadays, many dental schools have access to and sometimes own a computer, and often they have teletypes easily accessible. Some practicing dentists even have a Decwriter in their practices.

5.3 User orientation

Even though the game was originally proposed as a tool for teaching dental practice management, it was clear, even at its design stage, that the game would be of great value as a planning and decision-making tool to practicing dentists. However, designing a game which achieves these two goals has to reconcile the conflicting objectives of generality and specialization.

In order to provide a meaningful educational tool, it is necessary to present a typical situation. Since we are considering a management game which is based on a computerized model and its manipulation, it is essential to abstract the real world. However, when it comes to the details of real-world dental practice, one practice is never identical to the other and often there are major differences between them. For example, EFDA's (new paraprofessionals) can be used in some states, whereas other states do not allow their introduction.

To achieve the goal of constructing a game which can be used as both an educational and a planning tool, it was decided that the fixed structure of the game (the part which cannot be changed without modifying the program) should reflect just those aspects of a dental practice which would be generally agreeable to anyone; everything else should be flexible. Thus, the game is equipped with the administrator's program which can modify the parameters of the patient population, fee structure, etc., which are stored in data banks, so as to create any desired environment.

Sometimes some features of the game, designed to teach good practice management, are not desirable if the game is used for planning purposes. For example, the patient generation subroutine includes a mechanism which connects the fee structure with the potential patient load: higher fees, beyond a certain point, discourage patronage. A dentist planning (or simulating) his own practice often does not like this feature. He may know the size of his practice from long experience. In such a case, this feature will be eliminated when used as a planning tool.

5.4 Flexibility

Some models included in the game, mostly among the decision support systems, are somewhat subjective. Specifically, take as an example the fee determination subroutine, part of the decision support system. This subroutine was designed to help a player determine a reasonable fee structure, considering various economic factors. Even though this model was carefully and logically designed, clearly there are many different procedures that could be used to come up with a fee schedule, each reasonable from a particular standpoint. Thus, some users may not like the approach and may not want to use this subroutine. For this reason, the game is designed so that the game administrator can control the use of this and similar models. As the whole system is modularized, this can easily be done. The rest of the game program system deals with simulating a dental practice and obtaining the performance of the simulated practice which is more mechanical and less controversial.

5.5 Ease of usage and player motivation

The game has to be interesting, sometimes entertaining, and motivating in order to be successful. To make the game stimulating, two important factors are the ease and speed with which it can be played. The game should not require complicated operations or computations on the players' part. The computer should do as much of the dirty work as possible, so that the player can concentrate on understanding where he stands, and finding and evaluating alternative strategies. Also, if the answer to a question gets too lengthy or complicated, players lose interest. The following example indicates how we have avoided this.

In order to simulate a dental practice, we have to consider over 50 "procedures" (i.e., the different kinds of treatments a dentist performs) together with their fees. Deciding upon a fee to charge for each procedure is one of the important questions, not only determining earnings and profit, but also affecting the patient load through a subroutine that tends to diminish the number of new arrivals if the fees are too high. A player easily gets bored if he has to input fees for over 50 procedures. To avoid this, the game selects a few (typically five) procedures (which are called "representative" procedures), and only those fees need to be given by the player. The fees for the rest of the procedures are shifted up or down from a predetermined "standard" (say, national average) fee structure based on his input for these representative procedures.

5.6 Evaluation of performance and competitiveness

The game has not been designed as a competition between two players, as in the case of many industrial management (or business) games. Instead, each player (or team of players) is in effect matching wits with the computer. Of course, players can compete by playing the game separately, under uniform assumptions, and comparing results.

The main reason that direct competition was avoided is our lack of knowledge about the true nature of real-world competition between dentists. Furthermore, it was felt that, to a large extent, a dentist's success depends less on his competitive interaction with other nearby practices than on how well he runs his own practice.

The game, then, simulates a player's practice interactively and dynamically, in response to his decisions. Decisions may be changed if the player is dissatisfed with his performance. Since different criteria might be considered important by different practitioners, several measures of performance are presented; the financial report, as mentioned earlier, shows profit and loss, while worker utilization, overtime hours, and customer waiting time are also presented (Figure 4).

5.7 Randomized elements

In order to reflect the random nature of the real world, the game uses a random mechanism for the following purposes.

1. the assignment of a procedure (i.e., a particular treatment to be performed) to each patient.

2. emergency patient arrivals

3. patient no-show occurrences

4. random fluctuation of patient arrival time around his appointment time.

The parameters which control these random effects can be adjusted through the administrator's program. If desired, it is possible to eliminate randomness completely except for the assignment of a procedure to a patient.

Other parameters of the game could have been randomized also, notably the durations of each procedure. The decisions not to do so was based on tests that showed the results to be rather insensitive to fluctuations in procedure times, on the wide variation among different dentists in this regard, and on the desire for program simplicity.

Some of the other random elements, such as emergencies and no-shows, also make a negligible difference to the numerical outputs and could have been omitted, but their absence would (indeed, did, before they were added) cause unfavorable comment from the player-dentists, for whom such a glaring omission would cast doubt on the accuracy of the entire exercise.

The question of statistical significance of the results becomes important in evaluating performance when random elements are present. Though this has not been rigorously investigated, iterations of the game under the same assumptions has shown that consistent results are obtained.

For educational purposes, it is not important that the outcome be precisely reproducible. Even for design purposes, the precisions of the results is easily sufficient to answer the broad questions that are characteristically asked, such as, "Shall I hire one hygienist or two?"

6. Conclusions

The game has been successfully adopted by several dental schools in addition to CWRU. At the latter location, the current version of the game is implemented on a Honeywell 400 series time-sharing computer at the Chi Corporation, Cleveland, Ohio. The game consists of approximately 4000 cards including the administrator's program. The game is also set up as a library program at the Chi Corporation so that any interested dentists can play the game through teletype connection.

Simulating two years of a dental practice takes roughly two to three hours, depending on the options taken, the size of the practice (especially in terms of the number of patients to be scheduled), the preparation of the player, etc. This does not include time for setting up the data banks to fit a particular situation. The game is equipped with default data banks which contain national averages for educational purposes.

The game provides several "exit points" where a player can stop playing the game for a while to think over his progress so far and to perform calculations. All necessary information is stored in the computer disk file, so that it can be retrieved when a player restarts the game. For example, a player may want to spend some time constructing a good schedule. If so, then after he gets a patient list, he takes an exit point. In sum, the number of times the player comes to the teletype to simulate a given number of years or months of dental practice and the time spent each time depends upon the extrapolation of performance chosen and upon the number of exit points selected by the player.

The development of the management game is completed, even though several features are being refined. For example, the game is being modified to incorporate pre-paid dental practices. The evaluation of the game and its pilot use are underway, as well as its incorporation into regular dental school curricula and into continuing education programs.

REFERENCES

[1] Reisman, A., Emmons, H., Morito, S., Rivaud, J., Green, E., "Dental Management Game-User's Manual," Technical Memorandum No. 399, Department of Operations Research, Case Western Reserve University, March 1976.

[2] Reisman, A., Emmons, H., Morito, S., Rivaud, J., Green, E., "Dental Management Game-Administrator's Manual," Technical Memorandum No. 398, Department of Operations Research, Case Western Reserve University, March 1976.

[3] Reisman, A., Emmons, H., Morito, S., Rivaud, J., "Dental Management Game-Programmer's Manual," (in preparation).

[4] Reisman, A., Emmons, H., Green, E.J., Occhionero R., Dadchanji, K., Morito, S., and Mehta, S., "A Methodology for Forecasting Patient Load for a Dental Practice," Technical Memorandum No. 334, Department of Operations Research, Case Western Reserve University, 1974.

[5] Emmons, H., Reisman, A., Morito, S., Mantell, J., Rivaud, J., Tsao, W.L., Chowhury, A., Green, E., and Occhionero, R., "A Dental Management Game," Technical Memorandum No. 390, Department of Operations Research, Case Western Reserve University, April 1976 (revised).