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IMPLEMENTING STUDENT PROJECTS IN A SIMULATION COURSE

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ABSTRACT

The purpose of this paper is to describe an innovative approach for administering student projects in a simulation course. Using this approach, the instructor plays the role of a decision maker with a problem for the class to study. This approach provides the class with a nearly realistic project experience and overcomes many of the administrative difficulties of allowing the students to work on real projects. This paper highlights the value of student projects, discusses several administrative and educational issues involved in project assignments, explains in detail how the instructor can play the role of the user, and provides a specific example problem.

1. INTRODUCTION

Most of the popular simulation textbooks (for example, Shannon 1975, p. 24, Law and Kelton 1982, p. 44, and Banks and Carson 1984, p. 12]) begin with a flowchart depicting the phases of a simulation study starting with the initial problem formulation, following with model formulation, data collection, model construction, and validation, and ending with experimentation, statistical interpretation, and implementation. This flowchart forms a model for a simulation course and shows how the different topics within the course fit together. Frequently, as the course proceeds through the study of individual topics such as random number generation or simulation programming, the students lose track of the overall purpose of simulation as an aid to decision making. The use of simulation in problem analysis and decision making needs to be emphasized.

One of the best ways to accomplish this decision making orientation is to ask the students to complete a project study from the initial problem formulation stage to the statistical interpretation and implementation stage. Many instructors assign projects in a simulation class but, in reality, they are simply programming exercises. By assigning a complete project involving all phases of a simulation study, students will understand how the various parts of the course fit together and will be able to relate the simulation model to the decision situation being studied. The purpose of this paper is to suggest a method of implementing projects in a simulation course in an educational and efficient manner.

2. PROJECT SELECTION

Perhaps the major issue involved in assigning a project to a simulation class is the type of project to assign. Should the entire class work on a single project or should each project group or member of the class have a separate project? Should the project involve a real system with a real user or should it be a hypothetical problem constructed by the instructor? Each of these alternatives is discussed below.

2.1. Multiple, Real Projects

Using this approach, each project group works on a separate real project with a real user of the simulation results identified. These projects may be identified by the instructor or by the students themselves. This real system approach provides numerous educational advantages, particularly in the problem definition phase. It gives students the opportunity to define the problem, make assumptions, request data needed, establish system boundaries, and interact with a user. However, this approach has some administrative and educational difficulties. On the administrative side, sufficient projects must be solicited by either the instructor or the students and users must be willing to give of their time and provide access to the necessary data. On the educational side, it will be almost impossible for the instructor to know if the students have defined the real user problem. A common problem students (or all of us for that matter) have is defining the correct problem. With numerous groups working on numerous projects the instructor cannot be familiar with the details of each. Furthermore, even if the correct problem is defined, that problem may not lend itself to simulation or the system may be too simple or too complex to match the educational goals of the course. In addition, the project difficulty will vary from one group to the next.

The author has used this approach when teaching graduate simulation classes to part time, evening students. Each student in the class (8-10 students) was asked to define a real system from their work environment for study. This worked reasonably well (except for checking the problem definition) due to the small class size and the easy access the students had to problems and data. In fact, the students appreciated the opportunity to apply the simulation class to their own work.

2.2. Single, Real Project

Using this approach, the entire class works on the same project with a real user. Generally, this is implemented by allowing the user to attend one or more classes to explain the problem and handle questions from the class. The user may or may not provide additional time for individual project group interviews. This approach offers most of the advantages of the real project outlined above and in addition allows the instructor to become familiar with all of the details of the user's problem. This makes it possible to evaluate the problem definitions submitted by the project groups and to properly advise the project groups. It also allows the students to see different approaches to the same problem. Administratively, the instructor only needs to arrange one project per semester and since all groups are working on the same project, the groups are experiencing equal difficulties. Although less of a problem than with multiple real projects, the major difficulty with this approach is in project selection. A project must be found that requires simulation, is of the appropriate difficulty level for a one semester course, has data readily available, and has a user with sufficient time to give to the class. Another slight educational disadvantage of this approach is that the interviews are taking place in a classroom setting so that some project groups will benefit from the insightful questions of other groups. However, one could argue that this is an advantage in the sense that the interviewing process is demonstrated.

This approach is widely used by my colleagues in teaching a course in Systems Analysis. Often, the same project is used in multiple sections of the course.

2.3. Single, Hypothetical Project

Using this approach, the entire class works on the same project but the project is constructed by the instructor. There is an attempt to make the problem seem real but there is no real user. The problem, the data, and the system are hypothetical. This approach has all of the advantages of the single project discussed above and in addition allows the instructor to control the degree of difficulty and to provide the students with the educational experiences desired. This approach allows the instructor to develop a model of the system before the project begins. This way the instructor is aware of the difficulties the students will encounter and is able to determine if the results that the students obtain are in the right order of magnitude. However, unless this approach is carefully implemented, the student misses out on the problem definition phase of the simulation study and does not get to interact with a user. The thrust of this paper is to describe how to implement this approach so that the student gains the valuable experience in problem definition and the instructor gains the administrative and control advantages of a single, hypothetical project.

3. OTHER PROJECT ADMINISTRATIVE ISSUES

There are many other issues involved in administering simulation projects including group formation and size, software, complexity, and evaluation methods. However, the major focus of this paper is to suggest an approach for administering a single, hypothetical simulation project in a way that provides as much realism as possible. For the sake of completeness, a brief description of the way these issues are handled is provided. The students are asked to form project groups of maximum size three and are encouraged to join students with a similar motivation level. This produces some excellent project groups and some poor project groups but it relieves some of the frustration caused by mixing highly motivated students with lazy students. Any students who are unable to find a project group to work in are grouped together by the instructor or added to a two person group. All of the simulation models are written in GPSS since this is the language covered in the course. An attempt is made to design a project that requires a relatively simple simulation model (30-40 blocks). This insures that there is sufficient time to work on the other phases of a simulation study such as problem formulation and the interpretation of the simulation results. Finally, all students in a group are given the same project grade regardless of any innuendoes or grumbling that a particular person is not participating at the proper level. The method of assigning these grades is discussed in the next section.

4. SUGGESTED APPROACH

The suggested approach is to assign a single, hypothetical project involving simulation. This study is to be carried out from the initial problem formulation stage until conclusions are derived from the model. The goal is to administer this project in the most realistic way possible.

4.1. Project Introduction

In this approach, the instructor plays the role of the user. Students are informed that the user will be coming to class on a particular day and that they are to be prepared to listen, take notes, ask questions in such a way as to help the user solve his/her problem. On this day, the instructor arrives as the user. It is a nice touch to dress the role by wearing an appropriate outfit or at least a hat so that the students know that you are someone else. Begin by introducing yourself, giving some background about your business, and outlining your problems or concerns. Then open the floor for questions from the students (there are usually many). These questions should be responded to in a manner in which a typical user might respond. If the students use technical terms, act confused and ask for clarification. Provide extraneous information as well as important information. Save some of the information until it is asked for. At the end of the class, inform the students that they may contact you for further questions in the instructor's office during office hours. When students come to the office, determine whether they want to talk to the user or to the instructor. Then put on the appropriate hat and talk to them accordingly.

Notice that this method of introducing the project is entirely verbal. It gives the student the opportunity to interrogate the user and to ask questions to define the problem. It also gives the instructor a tremendous amount of control over the problem being formulated. It is a good idea to keep a list of information given so that each project group is operating on approximately the same set of facts.

4.2. Report 1 - Problem Definition/Initial Model Ideas

The first report is a typewritten preliminary statement of the problem to be studied and some initial modelling ideas. Generally, this report contains information similar to the initial report of the analysis phase of the systems development life cycle. Specifically, the students are asked to include the following items: a clear statement of the problem being studied and the decision alternatives under consideration; a description of the operation of the current system including graphic aids as appropriate; a discussion of the system boundaries and factors that will be included or excluded from the model; a discussion of performance measures to be obtained from the model and possible objectives for these performance measures; and a list of data required from the user. Generally, these items are being discussed in class and the first phase of the project gives the students an opportunity to use these ideas.

4.3. Feedback from Report 1

After grading and commenting on each project group's report, the goal is to provide the class with a common problem definition. This can be accomplished by using a single group report that is very good, by using parts of several reports that are good in one area but not another, or, as a last resort, by writing a brief outline. This written problem definition is copied and passed out to each project group to provide a common starting place. A good way to provide this feedback is for the instructor to return to the class in the role of the user.

At this time, the user provides the students with the data items requested. Each group is given a written copy of the raw data and its source. It is up to the student groups to decide how to use this data to model various activities. It is convenient for the instructor to write a computer program to generate this data from specific theoretical distributions (unknown to the students). This makes it easy to check the results of the data analysis contained in the next report. Generally, all of the necessary statistical data is provided at this point.

4.4. Report 2 - Model Walkthrough

The next report is an oral report conducted in a private meeting between the instructor and each project group. In this report the students are to walkthrough in a step by step fashion the model of the system that they have developed. Specifically, they are to walkthrough the data analysis and explain the logical reasons they chose certain models, the statistical tests they performed, and where the results of the data analysis are used in the simulation program; walkthrough a well documented listing of the simulation program and explain how the various activities in the system are modelled; and walkthrough the steps they followed to verify that the simulation program is working properly.

This report gives students immediate feedback on data analysis errors and program errors. This is a very important report because without this report some project groups will be experimenting with an incorrect model. This meeting avoids most of those problems.

4.5. Report 3 - Final Report

The final report is due the last week of classes and summarizes the entire project. It is helpful to specify an outline of both the content and the format of the final report. That way the students know what you want and its easy to find what you want for grading purposes. It also insures that each project group will think through all of the important issues and not unintentionally ignore one. This approach may seem to some readers a little too structured but, in fact, this is often the approach used in industry to obtain some degree of consistency and uniformity.

One possible organization is to ask the students to divide their report into a main body and a group of technical appendices. The main body of the report should include a description of the problem studied, a description of the approach used to study the problem, and a discussion of the conclusions and recommendations based on the simulation experiments. This section of the report should be readable and understandable to the user.

It is also helpful to specify the organization of the technical appendices. These may include technical jargon and need only be readable by the instructor. One possible organization is as follows:

A. Data Analysis - includes a summary of the data analysis performed, the test statistics, the conclusions reached, and how the data was implemented in the simulation program.

B. Program listing - internally documented listing of the simulation model.

C. Experimental plan - describes the cases to be simulated, how an observation was defined (or how independent observations were obtained), and how random number streams were handled.

D. Run length/initial condition analysis - describes how initial conditions were handled and shows calculations to determine how long to run the simulation.

E. Statistical analysis - shows the calculations performed in computing confidence intervals and/or performing statistical tests. Show at least one calculation in detail and summarize the results of any other calculations.

4.6. Evaluation

The first two reports are designed to illustrate the iterative nature of problem formulation and model construction. For this reason, these reports should not be weighted too heavily and errors should not be judged too harshly. A possible weighting scheme would be to weight the first report 10% of the project grade and the second report 20% of the project grade. Grades should be based not only on the correctness/quality of the work but on the effort made. Give plenty of feedback in these two reports but do it in a constructive manner since the ultimate goal is to produce a quality finished product (final report).

One of the advantages of specifying a specific structure for the final report is that it simplifies grading. A separate evaluation can be made of each part of the report and these evaluations totaled to determine the final project grade. For example, the first two reports may count 10 and 20 points, the main body of the final report 20 points, and each appendix 10 points. This gives a total of 100 points and depending on the instructor's evaluation in each category the project groups can identify the strengths and weaknesses of their project.

5. EXAMPLE

A recent project I used involved an evaluation of the adequacy of operating room and recovery room facilities in a hospital that was undergoing a major expansion. The idea for this project came from a series of articles involving the authors Kwak, Kuzdrall, and Schmitz (1972, 1974, and 1976). I played the role of a doctor in charge of scheduling surgeries and obtained a surgical mask and hat to wear when playing this role. During the project introduction, I introduced myself, gave some background on the hospital, talked about the expansion and what effect I thought it might have on the operating and recovery room facilities, described the current facilities, described the current scheduling procedures, and suggested that I was concerned about the number of operating rooms, the number of recovery beds, how late in the day surgeries would have to be scheduled with no changes, and the possibility of reducing this time if surgeries were ordered based on the possible duration. Students proceeded to ask questions about types of surgeries, length of patient stay, number of beds, staffing the surgery and recovery rooms, emergencies, anticipated utilization of new beds, objectives for time of last surgery, and so forth.

Based on the problem definitions submitted and my goals for the project we came up with the problem definition outlined below:

Problem: Determine if the hospital can schedule 27 surgeries per day using the current facilities and an improved scheduling rule such as major surgeries first or minor surgeries first. If not, determine what additional facilities are required.

Factors to include/exclude from model: Types of surgeries and associated surgery times and recovery times; Preparation time between surgeries; Travel time from surgery to recovery; Ignore emergencies; Ignore patient activities outside of surgery/recovery area; Ignore staffing considerations; Assume no cancellations.

Performance measures and objectives: Time last surgery is completed (preferably before 6:00 P.M.); Time last person leaves the recovery room (as early as possible but may be in the evening); Maximum number of recovery beds in use (less than or equal to 12 beds); Length of time recovery room is in use each day (as short as possible)

Data provided: Surgical data for the last 10 days (180 surgeries) which includes the type of surgery (major/minor), the length of surgery, and the length of recovery; Operating room preparation time; Travel time from surgery to recovery.

Unknown to the students, the data that was provided was generated from specific theoretical distributions. For example, I used a Gamma distribution with alpha = 2 and beta = 30, shifted by 60 to generate the number of minutes a major surgery type of operation took.

Based on this problem definition, I developed a simulation model of surgery and recovery room activities. I developed confidence intervals for the various performance measures using different scheduling rules and different facilities. This effort made me well prepared to discuss data analysis difficulties, modelling difficulties, and experimentation difficulties with the students. This also helped me to quickly determine if the data analysis, model results, and conclusions in the final report were reasonable.

6. SUMMARY

The purpose of this paper is to suggest an approach for implementing a simulation project involving a hypothetical system that comes as close as possible to a project involving a real system. Though the effort involved in administering this project is significant (as is the effort involved in administering any class project), it provides a very worthwhile educational experience for the students. And, the effort all seems worthwhile when a student says "That project really tied all of the ideas in this course together" or "I really see how my Systems Analysis course relates to Simulation".

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