Simulation of Student Flows in a Three-Year Diploma Program

R. Greer Lavery P. Eng
Ryerson Polytechnical Institute

ABSTRACT

This paper describes the two-model simulation using GPSS, of the three-year diploma programme, "Computer Applications Technology" at Ryerson Polytechnical Institute, Toronto, Ontario. One model includes a prerequisite relationship between the programme courses, the other does not. The objective of this simulation was to study the effect of these different structures on student flows within the programme, particularly noting numbers of dropouts at various levels in the programme and eventual graduates.

The results of this simulation study formed the basis of recommendations for future operation of the programme.

INTRODUCTION

The Computer Applications Technology programme is a three-year diploma programme offered by the Department of Mathematics and Physics at Ryerson Polytechnical Institute, Toronto. Students were first accepted into this programme in September 1970 and the first diplomas in Computer Applications Technology were awarded in May 1973. New students are accepted into the programme only once each year, in September, although occasional transfers from other programmes are accepted in January.

From its inception, the programme has maintained high academic standards in order to establish a reputation of quality for its graduates in the computer industry. It has been quite successful in this regard as over 90% of the programme graduates are known to have found employment in the computer industry and no graduates are known to be working outside the computer industry.

The high academic standard maintained in each course, reinforced by a rigid prerequisite structure between courses resulted in large numbers of students dropping out of programme prior to graduation. It was felt that many of these students were capable of graduating from the programme but left school rather than spend the (often) several extra semesters required to make up failed courses and their successor courses. To avoid reducing the academic standards in the programme, it was decided to investigate the effect of eliminating all course prerequisite requirements in the programme. This would allow a student who had failed (say) first semester mathematics to take the second semester mathematics course in the semester immediately following without having to wait a year until he could re-take (and hopefully pass) first semester mathematics. Under this system, a student could take a full load of courses each term and pick up the failed course a year later on top of his regular load. (Due to relatively small total enrollments, it was not possible to offer 'repeater' courses in off-semesters).

To investigate the effect of this proposal without modifying the real-time operating policy of the programme, a GPSS model of the proposed system was designed and run under anticipated conditions. A model of the existing system was built and run to help evaluate the validity of the model simulating the proposed system.

PHILOSOPHY AND DESIGN OF THE MODEL

GPSS V was used as the simulation language for these models as (i) it was the only formal simulation language available at our installation at the time,

CH1437-3/79/0297-0299$00.75
1979 Winter Simulation Conference

(ii) the author had significantly more experience in simulating with GPSS than with procedural languages such as FORTRAN and PL/1 and (iii) the student flow system was very conveniently represented by a discrete-entry, queueing system model.

Transactions are used to represent individual students and each incoming freshman 'class' of 80 transactions is routed into a sequence of 42 statistical-mode transfer blocks which represent the 42 individual courses in the programme. For each course passed, the corresponding course flag (Pj for course j) is set for each student or left reset if the course was failed. At subsequent points in the model tests are made on these flags to determine if an individual student has any courses to repeat in a given semester, if he is elegible to graduate, etc. Students failing a given percentage of courses are removed from the model in keeping with departmental withdrawal requirements. A count is recorded of the number of students leaving the programme at the end of each semester as well as the number of graduates, both with and without any failed courses during their time in the programme. A single ADVANCE block in each semester segment of the model simulates the passage of one semester of time.

The model II uses 324 blocks and consumed 0.76 minutes execution time on an ITEL AS/6 7032 computer system. Reallocation of transactions to 360 and COMMON to 50,000 was required to obtain successful execution.

For validation purposes, a similar model was designed which included the existing prerequisite conditions, i.e. students could not take any course until any or all prerequisite courses had been passed. This model contained 352 blocks and consumed 0.81 minutes execution time.

Both models were run for a total of five years of simulated time in order to reach 'steady-state' conditions, i.e. students entering all three years of the programme and those entering second and third years having various combinations of passed and failed courses over the previous years. The models are then RESET and re-run for a period of five years with data being gathered beginning for the class which 'graduates' three years after the establishment of steady-state conditions.

MODEL VALIDATION AND DATA

To investigate the validity of the model simulating the proposed no-prerequisite system, a second model was designed using the same general structure as the original model but incorporating the prerequisite requirements currently in effect. Class average pass rates were gathered for four years of operation under the prerequisite system and used in the model deterministically. (Very little difference was found in the average pass rates for each course over four years).

Excellent results were obtained from this model relative to the actual, known results. For the first graduating class simulated, the total number of graduates agreed exactly with the actual number for that year and subsequent year results, while not matching the known data exactly, were very close. Based on the good performance of this model I concluded that the similarly structured model of the proposed system should show results which would be at least representative of operation under the proposed system.

Pass rate data for the simulation of the proposed system were gathered from similar courses offered elsewhere in the school under similar conditions (e.g. evening studies). For courses where it was felt that the elimination of existing prerequisites would not affect the average pass rate, data from the validation model was re-used in the experimental model.

RESULTS OF THE SIMULATION

Output from the no-prerequisite model indicated a significant reduction in the number of dropouts from the programme. Moreover, the average number of total graduates from the programme each year was increased, although little change was found in the average number of graduates who did not fail any courses along the way. The increase in graduates was through students who had failed one or more courses in the programme but who were allowed to proceed to the subsequent semester and pick up their failed courses at the next opportunity.

Some of the output data from the two models are shown in Table 1.

TABLE 1
SOME OUTPUT DATA FROM
THE TWO SIMULATION MODELS

SEMESTER	PREREQUISITE MODEL AVERAGE NO. OF REPEATING STUDENTS	PREREQUISITE MODEL NUMBER OF DROPOUTS	NO-PREREQUISITE MODEL AVERAGE NO. OF REPEATING STUDENTS	NO-PREREQUISITE MODEL NUMBER OF DROPOUTS
1	31.0	41	62.8	25
2	40.8	6	50.3	13
3	38.0	8	39.5	3
4	32.0	1	36.5	6
5	18.3	1	9.3	1
6	10.8	21	13.0	10

CONCLUSIONS AND IMPLEMENTATION

As a result of the favourable results predicted by the simulation model, the no-prerequisite system was put into effect at all levels of the programme in September 1976. Less than one year was required for the effects to become apparent. The number of students remaining in the programme,albeit with mixed and partial timetables, increased immediately, especially in first year. The number of graduates from the programme soon rose to the predicted levels and class sizes in the latter half of the programme became more stable. Data gathered from operation under the no-prerequisite system confirmed that the numbers used in the prediction model were valid. Only small discrepancies were noted between the actual results and the assumed values used in the model.

An additional, unexpected benefit was gained in the increased numbers of students who, while never graduating from the programme, were able to stay in the programme long enough to acquire a strong computer background and thereby obtain more promising employment.

Today, the no-prerequisite programme is still in effect and the model is continually being updated as more data is accumulated.

The model has since been used to study the effect on the student flow profile of significant changes in pass rates of individual or sequential courses and to predict class sizes resulting from large increases in the size of the freshman class.