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SYSTEM DESIGN FOR A CONTINUOUS PROGRESS SCHOOL--COMPUTER SIMULATION OF AUTONOMOUS SCHEDULING PROCEDURES.

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A COMPUTER SIMULATION OF A CONTINUOUS PROGRESS SCHOOL THAT PERMITS STUDENTS TO SCHEDULE THEMSELVES FOR COURSE WORK ON AN AUTONOMOUS BASIS WAS CONSTRUCTED AND TESTED. THE SYSTEM WAS SET UP TO FREE THE STUDENT FROM THE DISADVANTAGES OF TRADITIONAL PROGRESSION BY ALLOWING HIM TO WORK IN OTHER COURSES WHILE WAITING FOR TEACHING ASSISTANCE IN ANOTHER. PATTERNS OF RESOURCE DEMAND WERE DETERMINED FOR THE ASSIGNMENT OF 100 HIGH SCHOOL STUDENTS TO FIVE COURSES AT ONE TIME. WHENEVER SUCH A STUDENT WOULD REQUIRE HELP, HE COULD FILE A REQUEST FOR HELP AND GO ON TO HIS WORK ON ANOTHER COURSE. THE SYSTEM WAS DEEMED USEFUL FOR EXPANDING SIMULATION CAPABILITY AND FOR EXPLORING ITS USES IN COURSE DESIGHN. IT WAS DEVELOPED IN ASSOCIATION WITH THE CONTINUOUS PROGRESS SCHOOL PLAN OF DR. EDWIN READ OF THE BRIGHAM YOUNG UNIVERSITY LABORATORY SCHOOL. RELATED REPORTS ARE ED 010 561 THROUGH ED 010 563. (GD)

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System Design for a Continuous Progress School--

Computer Simulation of Autonomous Scheduling Procedures

ABSTRACT

This document is one of a series reporting work done related to the Continuous Progress Plan at Brigham Young University Laboratory School in connection with the study New Solutions to Implementing Instructional Media Through Analysis and Simulation of School Organization. This document describes a computer simulation model of a plan for organizing instruction that permits students to schedule themselves for course work on an autonomous basis.

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I. INTRODUCTION

In SDC document (Reference 1) project personnel described the initial development of a computer program (EDSIM) designed for simulating models of instructional systems and illustrated the use of the model in simulating students going through the ninth-grade algebra course at Brigham Young University Laboratory School. The course was organized for continuous progress so that students worked at their own rate on an individual basis but were scheduled to meet in small groups with the teacher when they needed help.

II. TECHNICAL DISCUSSION

A. PROBLEMS

The analysis of the ninth-grade algebra course indicated that the procedure of scheduling students to meet in groups for help would become more and more inefficient as students become more widely distributed in the extent of their progress in the course.

The analysis indicated that not only would the availability of teacher time for giving help be reduced, but also, students who needed help would probably have to wait for longer periods of time to get help because of the reduction of available teacher time.

If students are truly in need of help, the requirement of making the students wait to receive assistance should create a critical problem in the system. Students who need help should not be expected to continue to study the course material. In fact, they should be encouraged not to continue if they are having problems that they can't solve in the learning process. Forcing the student to continue might compound his problems. If students are unable to continue to learn when they are in need of help, the time between the occurrence of the need for help and the time that help is obtained may be viewed as wasted time. If a student finds that he needs help at the beginning of a class hour, and that help is unavailable, he loses, at a minimum, the full class time, or approximately 50 minutes. Consider a class of 100 students. If we estimate that only 15% of the students need help and we use the median time of 25 minutes after the course begins as the time when each student finds that he does need help, the total time spent in waiting would be 15 x 25 minutes, or 375 minutes for the class. In other words, this scheduling procedure could result in a total of 6 hours and 10 minutes of student time wasted in one class in one day.

An organizational plan that would maintain the present advantages of the Continuous Progress Plan, but which might overcome some of the disadvantages, would be to break completely with the lockstep system by allowing students to schedule themselves. The individualized plan could be carried further if students would not only be free to vary their rate of progress, but also could be free to schedule the time that they work on their courses. If such an autonomous scheduling procedure could be evolved, students would not have to lose time waiting for needed help--they could work on other courses until the help arrived.

Autonomous scheduling procedures might also offer other advantages. The organizational plan would help the school to perceive and treat the student more as an individual rather than as a member of this or that course. Students would be given greater freedom in planning and budgeting their activities. On the other hand, although the greater amount of freedom could foster growth in maturity, a certain degree of maturity would be necessary before students could function comfortably in such a plan. It has been the experience of the staffs at both the Brigham Young University Laboratory School and the Theodore High School that some students are not able to function well with the greater degree of freedom and independence that the Continuous Progress Plan offers.

It is true that the maturity of the students would have a decided effect on the success of any attempt to organize a school on an autonomous scheduling basis. The study of this problem, however, must be empirical. But before students can be given the experience of working under such conditions, the scheduling procedures have to be developed. It was the purpose of this study to use the computer simulation capability described in Chapter V to design and study some of the implications of autonomous student scheduling procedures.

B. METHOD

A model of a continuous progress school with students scheduling themselves autonomously was constructed with the computer simulation capability described in Chapter V.

1. Definition of the Model

a. One hundred students operate in the system.

b. The student population is divided into three groups: 19 "fast" students, 62 "medium" students, and 19 "slow" students.

c. Each student is assigned to five courses (Courses 1-5).

d. Students are randomly assigned to work on courses on a periodic basis. The procedure is as follows for each student:

(1) The student's decision to select a particular course for individual study is simulated by randomly selecting a course number from 1-5.

(2) The student is assigned to the selected course and his mode of response is selected.

(3) Three modes of response are possible in each course:

- the student can work in individual study on the course;
- the student may file a request for help in the course; or
- the student may file a request for assessment in the course.

(4) The modes of response are randomly selected according to the following proportions for each of the three subgroups:

(These proportions are estimates based upon discussions with teachers about the behavior of students in ninth-grade algebra. The model does not assume different proportions for the five courses.)

For Fast Students

Elect Individual Study	80%
Request Help	5%
Request Assessment	15%

For Medium and Slow Students

Elect Individual Study	70%
Request Help	15%
Request Assessment	15%

(5) If a student elects individual study (the choice is simulated by a random-number generator program subroutine), he spends eight time cycles (one hour) in individual study. At the end of the hour, he stops work on the course and goes to work on another course. If a student requests help, he files a request for help and goes to work on another course. (The choice is again simulated by a random selection of the next course.) If a student needs to take a test, he files a request for assessment and also goes to work on another course.

(6) When a student is simulated to stop individual work on one course, he is simulated as selecting another course. After selecting the course, he is simulated as electing one of the three modes of response--individual study, filing a request for help, or filing a request for assessment (described in (5), above).

e. Each day of simulated operation allowed five hours of time for students to work in individual study. It was assumed that requests for help and testing would be accomplished in a period of time following the five-hour individual study period.

f. The period of time for providing help and giving tests was not actually simulated in the model. It was assumed that the period of time would begin at the completion of the five-hour individual study period. The length of time that would be required for help and assessment each day could be determined by considering the number of requests for help and assessment that were filed each day. It was assumed in the simulation that all of the requests would be processed before beginning the five-hour individual study period the following day.

g. The period of time simulated was 30 school days.

h. The following output data was selected from the recording tape for printout:

(1) The number of students requesting help each day in each course. These data are presented for each category of student--"fast," "medium," and "slow."

(2) The number of students by category of "fast," "medium," and "slow" that requested assessment each day for each of the five courses.

(3) The number of students by category of "fast," "medium," and "slow" taking individual study in courses 1-5 each day.

(4) The total number of requests for help and/or assessments made by each student each day.

2. Assumptions About the Model

The proportions of help demand were based upon estimates obtained at Brigham Young University Laboratory School. It cannot be assumed that these rates would be true in courses elsewhere.

The demands for assessment probably exceed those of any plan that is currently being implemented, but the demand was defined at this level to include both informal progress checks and formal unit-type tests.

It was assumed that random assignment of students to help and assessment requests is the best procedure for estimating demand patterns because, in the actual school situation, the number of interacting variables would be large enough to cause the patterns to vary as if they were randomly determined.

It was also assumed that the patterns of resource demand that occur when 100 students are each assigned to five courses at one time reflects the kinds of demand patterns that will occur with larger populations of students in a school with a larger number of courses. It is assumed that the number of demands for any other configuration can be determined by simple multiplication. In other words, if the simulation study indicates that a school might operate with an allocation of space for individual study that is equal to 90% of the student population, then the total seating capacity required for any given school for individual study would be 90% of the number of students in the student body.

The actual number of students assigned to any course at any time should vary in a Continuous Progress Plan School. The simulation study of the Garber High School Plan (Reference 2), demonstrates the use of the simulation vehicle for predicting variations in course loadings over time. A plan to utilize space efficiently for a particular school would require a combination of these two simulation studies with a very detailed description of the rules for assignment of students to courses.

The generalizability of the demand patterns of this study will be greatly reduced in plans where students are not required to distribute their time over approximately five courses at any given time.

It was assumed that 30 days of school operation would show a pattern of demands that would reflect the variations that would occur for any period of time in the history of the plan. Obviously variation in course loading would affect these demands. The type of simulation performed in the Garber High School study would be required to study the effects of course loadings on demand.

For this study, all students were simulated as working for an hour on each course whenever they elected individual study. However, if the study was extended to develop more hypotheses about problems in the use of space, this assumption would not be valid. It would be necessary to randomly vary student time in individual study according to a normal distribution of time periods. The effects of variation on space utilization could be studied more thoroughly by varying the values of the distributions. Under these conditions it would be desirable to obtain a printout of space demands for every time cycle (every 1/8 of an hour).

C. RESULTS

The output data from the simulation were studied to provide estimates of the resources and procedures that would be needed to operate a continuous progress school on an autonomous scheduling basis. The results are considered in relation to the resource and scheduling demands for individual study, the resource and scheduling demands for getting help from the teachers, and the resource and scheduling requirements for testing.

1. Resource Requirements for Individual Study

Table I shows the median number of student-hours spent each day in each of the five simulated courses during a five-hour period devoted to individual study. The ranges of the daily student hours for day 3 through day 30 are also shown. These simulated data suggest that the number of seats required for individual study could be less than the total number of students and still be adequate to meet the majority of demands for individual space. If the students were spending all of their time in individual study and no time was lost in changing

Table I. Medians and Ranges of Daily Student-Hours Spent in Individual Study for Courses 1-5 for 100 Students

Courses	Ranges	Medians
1	64-113	78
2	59-94	77
3	59-89	76.5
4	67-95	79
5	59-97	76.5

from course to course and in filing requests for help and testing, the simulated data would show that the number of carrels would equal the number of students. Therefore, the frequencies in Table I would all be 100--the same as the student population total. However, the simulation model included students taking time, in addition to study time, for filing requests and changing from work on one course to work on another. The model did not simulate students doing work in laboratories, participating in group activities, and consulting privately with teachers during the independent study time. The addition of these activities to the model reduced the amount of time estimated as being spent in the individual study space. Although the actual amount of use of space would depend upon many factors, the simulated data suggests that student needs for independent study space could be met without requiring a study space for every student. Table II shows the frequency of times that the simulated demands for independent space would exceed the supply, and the frequency of times that the demands would be less than the supply of carrels for all five courses if 100, 95, 90, 85, and 75 carrels were available. The frequencies were based on 28 days of operation. If 90, rather than 100 carrels were available, the data in column four suggest that there would be only two or three days out of 28 in the history of any course when there would not be enough seats. There would be enough or more than enough carrels for the demand for 25 of the 28 days of operation. If only 85 carrels were available, column five shows that the number of days that there would not be enough carrels would be double the number obtained when 90 carrels were available.

These data support the hypothesis that the times required for other activities such as filing requests for help and changing courses might reduce the amount of space that needed to be available to meet independent study needs. Since the model excluded the simulation of students in other activities that would tend to reduce the demand for independent study space even further, the simulated data would seem to be conservative. Therefore, the further hypothesis is advanced that it would be advisable to provide independent study space for 90% of the student population.

2. Resource Requirements for Teacher Help

Table III summarizes the data obtained from the model regarding the requests for teacher help--column one shows the five simulated courses; column two shows the ranges of daily requests for help; column three shows the median number of daily requests for teacher help. The proportions of students simulated requesting help and testing were the same for all five courses. It is unlikely that data from five real courses would all provide the same frequencies. Hopefully, however, most real courses would not have requests for help that would exceed the upper limits of the five ranges. The day-to-day variation in the range of demand suggests that the task of scheduling help could be a problem that would require some development of a scheduling strategy. Table IV shows the range of times that would be required to provide individual help if an average of 10 minutes of individual attention were given to each student. Columns one, two, and three show the range of times required for each of the courses if the teacher/student ratio were 1/100, 1/50, and 1/25, respectively.

Table II. Number of Days that Student Demands for Individual Study Carrels Would Underestimate and Overestimate the Supply of Carrels for Five Levels of Resource Allocation

Courses	Student Demands for Study Carrels	Levels of Resource Allocation--Percent of Student Body for which Carrels would be Available				
		100%	95%	90%	85%	75%
C_1	over-supply	1	3	3	10	17
	under-supply	27	25	25	18	11
C_2	over-supply	0	0	3	6	16
	under-supply	28	28	25	22	12
C_3	over-supply	0	0	0	6	16
	under-supply	28	28	28	22	12
C_4	over-supply	0	0	3	5	19
	under-supply	28	28	25	23	9
C_5	over-supply	0	1	2	5	17
	under-supply	28	27	26	23	11

Table III. Medians and Ranges of Help Requests (Based on five courses for 30 days of simulated operation)

Courses	Ranges	Median
1	6-22	13
2	10-21	14
3	10-20	14
4	6-22	12
5	8-20	13

Table IV. Ranges of Time Required for Three Teacher/Student Ratios
(Based on the assumption that each student received
an average of 10 minutes of individual help)

Courses	Ranges of Time for Help; Teacher/ Student Ratio = 1/100	Ranges of Time for Help; Teacher/ Student Ratio = 1/50	Ranges of Time for Help; Teacher/ Student Ratio = 1/25
1	1 hr - 3 hr, 40 min	30 min - 1 hr, 50 min	15 min - 55 min
2	1 hr, 40 min - 3 hr, 30 min	50 min - 1 hr, 45 min	25 min - 53 min
3	1 hr, 40 min - 3 hr, 20 min	50 min - 1 hr, 40 min	25 min - 50 min
4	1 hr - 3 hr, 40 min.	30 min - 1 hr, 50 min	15 min - 55 min
5	1 hr, 20 min - 3 hr, 20 min	40 min - 1 hr, 40 min	20 min - 50 min

Table IV suggests a number of various possibilities for meeting help needs. If the teacher/student ratio was 1/100, an average of 10 minutes of individual help could be given to each student in a help period lasting for as long as 3 hours and 40 minutes. If it is assumed that the lunch hour would be scheduled on a shift basis during the school day, the total school day would have to be 8 hours, 40 minutes in length on peak days. Under better conditions, with a teacher/student ratio of 1/25, on days of minimum demand for help each student who asked for help could have an hour of individual attention from a teacher during a two-hour help period. If we assume a teacher/student ratio of 1/50, an average of 20 minutes could be spent with each student who asked for help in help periods lasting the lengths of time shown in column one. Another way of scheduling help would be to limit the average help time for each student to ten minutes and the total help period to two hours, while varying the number of teachers to be assigned to the help period each day. On days of minimum demand, one teacher could handle the need; on days of maximum demand two teachers would be required in a two-hour period. If it were desirable to have individual help sessions lasting on the average for 20 minutes, then two teachers could handle the requests on minimum days and four teachers could handle the requests on maximum days.

Teacher assignments would have to be based upon an analysis of the requests that were filed each day. If the procedures for filing help requests included well defined descriptions of the particular needs of each student, daily teacher assignments could be made more efficiently. If the availability of a computer-based instructional management information system is assumed, it would be possible to develop sophisticated computer programs for analyzing the requests filed by students to determine the number of teachers required each day. Such a program could include rules for estimating the length of time required for each student. If teachers were identified in terms of subject-matter strength and weakness and in terms of their ability to work with different students, the program could take these values into consideration. In addition, the program also could make up efficient student schedules. Such a student-scheduling program would take into consideration the total needs for help and assessment of each student every day and would schedule students to teaching spaces so that students would be available in queue when the teachers were ready for them.

The requests of students for assessment and the total needs for both help and assessment by each student must be considered in order to design an effective organizational plan.

3. Resource Requirements for Testing

Table V shows the median and range of daily requests for assessment for the entire 30-day period of simulation. If it is assumed that every student filing a request for assessment each day requires a different test from every

Table V. Medians and Ranges of Total Daily Requests for Assessment

Courses	Ranges	Medians
1	9-29	17
2	9-26	16
3	10-20	16
4	10-25	16
5	10-25	14

other student, test administration may be difficult. The data indicates that it would be desirable to have one testing space available for each course. Although one testing person might be able to monitor testing for the total group, the problem of administering as many as 29 different tests at one time could be extremely difficult. If the tests did not exceed 30 minutes in length, two testing sessions could be scheduled on days that the demand approaches the maximum. With two 30-minute test periods, and with maximum demand for assessment, the size of each testing group would be about 15. If one test administrator could handle 15 students at a time, half of the time he could handle all of the testing required. If the requests for assessment that have accumulated through the first four hours of individual study were collected by the persons responsible for testing, the appropriate test materials could be selected and arranged for most of the students in advance. It would also be extremely important to develop written instructions for each test that are clear and require minimum help from the testing personnel. Well developed procedures for testing could enable one person to administer and monitor as many as 15 different tests at one time. If it is assumed that the testing periods occur during the same period of time in the day as the help period, the effects on student and teacher scheduling must be considered. Nonprofessionals could be used for test administration to maximize the availability of teachers for individual help periods.

Table VI shows the total number of requests filed by each student each day for help and assessment for 30 days of operation. No student exceeds a combined total of five requests for help and assessment on any one day. Column one in Table VI shows the possible combinations of help and assessment that can reach the maximum total possible for any one individual. No student can obtain a total greater than five because the student should not be able to continue in any course until he receives help or is tested. Some of the simulated individuals in the model did obtain the maximum number of five requests. The second through the sixth column in Table VI show the total amounts of time required for each student under various rules for assigning time to the help and assessment periods. The seventh column shows the amount of time that would be required if the students required five minutes to change courses. The most pressing scheduling problem occurs when it is assumed that each help session lasts for one hour.

If a student makes three requests for help on one day in addition to two requests for assessment, the total time required for him to have all of his requests met would exceed four hours. In these cases it would be necessary to reduce the amount of time for each help session.

Table VI. Total Time Periods Required for Daily Help
(Assessment periods for those students making a combined total of six requests in one day)

Assessment	Help	Total Time When: Assessment=30 Help=10	Total Time When: Assessment=30 Help=20	Total Time When: Assessment=30 Help=60	Total Time When: Assessment=20 Help=10	Total Time When: Assessment=20 Help=20	Total Time When: Assessment=20 Help=60	Additional Time for Changes
5	0	2 hr, 30 min	2 hr, 30 min	2 hr, 30 min	1 hr, 40 min	1 hr, 40 min	1 hr, 40 min	20 min
4	1	2 hr, 10 min	2 hr, 20 min	3 hr	1 hr, 30 min	1 hr, 40 min	2 hr, 20 min	20 min
2	3	1 hr, 10 min	1 hr, 20 min	4 hr	50 min	1 hr, 40 min	3 hr, 40 min	20 min
3	2	1 hr, 40 min	1 hr, 50 min	2 hr, 30 min	1 hr, 10 min	1 hr, 20 min	2 hr	20 min
1	4	1 hr, 10 min	1 hr, 50 min	4 hr, 30 min	1 hr	1 hr, 40 min	4 hr, 20 min	20 min
0	5	50 min	1 hr, 40 min	5 hr	50 min	1 hr, 40 min	5 hr	20 min

4. <u>Implications of the Results</u>

a. Changes in Methodology

This study was useful for expanding the simulation capability and for exploring its uses in design. The use of the simulation capability in this study, especially the involvement in the analysis of the output data, created a strong subjective feeling for the validity of the simulated procedures. If this effect of vividness and of face validity is generally experienced by others who use the simulation capability, two implications should be considered. The experience of working with a simulated model of a plan for innovation may lead to a much increased readiness to implement innovation. The feeling that one understands the plan and can anticipate the consequences may do much to reduce resistance to innovate. However, if further use of the model does support this hypothesis, caution needs to be exercised in its use. The heightened sense of the validity of a plan does not mean that the plan is valid. Further research and development work should be oriented toward further understanding of this phenomenon.

b. Problems Defined by the Study

(1) Teaching-Personnel Role Change

<u>Problem</u>: If autonomous scheduling procedures like those hypothesized in the simulation model were implemented, the teacher's role would change in many undetermined ways.

<u>Solutions</u>: This study has shown that teachers' roles can be expected to change in the following ways:

- Teachers would not meet with classes of students for specified periods of time.
- Teachers would probably stay in their offices during a large part of the five-hour individual study time.
- Students would come to the carrel areas which would be in view of the teacher's office for each course.
- The teacher would work on planning, meet with small groups, supervise laboratory work, and monitor students in the carrel area during the five-hour individual study period.
- Students would determine the times that they would go to the learning areas associated with particular subjects.

- Teachers would be available in their teaching areas during the afternoon help period.
- Teachers would have a list of the names of students who need help so that they could plan their time.
- Test clerks would be responsible for administering tests.

(2) Effects of Use of Media in Interactions

Simulation of autonomous scheduling procedures supported the hypothesis that each student who needed help could receive it on an individual basis on the day that the need occurred.

(3) Uses of Information Processing Technology

<u>Problem</u>: The procedure of allowing students to schedule when they engage in independent study would make it impossible to know when students would require various resources.

<u>Solution</u>: Automated scheduling procedures would have to be developed that would schedule teachers and students, space, and equipment on a day-to-day basis so that optimal use of resources would be allocated and so that the individual needs of students could be given adequate consideration in the scheduling.

(4) Implications for Space

<u>Problem</u>: The procedure of allowing students freedom to schedule when they engage in independent study would make amount of space for independent study difficult to predict.

<u>Solution</u>: Simulation of autonomous scheduling procedures indicated that a conservative rule would be to plan for enough independent seating space for 90% of the student population.

<u>Problem</u>: School authorities do not know if the carrels for independent study should be located in one large central area where monitors or teachers are available to the students, or if they should be located in departmental areas near the teacher. Another way of posing this problem is to ask, "Should the resources be arranged around the student or around the teacher?"

Solution: The answer to this question is difficult and cannot be answered definitively at present. However, the fact that some saving could be achieved by not providing a carrel for every student, and the fact that the teacher is one of the most limited resources in a school argues in favor of locating the carrels around the teachers rather than having the teachers come to a central carrel area. If enough carrels were located near the teachers' station, the teachers could work at their desks while monitoring students in the carrels. If teachers had to spend time going to a separate carrel area to monitor students, there would be a loss of valuable teacher time. A rule that might provide a reasonable estimate for planning the number of carrels that should be available for a course of study would be to divide the total number of students assigned to the course by the average number of courses that the students are taking. Thus, if 100 students were assigned to algebra at a given time and each student was taking an average of five courses, the number of carrels needed for algebra would be 100/5, or 20. If the 90% rule was applied, the number of carrels needed would be 18. Further insight into the feasibility of this procedure might be gained by additional simulation.

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