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ABSTRACT

Systems approaches, developed in World War II for military and business operations, have been applied increasingly to educational affairs. Educational systems analysis has received widespread usage in finance and accounting, and has also been successfully applied to information systems, instructional systems development, school design and construction, and evaluation techniques. A 66-item bibliography of related literature is included. (RA)

SYSTEMS ANALYSIS AND EDUCATION

RESEARCH LITERATURE REVIEW

Bureau of Research

Department of Public Instruction

Commonwealth of Pennsylvania

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Division of Applied Research

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There is much active interest today in applications of systems analysis to education. Inquiry has ranged from questions like, "What is a system?" and "What is systems analysis?" to the actual design of new types of schools. This report deals with the first two questions, some school districts in which systems analysis is in use, and the relations of systems analysis to: the aims and objectives of education, instructional systems development, the educational institution as a system, educational finance, plant construction, counselling, school district processes, and educational policies outcomes. System analysis has been used in each of these varied areas.

The systems approach to education originated during World War II in research projects on the control of man-machine systems, using interdisciplinary teams and scientific methods to produce answers that best served the objectives of an organization as a whole. During war-time it was sometimes termed operations research, Ackoff (1964).

The stages of analysis included formulation of a problem, construction of a model, discovery of a solution, testing, evaluation, control, and implementation of the solution. Ackoff (1964) suggested that operations research could advance educational media research by developing measures and means to facilitate curriculum evaluation and modification, but the systems approach is being used specifically to develop quantitative answers to questions on the allocation of funds, personnel, and resources to specified tasks.

Mauch (1962) said that the aim of systems analysis is to find the most efficient and economical methods to accomplish educational tasks. In finance, e.g., the school budget is usually an object classification. Conventionally, the budget shows what money buys--books, chairs, teacher time, etc. In contrast, systems analysis requires "performance budgeting." It collects and assigns data on costs to major inputs in combinations that carry out functions. The results tell us, e.g., that the per pupil cost is $50 per year to teach high school mathematics. This figure helps us to compare alternative processes according to costs. Performance budgets make alternatives more comparable and the choices between them more clear. Systems analysis studies the relationships between inputs and outputs, how outputs compare to established goals, and how several alternatives can be used in different ratios. To facilitate these studies, flow charts or models are prepared, and processes are quantified in all essential dimensions--time, space, materials, personnel, etc. Systems analysis can help us to get more output for our resources, aid us to achieve our goals, help us to make decisions that advance a system toward its goal, give us a yardstick to compare alternatives, aid us to justify expenditures, and advance public relations.

Tondow (1967) defined systems as man-machine interactions.

Davis (1967) said that the process of systems design includes:

(a) Preparation of an operating description
(b) Statement of objectives
(c) Trade-off analysis between alternatives
(d) Flow charting
(e) Production of materials
(f) Evaluation

In the same vein, Flothow (1967) said that systems analysis asks, "What are the outputs of the essential functions performed within our schools?" To answer this question, the analyst begins with functions and describes them as performed by individuals and organizations. A model is prepared from these descriptions. A survey of individual professionals and departments is made in terms of objectives, functions, and responsibilities. The nature of information requirements is determined, and system effectiveness criteria are formulated. These analyses are performed with the guidance of the superintendent, utilizing relevant personnel as the curriculum director, and records from instruction, personnel, research, guidance, and business activities. This systems analysis helps to gain an input/output model, which can help people to function effectively on a rational basis and to maximize the human quality in teaching.

Perhaps the most ambitious study of the nature of systems analysis itself is Project Aristotle. This is the Annual Review and Information Symposium on Technology of Training, Learning, and Education. In 1967, there were ten active task groups, one of which worked exclusively on the systems approach to education. The committee reported eight steps in the systems approach, namely:

(a) Statement of the need or problem
(b) Objectives--measurable learning goals
(c) Constraints
(d) Alternatives
(e) Selection
(f) Implementation--pilot operation
(g) Evaluation
(h) Modification

For each of these steps, the committee presented eight figures, including definition, procedure, and pitfalls encountered at each step.

Systems analysis is used in industry and government where the penalty for a wrong approach or decision is too costly to accept, and we cannot afford to do less in structuring our educational systems. We must search for a better educational product by systems analysis, Lehmann (1968).

Locations Used

Systems analysis has significantly affected the operations of at least five schools: Palo Alto Unified School District, the University of Connecticut, schools at Livonia, Michigan, South Connecticut State College, and Oakland Community College. Experiences at these schools may serve as a helpful introduction to expectations of other educators and administrators who consider the use of the systems approach.

Palo Alto Unified School District appointed a committee to study problems related to the systems approach: (a) what the systems approach means, (b) advisability of hiring a professional analyst, (c) financing analysis with outside funds, (d) possibilities of affiliation with a larger study, (e) what units for study to take. Palo Alto began with a program of budget analysis and is considering a curriculum development project based on systems analysis, Cutler (1967). Tondow (1967) reported that the results of several years of study at Palo Alto are the construction and use of several information systems: (a) student information system to deal with scheduling, attendance, testing, report cards, etc., (b) personnel system, and (c) simulation of a segment of the counselling process, all three systems computer based.*

Goldberg (1965) described the application of the systems approach to administrative work at Livonia, Michigan, where workers are trying to wed machine technology (the use of a computer) to educational requirements, other than present use with student schedules.

The Oakland Community College has developed the Learner-Centered Instructional Systems Approach. Oakland's program resulted in learning laboratories built into carrels. Wiens (1966) said that the approach at Oakland constituted five steps, namely: (a) statement of objectives in behavioral terms, (b) organization of the sequences of media and study time, (c) orientation of learner by use of study guide, (d) self-paced participation of learner in experiences, (e) evaluation of criterion responses.

The University of Connecticut uses twelve carrels constructed through the systems approach, one process operating in each carrel. In each carrel an 8 mm. film demonstrates the task, and 2 x 2 inch slides break down each task into demonstration-practice segments. Students can start in any booth and work with equipment in any sequence. The best feature is that the trainee's self-confidence is developed with his use of processes and equipment, Curl (1967).

*Copies of about eight monographs on these developments are available from M. Tondow, Director of Education Data Services, Palo Alto Unified School District, Palo Alto, California.

The systems approach to instruction has been used at South Connecticut State College since 1964. Engleman Hall was designed by the systems approach for multimedia instructional systems. Engleman Hall has open and closed-circuit TV to all classrooms, a TV production center, a development laboratory, a mobile TV unit, preparation rooms for assembling multimedia, a lecture hall seating 400, classrooms with cameras, a discussion amphitheatre seating 150, a learning resources center with curriculum library, a reading center, and psychological laboratories. The program utilizes a full-time director of multimedia systems, varied groupings from 300 to 25, with individual study. Before the first class meets, a team of teachers decides on course content, organizes the purposes of each demonstration, and prepares a detailed list of independent study activities in the Learning Resources Center. Cost data suggest that it is possible to operate the multimedia systems approach at modest cost. The building cost $2,000,000, and the budget is about $140,000 per year, (Buley, 1965).

Annual Costs

Faculty	$103,940
Student	1,200
Director	16,920
Secretaries	5,710
Engineering	1,500
Materials	4,850
Artist	1,000
Maintenance	5,020
Total	$140,140

Aims and Objectives of Education

The first task in development of an instructional systems approach is the formulation of instructional objectives in behavioral terms, Wiens (1966). This step makes possible the other steps of systems analysis, e.g., evaluation of alternatives, feedback for system revision, preparation of a cost index.

Goodlad and Richter (1966) conducted a vigorous search for a conceptual system with which problems of curricular and instructional innovation could be identified. Three kinds of decision phenomena were distinguished--values, educational aims, and learning opportunities. Rational curriculum construction moves from values to aims, and from aims to educational opportunities, also from more general to more specific formulations. By this systematic process one could define objectives specifically. But one cannot legitimize educational ends from values, or learning opportunities from educational ends simply on logical bases. To make such deductions, one must introduce assumptions that are not obvious. To do this, it is necessary to consult with certain specialists or assess public wisdom. Rational curriculum planning is necessarily an ideological process resulting in an ideological curriculum. Flow charts for curriculum development are presented.

Mager (1962) identified three essential elements of a behaviorally stated instructional objective--task, conditions, and criteria of acceptable performance. Canfield (1968) suggested that a rationale is needed to accompany statements of behavioral objectives, e.g., in a Study Guide. The rationale would aid realization of the aims of the systems approach. Both instructor and learner need an explanatory or expository rationale to enhance the meaningful acceptance of the objectives by teacher and learner. Mager's statements of objectives should therefore be modified by two additions: (a) statement of a general goal as part of a rationale stating why the learner should achieve the objective, and (b) content that personalizes the objective in the language of the learner. This kind of rationale can obviate student resentment over lack of justification of an objective, and it can enhance the utilization of behavioral objectives by instructor and student. But one should remember that goals cannot be pursued as a linear planning process for

> Planning is an exercise in conflict management rather than on the sober application of technical rationality. Any real life planning process may be characterized by a stream of successive compromises punctuated by frequent occasions of deadlock or avoidance and occasional victories, defeats, and integrations.[1]

Instructional Systems Development

Horton (1963) proposed use of systems analysis, not just to produce a textbook or a workbook to guide instruction, but to coordinate all controllable stimulus sources that can reach a student. If this could be done, he suggested we might find that coordinated application of all stimuli has greater effects than the sum of separate effects and piecemeal applications.

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[1]Gross, Bertram M. "What are Your Organization's Objectives." Human Relations 18: 195-215, August, 1965.

The instructional systems approach has several concepts and lines of development.

Canfield (1967) said that the instructional systems approach has the following activities:

(a) Job and task analyses
(b) Statement of learner performance objectives and conditions
(c) Preparation of criterion measures
(d) Identification of incoming student characteristics
(e) Selection of content and media to achieve performance objectives
(f) Learning experiences
(g) Evaluation of student progress
(h) Evaluation-instructional system effectiveness

The major thrust in the systems approach is the use of feedback to improve and refine the system. In the systems approach, the content is the payload and the media are the vehicles; together, they make an operational unit.

McMahan (1967) suggested that all teachers need to develop media competencies. Development of a subsystem of teacher education in media must be based on an existing instructional media center (IMC), which should include a resource and materials area, an equipment area, individual learning spaces, group learning spaces, and work and storage areas for the staff of the center. Personnel should include specialists in curriculum and instructional development, selection and use of media, production techniques, and the organization of media for effective use.

Stewart (1965) reported on Project AIM at the University of Wisconsin, an Articulated Instructional Media Program, the purpose of which is to explore new ways to extend higher education by new patterns of teaching and learning. Planners here suggested that the "greatest waste of American resources is waste of human talent." AIM seeks to discover and develop human resources by extending higher education to qualified individuals otherwise unable to continue their education. To accomplish these purposes AIM will experiment with new media and methods, and will apply the learning systems approach to construction of courses. This approach to course development has a pre-construction and a construction state. In the pre-construction stage, learner behaviors and objectives are clearly and precisely stated and criterion tests are prepared and tried out. After evaluation, learning objectives are revised. In the construction stage, the revised objectives are analyzed to determine the most efficient media to be used. Subsequent stages are like those in programmed instruction--breakdown of learning tasks into small steps, learner response, and reinforcement. The learning systems approach is applied to courses to make them more efficient in relation to learning tasks and goals, saving the learners' time and improving the course content by elimination of content that does not contribute to objectives.

Michigan State University is engaged in at least two major development projects, in which careful attention has been devoted to the development of an evaluation center. The Learning Systems Institute has responsibility for this task, Dietrich (1965). Barson, Gordon and Hornbaker (1965) suggested that a major deterrent to effective use of newer media is the lack of systematic procedures to make instructional decisions. As part of the development of a Learning Resources Center (LRC), Michigan State University has developed these procedures--a system for producing systems--to serve as a prototype for use by other educational institutions. The purpose of an LRC is the production of instructional systems. To accomplish this purpose, an LRC would require the services of an evaluation specialist to aid faculty in identification of objectives and construction of criterion tests, an instructional strategist to select communication interaction patterns, and a media specialist to select representational teaching examples--enactive, ikonic, symbolic. The report is the result of a two-year USOE-supported study.

Foster, Kaufman, and Fitzgerald (1966) reported the results of three conferences that explored the development of the ungraded K-12 Cambridge Mathematics curriculum. Participants concluded that the curriculum could be developed best through an educational systems approach and recommended a pilot program (unlimited training for all).

Schure (1965) reported on project ULTRA at New York Institute of Technology. ULTRA is a bold, complex attempt to evolve by use of the systems approach to education, with aid of a computer, an educational system that will fully individualize education on a mass basis. Planners believe education must realize the potential of each individual in a heterogeneous population. To achieve this objective, ULTRA desires to provide methodologies and resources to develop human talent optimally and with a high probability of attainment. Many computer programs are being perfected and used with the computer in the Information Center. Since the general objective of ULTRA is to qualify each student for a career objective, there is an Occupational Inventory and a Schools Inventory. Results of information and tests on each student are compared by the computer with data stored in the Inventories, and predictions of success probability are made. Satisfactory students are processed through diagnostic examinations. Using computer evaluations of results, students are directed to one of four educational programs. By means of individual diagnosis and computer analysis, the student can enter the learning situation at the precise point of his needs. Both faculty and students use the computer to identify and keep account of these changing needs. The computer is used to select appropriate learning resources and to set the objectives. The student leaves the program when he satisfies the objectives.

ULTRA desires to obviate the fixed student-teacher ratio, the idea that a fixed number of years determines attainment, and the belief that traditional curricula meet student needs. With the aid of the computer, it is hoped that students will be able to organize their own curricula. The project is now using a teaching systems laboratory with 150 student stations. ULTRA is research and experimentation on applications of individual instructional systems at the college level.

The Educational Institution as a System

Taft and Reisman (1967) suggested that the major objective of a school is to allocate available resources in such a way as to maximize the difference in potential between entering and leaving students. The Educational Institution should be understood as a system. This concept should be used to develop generalized systems of educational institutions such as curriculum. In this development, two orientations can be used. Analysis can be done first of all in terms of control volume analysis. The second orientation is control mass analysis. The choice of orientation depends upon the type of student, the level of aggregation, and specialized questions that need to be answered. An iterative generalized systems design was described by means of a flow chart.

The Systems Development Corporation has approached the educational institution as a system and has completed a major project entitled, "New solutions to implementing instructional media through analysis and simulation of school organization." The project involved four major steps: (a) survey and selection of high schools for study, (b) system analysis of five selected high schools, (c) construction of a computer simulation vehicle, and (d) simulation and study of selected schools. Schools were selected for study by analysis of questionnaires sent to 200 innovative high schools. Addresses of the schools characterized as innovative were obtained from the state departments of education. Of 90 schools responding to the questionnaires, 24 of the most innovative schools were visited. Five schools were scheduled for analyses--the continuous progress school at Brigham Young University Laboratory School, Nova High School, Nova, Florida; Buena Vista High School at Saginaw, Michigan; Theodore High School at Theodore, Alabama, and Culver City High School at Culver City, California. The analysis of the schools consisted of descriptive data, flow charts, and systems analysis with subsequent design change recommendations. The effects of design changes were analyzed and evaluated by use of a computer simulation vehicle, Cogswell (1964, 1965). Cogswell (1963) described some features of the construction of a general simulation model called, "Instruct." Instruct is an experimental pilot version of a computer program which provides for students to be assigned to both group and individualized instruction in a representation of a continuous progress school. The program is built upon a hierarchical order of systems with five levels of generality--system, module, package, procedure, and activity. Routines and sub-routines were also included, and a flow diagram of Instruct (Version 1) was exhibited. The program was written with five modules--Control, Outside Resources, Subject Alpha, Subject Beta, Subject Gamma, Subject Delta, and Subject Epsilon. Thus, five different subject matter courses were simulated, each consisting of four units with four study packages, an evaluation package, and three projects. Rules of simulation were listed.

Cogswell (1964) described preliminary studies in the construction and use of the school simulation vehicle. Flow diagrams of a continuous progress plan, designed to permit students to progress at their individual rates, were presented and tried out. The simulation of an algebra course in which progress of 19 fast students, 19 slow students and 62 medium-fast students was reported. The fast students were assigned to use the Temac Algebra Course in 80 hours. As a result of analysis of the simulation data and comparison to real students, the simulation model was modified to accommodate a greater spread in pace among fast students, which was observed to be correlated with intelligence.

Yett (1964) described the construction of the pilot version of a resource allocation processor for the school simulation vehicle. The addition of the resource allocation processor to the simulation vehicle provides for the logical flow and the capability for control of resources--persons, places, or things--by analyzing the termination, continuation, and activation of activities according to the logical demands of the vehicle and the current expression of systems resource capabilities. Flow charts describing the resource allocation processor were included. Together with the first part of the school simulation vehicle--the activity processor described by Cogswell--the general simulation vehicle will permit modeling any school configuration. The vehicle shows the logical flow and control of activities performed by faculty, staff, students. The simulation vehicle did not include an information processor to effect control of data input and output, format, analysis, and processing. The surveillance and detection system was added later. The complete school simulation vehicle was described by Cogswell (1965). Systematic observation and analysis were performed at Nova High School in general terms. The Nova educational system was planned to extend over the school years K-12. Students must apply for admission and are selected on the basis of the relations of performance to aptitude. Students with poor academic records are accepted if they are academically motivated. No vocational training is provided. The aim is to provide academic curriculum for a lifetime of learning. No extra curricular activities are permitted during school hours. There are no cafeteria, auditorium, football stadium, or bus service. Food is furnished by privately owned snack bars on the premises. Faculty are not required to participate in extra curricular activities; staff are freed for professional duties, by using many non-professional aides. The school day is 7:45 a.m. to 3:45 p.m., with 70-minute class periods. Nova employs an artist to prepare visual illustrations. There is closed circuit TV with a dialogue system to 66 stations. There are three resource centers. The cost per pupil is less than that for some traditional schools in the same county.

ratten (1966) described Garber High School. The objectives of Garber High School are to: (a) accommodate several levels of student ability, (b) provide the means for each student to progress independently through substantive material, (c) to construct each curriculum as a complex sequence of inter-related concepts. In order to meet individual needs, the department holds an annual student planning conference, which sets the amount of progress (number of concepts and courses) the student of a particular level can realistically complete. The product of the conference with a student is an agreement by the student to complete particular concepts to get credit for the course.

Students at Garber High School may take a test and place it in an instructor's incoming box. Normally, the test is scored and returned by the next day. Study guides are used with each course to tell the student what he must do to prepare for each of the concept-mastery tests. For each concept, there is a list of aims to tell what he is to learn. The study guide specifies the time that should be spent on study of each concept. Students can shift to parallel courses of the same subject at a different level without completing the initial one. Students use classrooms, the department office, the Learning Resources Center (LRC), and a testing area. The LRC has a library, space for using audio visual materials, small group discussion space, space for independent study, and space to prepare learning materials. First and second year courses are taught principally by lecture and text. Third year courses are organized for continuous progress. Garber High School has attempted to change the role of the teacher to administrative, diagnostic, explanatory, and organizational functions.

The major innovation of Buena Vista High School is the use of closed circuit TV combined with team-teaching, Egbert (1966). The program includes a telelesson of 25 minutes followed by discussion. Telelessons are given all day to classes of 100 students. Most lecturing is done by TV. Most discussion is done in small groups.

Systems analysis techniques were used to study a tenth grade social studies course in American History at Nova High School, an eleventh grade English course at Buena Vista High School, a biology course at Theodore High School, and a mathematics course at Garber High School. Cogswell (1966) analyzed the course at Nova High School in terms of teacher roles, effects of media on the teaching, pupil relations, information requirements, the use of space, and the effects of course procedures upon students. Data produced by the computer simulation model corresponded well with descriptive data. The American History course was organized on a continuous progress plan. Most students in the class progressed at the same rate, but the gap between those who did much of the course work and those who did little increased as a function of time. As the gap increased, the demand on resources increased. There was insufficient time, staff, and resources to produce materials to meet the demands. The use of the continuous progress plan had to be terminated.

Egbert (1966) contributed a detailed description of the English course at Buena Vista High School. Course operating procedures, time spent in various groupings and activities, rotation of groups, and materials, the use of equipment and space were analyzed, along with TV activities, attendance checking and reporting, and personnel role and job descriptions. Flow charts of course activities were provided. The room was 55' x 80' in size. It was equipped with six TV receivers, a microphone, a Vugraph overhead projector, 400 pictures, 500 slides, and 250 illustrations relevant to the course. Egbert (1966) also proposed a modified program of English instruction, a continuous progress portion with telelessons, and the other part, a lock-stepping program, with three alternative time schedules. Any one student could schedule both types of experiences, and a typical student would spend, in a two-week time period, 225 minutes in the lock-stepping English study and 275 minutes in the individual progress portion.

Bratten (1965, 1966) did an excellent job of the systems analysis of a biology course at Theodore High School and a mathematics course at Garber High School. Theodore High School uses media for the individualization or individual progress of students through the eleventh grade biology course. Study guides, programmed instruction, special assignments, and instruction by ability levels are used. Creative use is made of a revolving flexible schedule and a revolving period, 9:12 a.m. to 10:02 a.m. Schedules are based upon weekly activities and are changed each week for every student. No regular class schedule exists for the revolving period each day. Large group instruction can be scheduled in the revolving period by approval of a coordinator of instruction. Health and personal development classes are scheduled into the revolving period, and school innovations and activities, such as aptitude testing, student government and groups are scheduled into the revolving period. Three different functions are scheduled on a weekly basis--individual study, mastery testing, and small group discussion. These three functions occur simultaneously in the same medium-size classroom.

Bratten (1965) described the course organization for individual progress at Theodore High School. The study guide has three sections, a preface, the guide proper, and a schedule of materials. The preface notes statements of course objectives, classroom and laboratory regulations and procedures, information on course materials, details of the grading system, and the requirements for papers and laboratory reports. The main body of the guide contains a detailed plan of assignments, sequentially arranged. Student progress in biology was measured by the number of units completed, with satisfactory performance on a mastery test. Each chapter in the textbook is described in the study guide by two headings: (1) specific objectives and (2) a checklist of activities. Each student accomplishes all activities. Some kind of written work is required for each chapter of the textbook. On completion of each item of work, the material is placed in the folder by the student and the list is checked. When the guide is completed, the student meets with the instructor to submit his folder and review contents for completeness. After approval by the instructor, the student schedules himself for a date to do the mastery test. Roles of teacher, counsellor, teacher assistant, and laboratory assistant were described.

Bratten (1966) studied the biology course at Theodore High School as a system for processing students. The course was simulated on a computer, and the results were compared with actual data. The concept of individual progress was examined as it related to the organization of courses in general and the biology course, in particular. The use of systems analysis in simulation to study possible behaviors of course organization was found to be feasible and valuable. Systems analysis design rules for the activities of the faculty provide information on the use of media for student interactions, new applications of data processing, information on the amount and use of space in innovating schools and estimates of the characteristics of graduating students.

The biology course at Theodore High School as a system is a sequence of 20 activities, with a study guide enabling the course designer to choose media with optimum flexibility to direct students to multiple sources for instruction, enabling the instructor to program interaction opportunities. The study guide requires all students to meet minimal progress requirements by specific dates to receive a passing grade in the course.

The course simulation vehicle is a set of computer programs in Jovial Language used on the Philco 2000 Computer. Programs are modular in type. The results of systems analysis indicated that a rule is needed in designing minimal group progress goals. The rule adopted said that the amount of time spent in a given unit of a course depends upon the total number of days spent in the course. It was suggested continuous progress courses should be constructed in such a manner that all students achieve the same degree of mastery. The rule adopted said that 90% of course objectives should be mastered. Systems analysis further suggests that a rule is needed in designing individual progress goals. The progress rate for a student depends upon his rate for the unit requiring the longest time in the course. Thus, progress in continuous progress courses requires individualized instruction, multiple levels within courses, a non-graded organization, criteria for basing a test, flexible scheduling, mobility of students, ready instructional materials established in the Learning Resources Center (LRC), and the use of a study guide. The medium for organization is the study guide, which releases the instructor from the organization of a particular textbook. Garber High School uses 100 carrels for the individual progress courses.

Bratten (1966) constructed a flow chart of the activities of the mathematics department at Garber High School. The department was considered as a system for processing students. The systems analysis presents three sets of rules, represented by arrows: (a) rules for branching or sequencing of paths, (b) rules for determining amount of time spent in activities, (c) criteria for branching students at each choice point. The specified activities and rules comprise the data used to simulate the mathematics curriculum of the department. In a typical problem of simulation, 100 students were processed through the model to determine the demands of a six-year period for various courses, assuming a 180-day school year. The product of simulation is a data tape recording each decision made about a student concerning specific activities and time. The use of tape with data reduction programs gives answers to questions about students, e.g., the simulator predicted 745 students would take 23 different courses. When class size was limited to 25, the simulation results suggested 33 classrooms and six teachers would be necessary to accomplish the aims of the mathematics department.

In summary, Cogswell (1966) reported on the exploration of the uses of systems analysis and computer simulation of school organizations. The attempt was made to find by system analysis new ways to use instructional media. Recommended uses of systems analysis include: (a) the improvement of present instructional and educational planning systems, and (b) exploration of the feasibility of proposed continuous progress school organizations. Recommended procedures for the use of systems analysis include: (a) definition of the major problem to be solved, (b) construction of a model of the system, (c) a use of the model to study effects of changes in the system. A simulation model named EDSIM was developed to simulate a system by means of computer programs. After evaluation of eleven analyses of school systems, it was concluded that revision of school programs to adapt to individual differences of students requires: (a) adequate self-study, instructional materials, and (b) adequate systems to provide information to instructors, counsellors, and administrators about the status of individual students. To meet these needs, the project recommended (a) developmen of a computer-based system to assist in planning, (b) study of information processing for student instruction, (c) in-service training of school personnel in preparation of individualized course materials, and (d) development of procedures for management of changes in schools.

Finance

Dressel (1965) described a challenging effort of the Michigan State University to use systems analysis for the procedural and cost analysis study of media used in instructional systems. The developmental work is being done by the Instructional Systems Development Division of the Audio Visual Center. Flow charts for analysis and design of instructional systems were described.

Koenig (1967) described the analysis of high school costs by means of the systems analysis approach, using a local citizens' committee on systems analysis, the business manager, superintendent, assistant superintendents, director of educational data services,and a principal from each level of education. In addition to the customary method of cost analysis by account classification, high school costs were analyzed in terms of academic areas,and costs for each academic area were computed in each of seven divisions: classroom expense, school service areas, regular school expenses, maintenance, depreciation, central services, community service expenses. The aim of the systems analysis was to state the cost per student per school year for academic areas of a senior high school. The approach for a junior high school is similar but it is not as lengthy. For an elementary school a time study was done by subject areas. In the first and second grade; e.g., 28% of the time was devoted to reading instruction, 13% for mathematics, 10% for social studies, 21% for language arts, 10% for art, 4% for music, and 7% for science and health. An estimated 500 man-hours was consumed in this process, plus 200 hours of clerical assistance. Systems analysis cost data are presented in Table 1 for some departments in Gunn Senior High School, and Cubberley Senior High School, Palo Alto Unified School District, California.

Table 1*

SUBJECT COST ANALYSIS, 1965-66

Department	Cost per Student Period Gunn H.S.	Cubberley H.S.
English	$221.91	$209.40
Foreign Language	225.98	236.37
Mathematics	208.79	214.47
Boys Physical Education	237.72	194.08
Girls Physical Education	204.64	185.34
Science	228.41	229.43
Social Studies	180.03	187.07
Business Education	237.34	251.65
Industrial Arts	341.14	330.59
(Not a complete listing)		
Average (All Departments)	$233.21	$228.59

Koenig reported the conclusion of the Citizens' Advisory Committee that the practice of reporting cost information by account classification and subject area is now adequate. In fact, the cost analysis for Gunn Senior High School, e.g., indicates that the percentage allocation of total expenses would be 17¼% for English, 11½% for foreign language, 7½% for boys physical education, and that such percentage allocations could reasonably be used for two or three years, or until there were a new cost analysis for the school.

Educational Plant Construction

McKenney (1967) reported on the construction systems development at Granada School, Reed Union School District, near

*Koenig, H. F. "Systems Analysis and the Economics of Education," Journal of Secondary Education, 42 (6), 256-60, 1967.

Stanford University. A flexible modular system of school construction was used, based upon a System Development Corporation project. The systems approach produces school buildings that are competitive with traditionally planned school buildings in initial cost but are much less expensive over a 15-year period. The systems approach can be used in the design of school buildings to save money through decreased maintenance costs and built-in flexibility of learning space.

Yurkovich (1966) developed a computerized method for determining the physical facilities requirements of a large university. Research on the facilities requirements of large institutions demonstrates the need for development and testing of systems for (a) classifying space, (b) maintaining a perpetual space inventory, (c) conducting room utilization studies, (d) providing for staff and space needs, (e) projecting future requirements, and the like. Each system was developed and tested by direct application to the requirements of the University of Wisconsin. Dimensions of the space program, the required data systems, and the organization of systems were discussed. Appendices of the report include code lists, data reports, detailed guides, flow charts, and supportive information on space management and planning.

Counselling

Cogswell and Estaban (1965) constructed models of a school counsellor's cognitive behavior in the appraisal of student information and his overt verbal responses in the educational planning interview. Counsellor behavior was simulated with computer programs. To construct the simulation vehicle, records of a counsellor's verbalizations were used while reviewing records of 20 ninth grade students prior to interviews and while conversing with students. The computer was programmed to conduct an interview by means of a teletype under control of a G-32 computer in a time-shaping mode. The automated interview program was planned to review student progress, collect comments from the students, gain counsellor's reaction to student plans, and to help students plan their schedules of high school courses. To assess the validity of the model, the results of automated interviews were compared to the responses of the original human counsellor with a new sample of 20 students from the same population. The results of the study indicated potential value of the automated procedure for both research and field applications.

Ellis and Wetherell (1966) presented the need for student access to a computer facility, the rationale behind the need, and a general description of the equipment required in order to aid students in making career decisions. There is a need to develop an information system to aid choices. Research intentions include construction of a model of student career decisions, design of basic components of the information system, construction of relevant computer programs, selection of computer hardware configurations, etc., to complete the development of the system. The investigators desire to provide by means of a computer the desirable, interactive reckoning environment which is essential to career decisions. Due to the limitations of human competence, such a role can be performed only by a properly programmed computer. A set of computer programs is needed to serve the interface between the student and the large quantitites of data that are relevant to career decisions. Ellis and Wetherell concluded that students must have access to a computer in this manner.

Multi-Media Methods

Ruark (1967) suggested the use of the systems approach to guide the selection of combinations of media. Students learn at different rates and in different ways. Individuals build their own learning style and patterns in the learning act. Combinations of media should be used to accommodate to individual differences--to gain motivation from one kind of media selection, special information from another. Miller (1967) suggested eight essential features of the use of systems analysis should be considered by schools planning to use systems analysis to control educational technology.

School District Processes

Sisson (1967) analyzed and simulated the functions of a large urban school district. The consequences of varying certain district parameters were explored: student population, staff, number and size of buildings, salary. Past and present values of parameters were used to forecast future trends. It was found that the simulator program can be used to predict optimum policy in terms of given parameters. In a similar fashion, the activities of a school board were simulated by Scribner (1966).

Policy Outcomes in Public Education

Dye (1967) analyzed the relationships of economic development variables (level of urbanization, income, industrialization, education) and political system variables (partisan character, party competition, political participation, malapportionment of states) to educational policy outcomes in states (educational expenditures, state efforts in educational organization and financing, status of teachers, number of dropouts). Economic variables are more correlated with educational policy outcomes than are political system variables. Multiple, partial, and simple regression methods were applied to data from 50 states, using a conceptual framework provided by David Easton. A model was displayed which has substantial explanatory power.

Cooperative Regional Data Processing Center

Grossman and Home (1966) developed and demonstrated a plan for a comprehensive agency capable of serving up to 300,000 pupils. The system was designed to serve groups of school districts. The overall systems plan, the necessary programming activities, and a technique for master coding were reported. The center will provide teachers and administrators with substantial assistance in registration and scheduling, attendance, accounting, grade reporting, test scoring and analysis. The system was programmed to maintain cumulative records on master file tapes at a regional center on each student in participating schools. The results of development work at Richmond Unified School District and at a Research and Development Center at Sacramento, proved that such a cooperative regional data-processing venture is feasible, and a regional-type center is preferable to local-type centers. The minimum operational costs would be about $185,000, and secondary schools using the plan could expect costs of $2.50 to $3.00 per pupil for one year.

Summary and Conclusions

1. The perspectives and techniques of systems analysis have been applied successfully and helpfully to the educational institution as a whole, and to many of the separate functions of schools. Educational institutions can and should be understood as related processes or systems of man-machine, space, time, and materials interactions.

2. Systems analyses can be applied to educational institutions in the following ways:

   a. Construction and use of information systems, e.g.:

      (1) Student information system as a resource to guide counselling, scheduling, curriculum construction, curriculum direction, student records

      (2) Physical facilities information system

      (3) Cost analysis data and classification system

      (4) Personnel information system

      (5) Vocational data inventory

      (6) Curriculum data inventory

      (7) Instructional materials inventory

(8) Media inventory

(9) Schools inventory

(10) Teacher character

(11) Regional data-processing center

b. Evaluation of systems, e.g., by use of programs to simulate the functions of an academic department, the results of a continuous progress course

c. Design of agencies of a school, e.g., an IMC, a Surveillance and Detection Center, an Evaluation Center

d. Design and simulation of instructional systems, or courses

e. Analysis of existing schools, for the purpose of recommending changes in school organization

f. Construction of school buildings

g. Understanding and forecasting of school district processes, and educational policies outcomes

h. Automated interview and testing of students.

3. If school districts desire to get started in applications of systems analysis, a good starting point may be in the construction and use of information systems.

4. There is no one formulation of systems analysis that is absolute. Each school district could probably benefit the most by preparing its own systems studies.

5. Systems analysis perspectives and techniques are not a panacea. They cannot be any better than the statements of institutional objectives upon which they are based.

6. Systems analysis exists for evaluation. If students fail courses too often, something in the processes of the institution should be changed.

7. A new kind of school can be envisaged in interactions between the concepts of evaluation, continuous progress

schools, and systems approaches, but there is nothing absolute about the nature of the design. The design features depend upon the nature of systems decisions. In the writer's view, the essential systems generating agencies would be as follows:

a. An Evaluation Center, to generate systems for formulation of objectives, construction and use of criterion and other tests, etc. Objectives should be formulated by specialists, and achievement of objectives should be measured by those who formulate them.

b. An Instructional Materials Center, to generate systems for preparation and use of instructional materials, and to report on use activities.

c. An Instructional Staff Center, to generate systems for learning, instruction, selection of media. Teaching staffs should be hierarchically structured in these systems, and paid according to position in the hierarchy.

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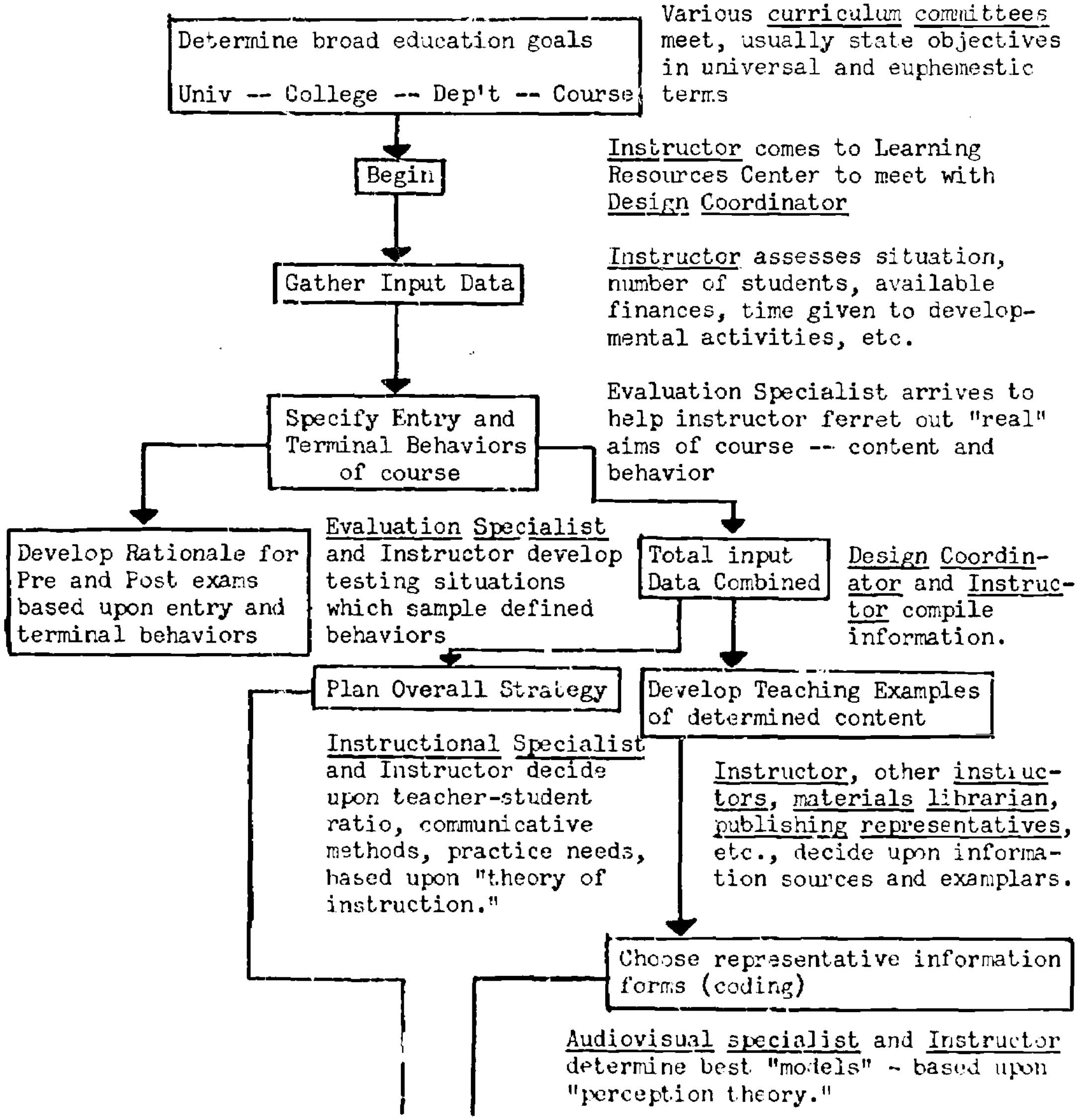
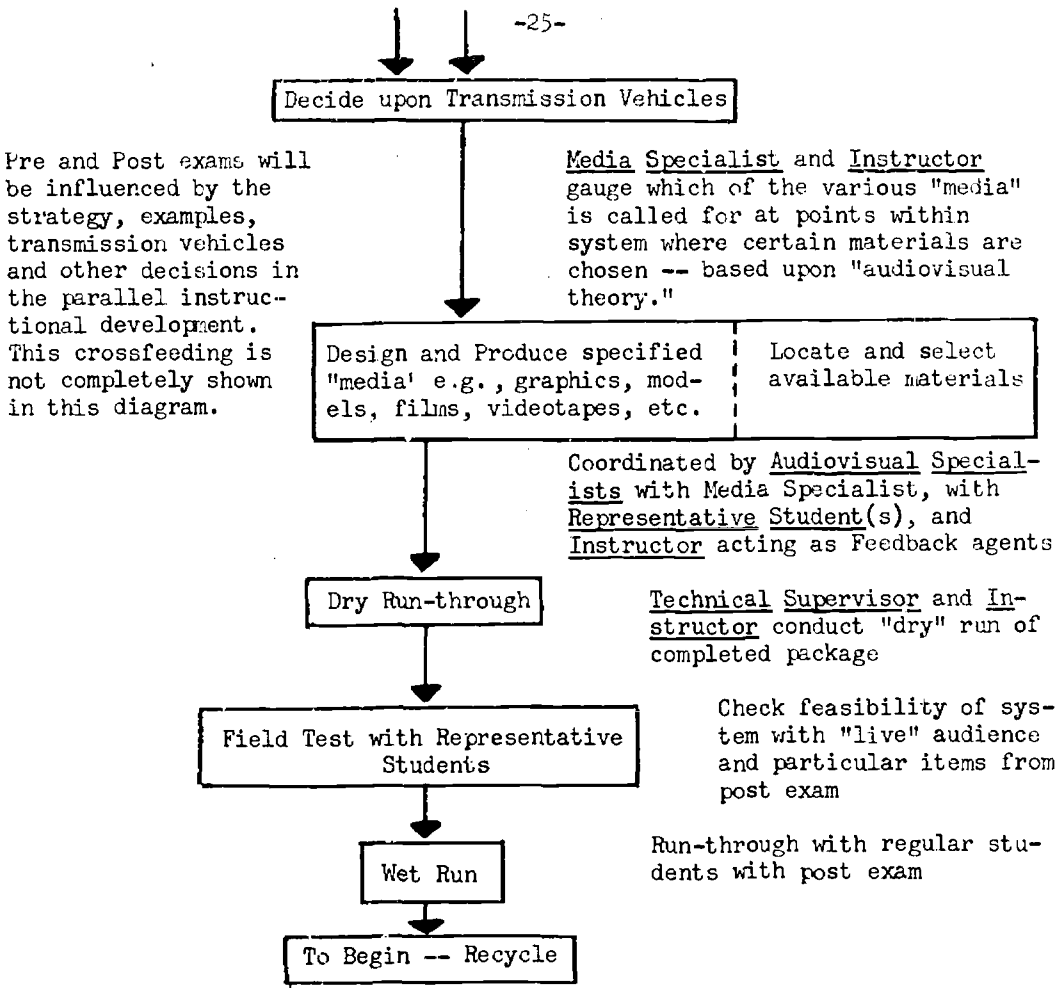
APPENDIX A

A FLOW CHART OF TRIAL PROCEDURES FOR ANALYSIS AND DESIGN OF INSTRUCTIONAL SYSTEMS EMPLOYING INSTRUCTIONAL MEDIA

The following flow chart represents a hypothetical elaboration of the System Analysis, Design and Development phases of the "System Approach to Education Planning" (Ryans, 1964). Important: For purposes of simplicity, communication feedback loops are not illustrated in this flow chart.





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