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ABSTRACT

This paper explains the systems approach. Of several definitions, the simplest is that a system is a set of parts coordinated to achieve a [goal or] set of goals. A modified systems approach could likely be an effective tool in educational planning. The information feedback loop permits the manager to base his actions on the actual performance of the system as related to its overall mission and on the performance of any subsystems as related to their objectives. The need constantly arises to determine alternative courses of action, which must be traded off according to system constraints and mission, and to accommodate successive generations of design, directed by re-evaluation as feedback on the initial system becomes available and as constraints and resources change. A course in remedial mathematics was set up under certain constraints: existing programed material was designed for children; it gave more drill than instruction; other departments needed students with particular math skills; money for change was scarce; new staff could not be expected; no grade, only competence, was required. Its aim was to help students qualify for several departments served by the math department. The author describes the components of this mission by subsystem, and the solution of the problem by the use of a core of courses in arithmetic supplemented by units in algebra, geometry, etc. Other details of the innovation are given. [Not available in hard copy, due to marginal legibility of original document.] (HH)

A SYSTEMS APPROACH TO THE DEVELOPMENT OF A JUNIOR COLLEGE COURSE IN REMEDIAL MATHEMATICS

BY

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"Now," said Rabbit, "this is a search and I've Organized it --"

"Done what to it?" said Pooh.

"Organized it. Which means - well, it's what you do to a search when you don't look in the same place all at once."

--from The House at Pooh Corner
by A. A. Milne

1. Introduction

1.1 Conventional Instruction Systems The concept of individual differences between students has received considerable attention from theorists in education. Research has verified the reality of these differences, teachers have been encouraged to consider them in planning classroom activities, and much thoughtful and dedicated effort has been spent in attempts to develop individualized programs. Yet the almost invariable model for American education, especially at the post-secondary level, involves scheduling random groups of students into a fixed sequence of activities for specified time intervals. Instruction has been artificially divided into courses and tied together with threats of grades, credits, and degrees. The relatively impersonal and inflexible lecture mode of instruction has become standard operating procedure through custom and administrative convenience. The usual college class is simply "teacher-talk" with all the excitement of being stoned to death with popcorn.

In conventional instruction systems courses are organized, as shown in Fig. 1, around a "curriculum target" usually

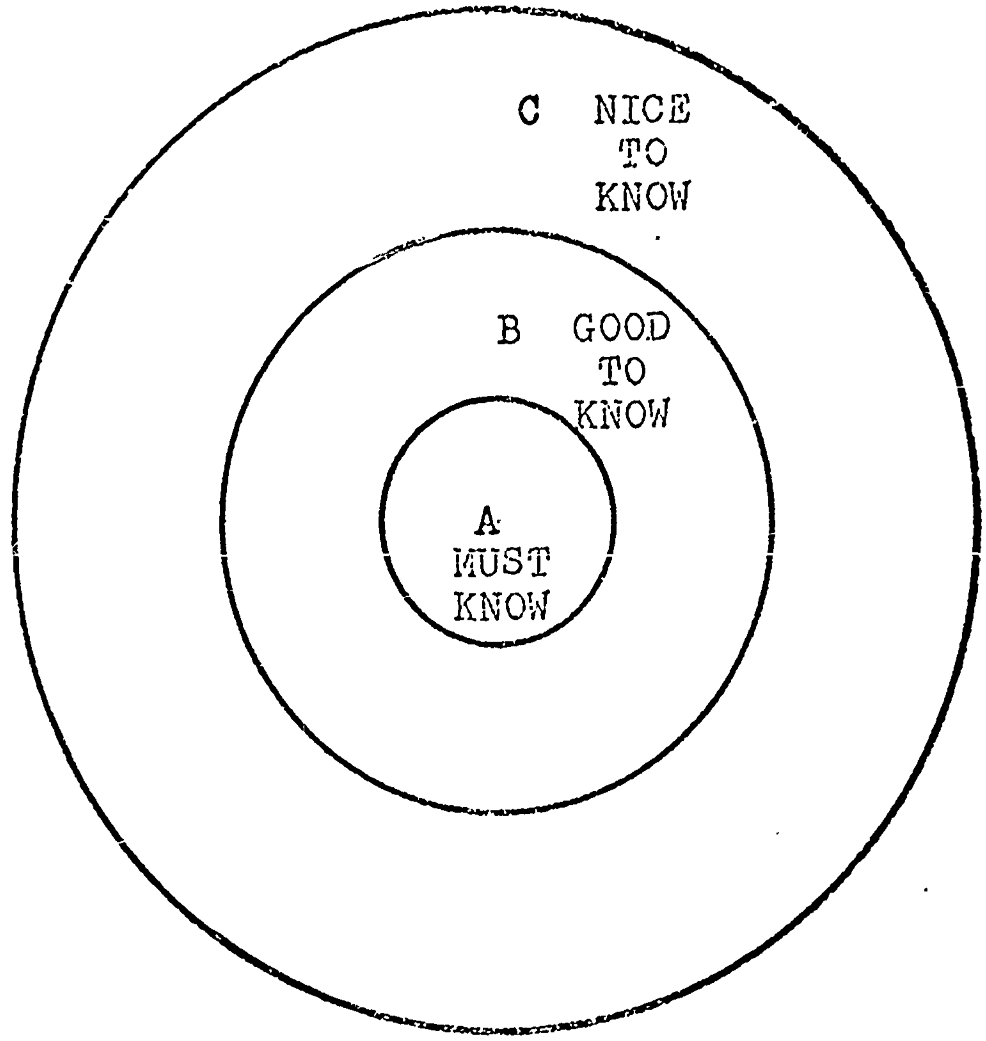

Fig. 1

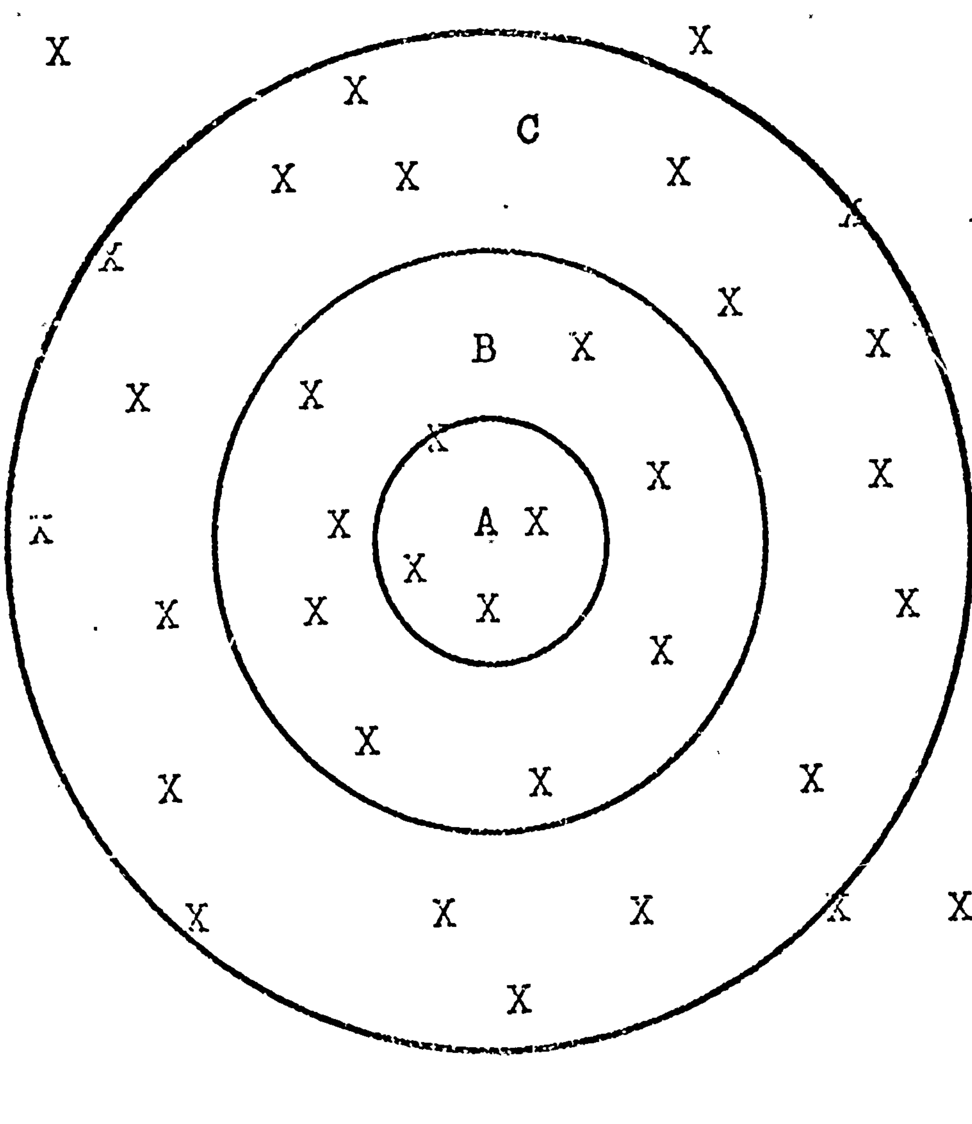

Fig. 2

representing an honest attempt at establishing instructional priorities. (36) Grading, however, is an administrative sorting device and, because it is very difficult to sort students who all have acquired the center-of-target learning, testing takes place as shown in Fig. 2. Examinations "sample" the course content. The net effect of this procedure is that a distribution of scores are obtained (Fig. 3) and the actual learning encouraged (Fig. 4) is not at all like that desired. (Fig. 5) Learning has been down-graded.

1.2 <u>Assumptions</u> A number of assumptions are made in the present paper. Perhaps chief among these is that our present education system is not designed for efficiently anticipating, comprehending, and dealing with the individual needs of students. More importantly, it is not organized for the systematic application and testing of new knowledge related to instruction. It is the bias of this paper that education must look to technology for assistance in meeting its complex problems. The economist, John Kenneth Galbraith has written

> "Technology means the systematic application of scientific or other organized knowledge to practical tasks. Its most important consequence...is in forcing the division and subdivision of any such task into its component parts. Thus, and only thus, can organized knowledge be brought to bear on performance." (28)

A second assumption is that in the design of instructional systems, we will find it most profitable to focus on and design our teaching around instruction - that part of what is taught

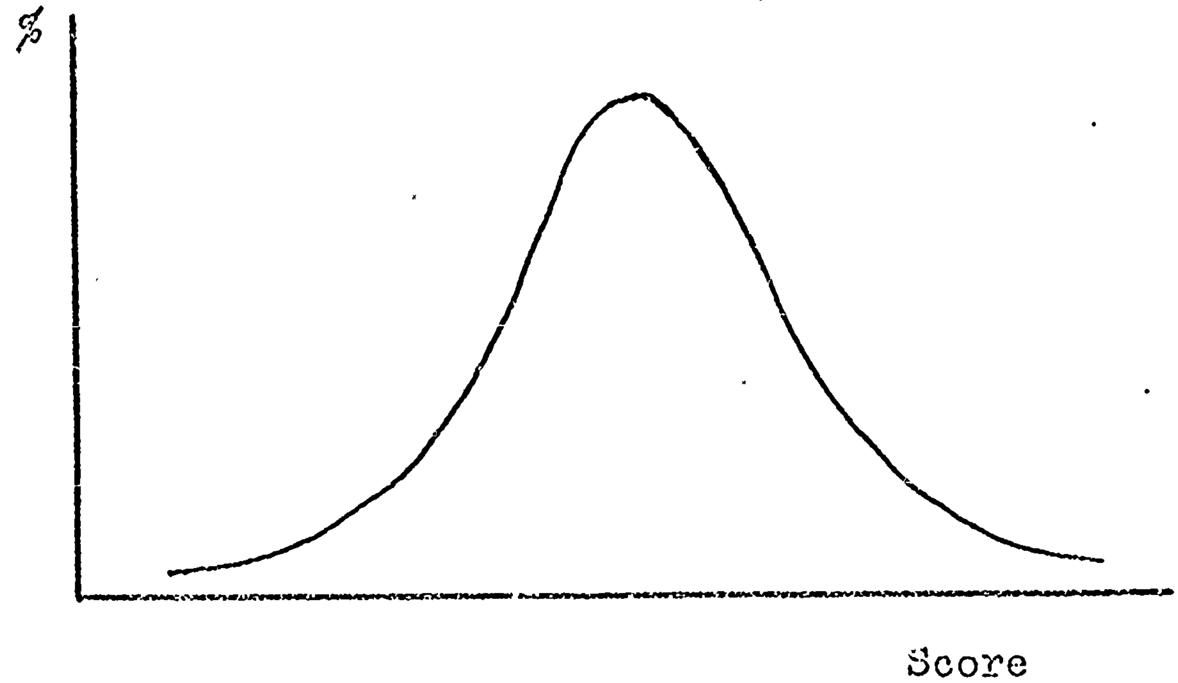

Fig. 3

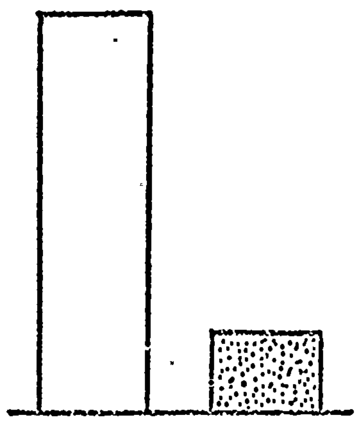

Fig. 4

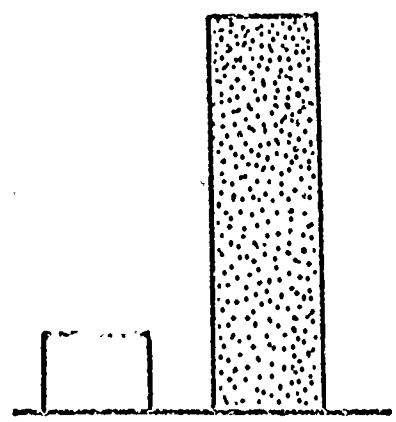

Fig. 5

that is demonstrably learned. This objective, performance-centered, approach is necessary if we are to avail ourselves of whatever benefits may be obtained from the application of technology.

It has been said that the first commandment of any truly civilized society is: "let people be different." A third assumption we shall make is that any instructional system should be truly civilized in this sense; that technology should most properly be used to enhance the individualization of the educational process.

2. <u>An Approach to the Design of Complex Systems</u>

There is an oft-repeated story in which a group of blind men is set the task of describing an elephant. One feels the elephant's leg, another the tail, another the trunk, and so on and an argument arises over the accuracy of the conflicting descriptions. The most interesting aspect of the story is not the debate of the blindmen, but the role of the story teller who assumes that he somehow has the ability to see the whole elephant. It is a piece of arrogance for him to assume that he can fully comprehend so large and complex an object. Our story teller, in his attempt to think in terms of the whole elephant, is a systems analyst.

Systems analysis has been defined (34) as

> "an attempt to give a phenomenological and rational account of the operations of an enterise. It is the application of the scientific method to the analysis of activities outside the conventional fields of science."

The enterprise in question is usually a complex one involving many interconnected components and relationships. This system concept arises frequently in our modern technological society. We speak of social systems, economic systems, communication and transportation systems. Military men design weapon systems and educators worry about educational systems. In physics an isolated set of interacting objects can be considered as a system, so that the physicist studies gasses, galaxies, atoms, and nuclei as examples of physical systems. For the anthropologist, a civilization or society is a suitable system for study. The sociologist studies institutions, the administrator is concerned with the organization or firm as an example of a system, the biologist studies the cell, tissue, organ or even the entire organism. A space ship is a mechanical system. In operation it is a man-machine system, and is in fact one component of a larger mission-control-system itself a subsystem of a complex society.

It is clear that the most important and spectacular developments of our society and our imagination are systems. (26) But what is a system? How is it defined? Definitions offered range from the superficial (46)

> "...all of a thing."

to the complex. (3)

> "Any recognizable delimited aggregate of dynamic elements that are in some way interconnected and interdependent and that continue to operate together according to certain laws and in such a way as to

produce some characteristic total effect. A system, in other words, is something that is concerned with some kind of activity and preserves a kind of integration and unity; and a particular system can be recognized as distinct from other systems to which, however, it may be dynamically related. Systems may be complex; they may be made up of interdependent sub-systems, each of which, though less autonomous than the entire aggregate, is nevertheless fairly distinguishable in operation."

Whatever, if any, definition of a system one accepts, it is clear that the following elements are a necessary part of any system:

1. a large number of functionally related, inter-connected components (14)
2. repeatable operations (60)
3. a common purpose or system integrity (6)

We may usefully and simply define a system as a set of parts coordinated to accomplish a set of goals.

2.1 The Systems Approach Most users of the systems concept consider it a planning device. Dr. Alain Enthoven, Department of Defense, has called it

> "...reasoned common sense...
> ...a reasoned approach to problems of decision." (55)

It is commonly used to aid a decision-maker in choosing a course of action, application of the scientific method to problems of decision-making. More accurately, it is not designed to make decisions but to enable us to ask the correct questions. As an approach to problems of great complexity the systems method seems to provide a way of attacking problems too complex for conventional scientific methods. Many generalists see the systems concept as a new approach to science. (2, 7, 8, 44)

The earliest systematic use of a systems approach was by A. K. Erlang in 1917. (56) Erlang, a Danish mathematician, used systems methods in analyzing complex problems involving a telephone exchange system. More spectacular successes came during World Wat II when the method was used to develop procedures for anti-submarine warfare. (46) Modern exponents of the systems approach see it as a process of cost effectiveness analysis, a view associated with systems planners such as the Pentagon's Robert McNamara, the Director of the Bureau of the Budget, Charles L. Schultze, and the University of California president, Charles Hitch. The success of their approach is evidenced in the immense savings in operating costs and increased efficiency in the defense effort. The recent Apollo 11 system, an unbelievably complex interaction of mechanical components and thousands of people, was spectacularly successful. The month-long launch process was 0.724 seconds late and final splashdown of the Columbia, after 8 days and 500,000 miles, was less than 30 seconds late - a planning feat unparalled in human history.

Educational planners usually find it more profitable to consider the systems approach as an attitude of mind, a way of seeing the world, an approach to education problems as a whole. (43) Applications of the method to problems of education have been fewer and less adventuresome and its successes correspondingly less spectacular. However, many educators agree on the potential usefulness of the approach in providing new solutions for teaching problems arising in an increasingly complex world. (15,32,38)

2.2 System Structure We may distinguish a number of basic elements of system structure common to all systems. (21)

2.2.1 Environment A system must be distinguished from its environment, those factors not under the direct control or influence of system components. These elements are "fixed" or "given" from the system's point of view and determine, at least in part, how the system behaves. Instruction systems very often must operate under fixed budgets that cannot be changed by any activities of the system. The limitations imposed on a system from without are usually labeled "constraints".

2.2.2 Objectives The objectives of a system are usually embodied in statements of generalized goals and in precise and specific performance measures. The system mission is a set of operationally defined objectives, concrete desired outcomes of system activities. Because the system is itself complex, the mission is usually a large scale task, e.g. put a man on the moon by 1970, or eliminate hunger on earth in this century.

2.23 Resources The resources of a system are the means that the system has available for accomplishing its stated mission. Resources, as opposed to environment, are the things the system can use to its advantage. It is significant that technological advances may be able to increase system resources enormously. For this reason, systems planners must pay attention not only to existing resources and constraints but also to the manner in which resources can be increased by means of research and development, by training and education of personnel, or by political activities. A systems component that deals with the increase of resources may be the most important component of the system.

2.2.4 <u>Components of Subsystems</u> In analysis of a system one must ignore the traditional lines of division such as departments, divisions, groups, single objects, etc. and attempt to break down the mission of the goal into a set of tasks that the system must perform. For example, rather than consider a city government as a set of departments, buildings and men, one breaks down the basic mission into components related to health, education, recreation, management, etc. Every system develops functional subsystems to perform its work, to maintain itself, and to help it relate to its environment.

One important aim of systems analysis is to arrange systems components into a logical hierarchy or mission profile designed to accomplish system objectives most effectively. In order to develop this profile the systems designer must identify subsystem and component parameters whose value will adequately characterize the element in question. Each component or subsystem must have clearly specifiable objectives related to the mission.

2.2.5 Management Subsystem One important component is the management subsystem that sets component goals, allocates resources and controls overall system performance. Implicit in this management activity is the use of an information-feedback loop that permits the manager to base his activities on the actual performance of the system with respect to its overall mission, and on the performance of individual subsystems according to their objectives.

The management subsystem is constantly faced with the necessity of determining alternative courses of action and trading off alternatives in the light of the system constraints and mission. In designing an effective system it is often necessary to plan in terms of successive stages or generations of system design. For example, an instructional system may appear initially in a first generation design. Planned changes direct the evaluation into second and third generation systems as feedback on the initial system becomes available, as constraints and resources change.

2.3 Systems Design The traditional design of a complex structure is an open-loop process in which evaluation of the effectiveness of the structure, if any is made, is not a factor in the design. One designs the structure on the basis of a hunch, an attempt to copy other structures, or as an application of some formal theory. The systems design approach is a closed-loop, feedback, or cybernetic model in which evaluation and revision on the basis of evaluation are a characteristic of the design process. Fig. 6 illustrates the flow of work during the design process. System evaluation must be made on the basis of terminal performance specifications and designed so that we can trace out the effects of any set of choices or decisions made in implementing the mission. (10) Fig. 7 shows an application of this closed loop process to instructional design. Note that the feedback may be directed to a number of places in the implementation process.

It is significant that the most noteworthy successes of the systems approach have been in systems where human variables play a relatively minor role. Because of the need for a clear-cut statement of mission objectives and specifiable subsystem outputs, and because of the difficulty of quantitative specification of human variables, the systems approach has tended to concentrate on the mechanical or hardware aspect of human systems. Johnson (33) has noted that this has created a concern lest the systems approach mechanize and dehumanize instruction. He notes that nothing in this approach restricts

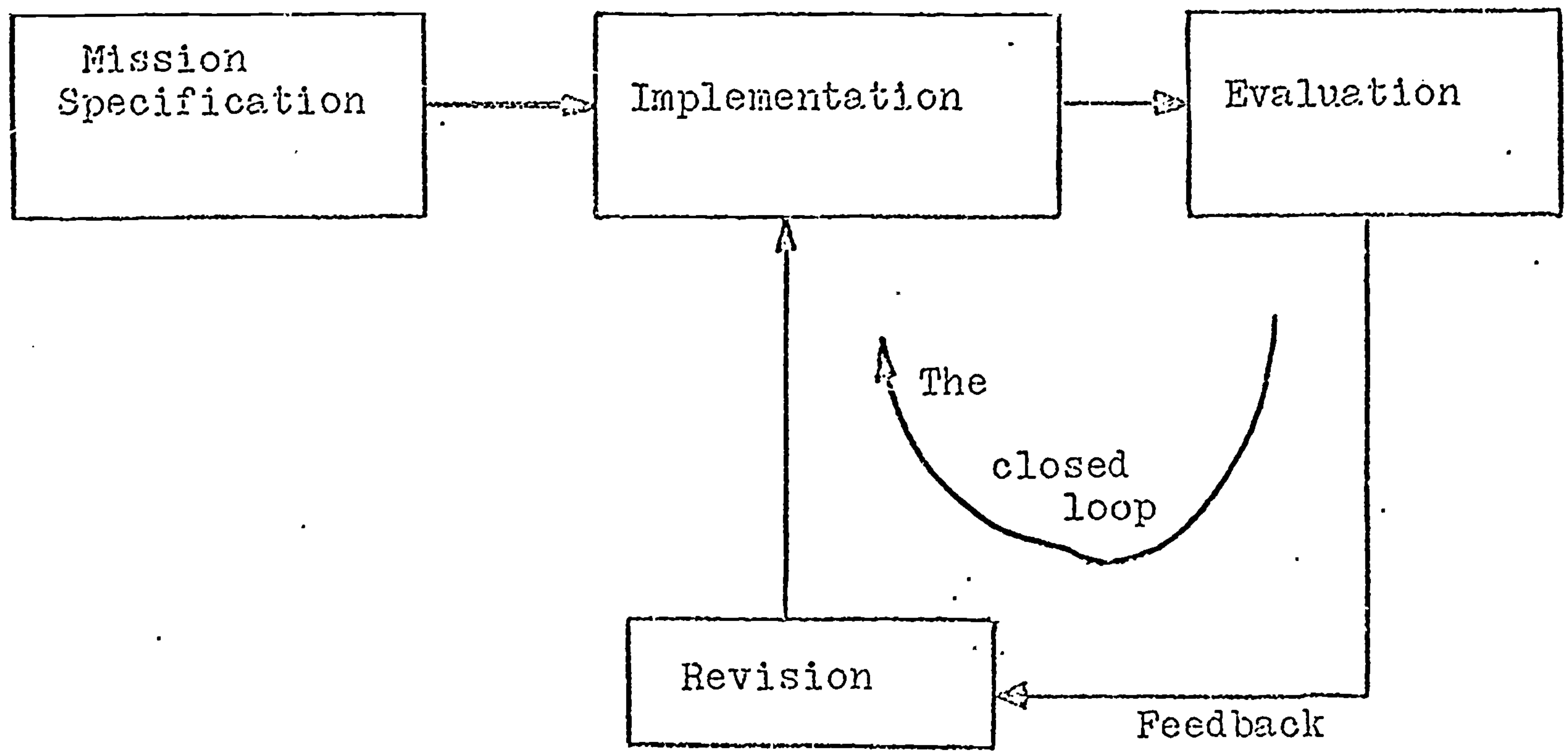
Mission Specification
Implementation
Evaluation
The closed loop
Revision
Feedback

Fig. 6

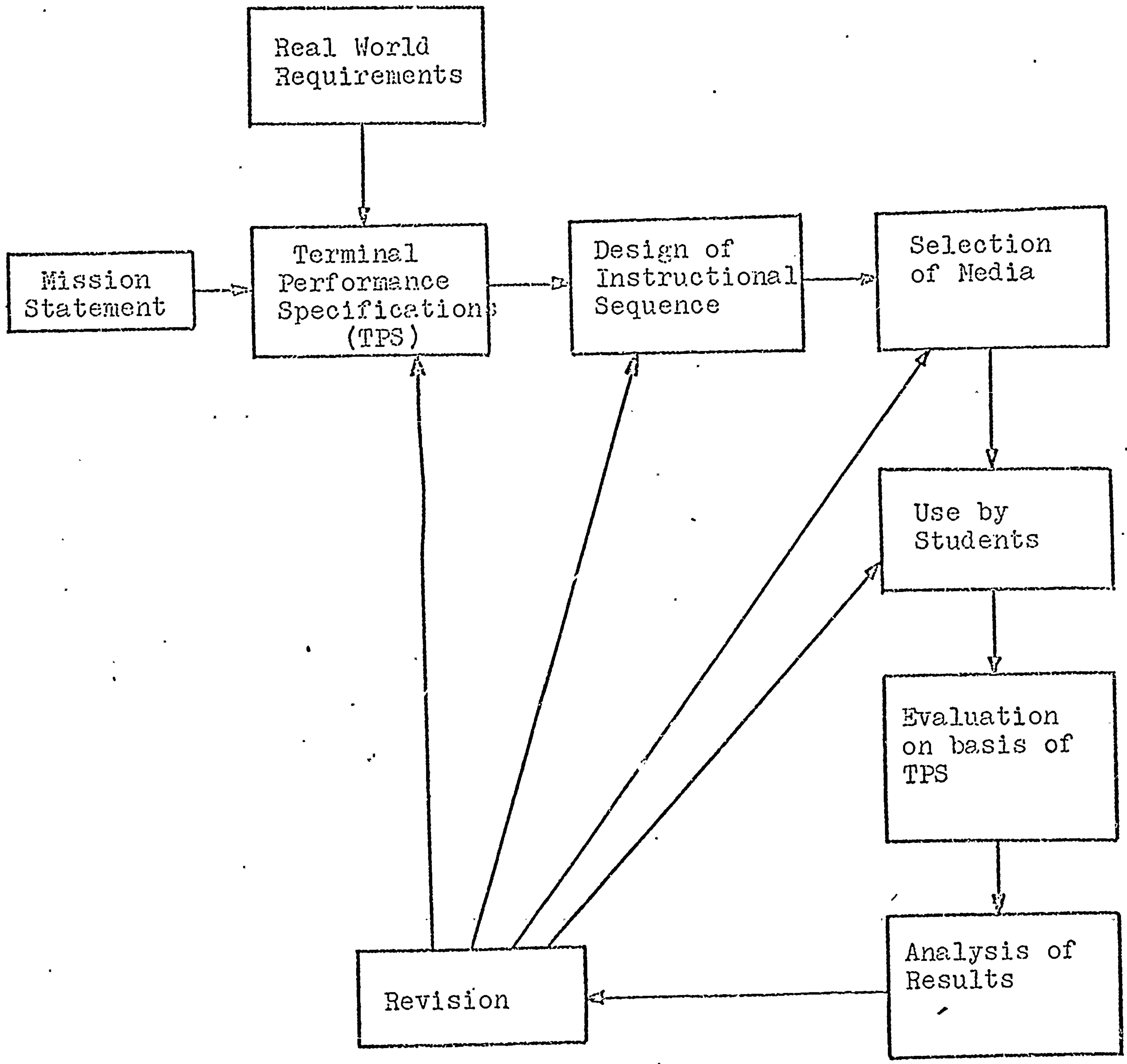
Real World Requirements
Mission Statement
Terminal Performance Specifications (TPS)
Design of Instructional Sequence
Selection of Media
Use by Students
Evaluation on basis of TPS
Analysis of Results
Revision

Fig. 7

planners to a mechanistic or hardware approach to instructional design. Ingenuity is the only limitation, and, in fact as others have noted (59) the individualization of instruction seems to be a major implication of the systems approach.

3. Remedial Mathematics in the Junior College: A Systems Problem

3.1 The Need for Remedial Mathematics A distinguishing feature of the community junior college is its open door admission policy and the necessity of offering remedial or developmental courses in order to assure that marginal students have a reasonable chance of success. (53) The task is difficult: junior college instructors are asked to do in one year what the public elementary and secondary schools have failed to do in twelve years. Teaching these remedial courses is often considered a distasteful chore. A mathematics instructor fresh from stimulating graduate work in advanced topology or analysis cannot be expected to become excited about the prospect of teaching long division to resentful adults with a built-in expectation of frustration and failure.

Nevertheless, basic arithmetic represents a major portion of the teaching responsibility of most junior college mathematics departments. In her study of this problem, Carol Kipps (35) surveyed 73 California junior colleges, questioning 178 mathematics instructors and found that 59 of these colleges offered basic remedial mathematics courses. This represents, in 1965, some 12,500 students. It should be stressed that the stigma of a "bonehead" course keeps these enrollments well below the number of students who actually need remedial work in mathematics. Schenz (57) found that 2/3 of all junior colleges require low ability students to enroll in remedial classes.

A startling finding was that the level of success in teaching basic arithmetic in these courses was less than 70%. This low effectiveness can be attributed to the wide variation in student ability, preparation and motivation (37) and to the techniques of instruction (35,62).

3.2 <u>History of Remedial Mathematics at Santa Barbara City College</u> The present problem involves the development of a course in remedial mathematics at Santa Barbara City College. The development of this course has already progressed through a number of stages.

3.2.1 <u>Conventional Course</u>: three lecture/discussion meetings per week; 30-45 students; traditional modes of instruction.

3.2.2 <u>Programmed Instruction and Small Classes</u>: Lecture methods were replaced by commercially available programmed instruction materials (9); class meetings were gradually reduced from 3 discussion sessions per week to no required attendance; enrollment was maintained at 30 to

45 students per class.

3.2.3 Credit by Examination: No required attendance; unlimited class size. In response to students complaints that the programmed materials were boring, the recommended text was changed. (31) Going from stage 3.2.2 to stage 3.2.3 resulted in a significant increase in the drop-out ratio.

3.3 Present Problems and Constraints

3.3.1 Students report that the programmed materials are not appropriate for adults, but seem designed for children.

3.3.2 Students report that the programmed materials do not "teach" but simply provide drill work.

3.3.3 Students indicate a desire for more feedback about their performance. A single final exam is not adequate.

3.3.4 Some students indicate that they would prefer scheduled classes and required attendance. Others are quite pleased with the freedom offered and do not want a change.

3.3.5 There is a need to better serve the other departments of the junior college that require certain basic knowledge in mathematics of their entering students. The present program is not producing students with the proper skills for all transfer programs. Individual departments differ greatly in their student requirements. There is a need for individualization of instruction matching it to the student's deficiencies and his future plans.

3.3.6 Money for elaborate changes will continue to be scarce.

3.3.7 Numbers of students will continue to grow at a rate greater than the rate of growth of financial resources.

3.3.8 Staff will not be added except as a last possible resort. At present the course, with an enrollment of about 200 per semester, requires only a small fraction of a single instructor's teaching load. It is extremely unlikely that there will be a return to smaller classes and traditional modes of instruction.

3.3.9 Grades are not required. In such a remedial course the emphasis is on demonstrated competence.

3.4 <u>The Problem</u> The present problem was to design and implement an instructional system for teaching remedial mathematics at the junior college level under the constraints listed above. The systems approach was adopted as a method of planning and design.

4. Systems Analysis of the Problem

The following components of the instructional system were first identified.

4.1 Mission The general statement of the system mission was: Produce students able to perform the mathematics requirements of a variety of other courses and do this under the given constraints. In order to state the mission in specific performance terms a user survey was performed and the specific requirements of each of the courses served by the remedial mathematics course was determined. These were assembled into a detailed set of behavioral objectives.

4.2 Mission Components A number of mission components or subsystems were identified:

4.2.1 Diagnostic Subsystem It is necessary to determine each student's unique needs and defficiencies. Diagnostic tools and procedures must be developed and validated so that student needs and initial level of performance can be ascertained.

4.2.2 Distribution Subsystem Each student must be brought into contact with a variety of materials and situations optimally designed to meet his unique needs. Possible distribution models include bookstores, libraries, study centers, classrooms, etc.

4.2.3 Scheduling Subsystem An optimal sequence of learning activities must be created for each student based on his unique needs as determined by the Diagnostic Subsystem. The Scheduling subsystem is a link between the Diagnostic and Distribution subsystems. All teaching involves decisions about what instruction should be given, but in an individualized system these decisions must be made relevant to the individual learner.(17)

4.2.4 Evaluation Subsystem Each student's performance must be evaluated at each significant step of the learning process including the terminal step. Monitoring and assessment must be a continuous activity.

4.2.5 Information Subsystem The information developed in the diagnostic and evaluation subsystems must be made available to any part of the system that needs it for feedback purposes. The information must be available in a form appropriate to the use that will be made of it and at the time when it is needed. It is important that only the information needed be presented so that the feedback is simple, direct, and readily used. Instructional decisions require a great variety of information about the individual student such as (a) criteria of competence (b) background (c) learning preferences (d) present status in the instructional sequence, and so forth. For truly individualized instruction a large amount of such information is needed, much of it on a daily or weekly basis. There is considerable evidence that knowledge of results facilitates learning. (25)

4.2.6 Management Subsystem: The role of the teacher-manager of the system must be defined and integrated into all parts of the system. It is important to recognize all places where management control is needed or available in the system, and to determine the mechanism of this control.

5. Solution of the Problem

5.1 Diagnostic Pretesting Paper-pencil tests will be designed to determine the extent to which any individual student entering the system already meets the terminal objectives. Although IQ, aptitude, preference, personality and other tests might also be used, it is clear (61) that it is more important to know the students entering mathematical competence than to know his IQ.

5.2 Computer Scheduling Diagnostic pretests will be computer scored and individual students will be scheduled into an individual sequence of activities on the basis of their pretest performance. The instructional program will, so far as possible, be tailor-made to fit the individual student. The data processing speed and capacity of the computer will allow this to be dome quickly for large numbers of students.

5.3 Individualized Instruction A large number of studies (39,24,22) indicate that individualized instruction, in the form of programmed instruction, produces learning at least as effectively as traditional instruction. Programmed instruction will be the basis of instruction in this system. Initially, paper-pencil programs will be developed. Later refinements may possibly involve the use of more sophisticated hardware, computer-assisted instruction, or audio-tutorial systems. The course content will be divided into a central core and supplementary units. The central core represents the minimum set of objectives for all students while the supplementary units are related to the need of specific courses of study. The central core will consist of the following units:

1. Basic Arithmetic: Addition, subtraction, multiplication and division of integers.
2. Fractions: Basic arithmetic of simple fractions.
3. Decimals: Basic arithmetic of numbers in decimal form and the relationship between fraction and decimal form.
4. Percentage: Finding percentages, converting from fractions to percentages, converting from percentages to fractions.
5. Elementary Algebra: Symbol manipulation, simplifying expressions, solving linear equations, formula substitution and solving.

The supplementary units will include:

1. Advanced algebra: Quadratic equations, simultaneous equations.
2. Graphs: Drawing graphs from tables of data, interpretation of graphs, slope and intercept of linear function, linear and quadratic equations.
3. Function: Introduction to simple functions.
4. Ratio and proportion.
5. Trigonometry: Trigonometric ratios and triangle trigonometry, use of a trig table.
6. Logarithms: Use of logarithms in arithmetic calculations.
7. Geometry: An introduction to simple descriptive geometry.

Each unit will consist of:

1. Diagnostic tests
2. Intrinsic branching explanatory program
3. Linear drill programs

4. Self-tests

5. Final exam (multiple forms)

Evidence exists (22,18,23,5,51,29,19,20) that branching programs may be significantly more effective than linear with adults on non-drill or explanatory instruction. Programs generally do not have sufficient review material and require additional drill and self-quiz materials. (50,21,41) In each unit these functions will be provided by the linear drill program and the self-tests.

5.4 Open Lab Setting Evidence in past versions of this course and elsewhere (50,58,27) indicates that students using programmed instruction miss the interpersonal contact found in conventional courses. Accordingly, the present course will be organized around an open mathematics laboratory concept. (12) An open lab will be maintained, staffed by faculty and student assistants. Students enrolled in the course will be required to attend the learning lab each week. If he so desires the student may simply sign in and leave. Those who wish special assistance will be encouraged to remain and will be given individual help.

5.5 Evaluation Initially, evaluation will take place through paper-pencil unit tests taken when the student feels ready. Tests will be available for self-diagnosis. Unit tests will be evaluated on a pass-fail basis.

It is planned, in a second-generation system, to use computer-generated unit exams taken by the student through a CAI console. Each unit test would be unique for each student, graded instantly, with the results immediately available to the student and retrievable by the instructor at his convenience.

Obviously, if 200 students, each working independently, were to be tested on each unit independently at his own convenience, the evaluation subsystem would be the overwhelming factor in system efficiency. A single instructor would work almost full time on testing alone. This will be avoided initially by phasing tests at one or two week intervals and eventually by using computer techniques.

5.6 <u>An Overview</u> A comparison of the present course with conventional courses is given below. (11)

	Conventional Approach	Instructional Systems Approach
Objectives	Non-behavioral Generalized	Behavioral, specific, detailed Given to the student at the start of each unit
Course Outline	Chapter, topic, textbook Fixed test dates	Detailed step-by-step objectives and programs
Course Conduct	Three weekly lectures Outside reading Homework Conferences by appointment	Independent self-study No scheduled classes Open math lab Tutorial assistance available
Grading	A,B,C,D,F,X End of semester only	Pass-fail, achievement based End of each unit

Knowledge of Results	Long delays Exams at long intervals Formal group testing	Many self tests No long delays Individual exams
Emphasis	Teacher, Text, Tests, Grades } instruction	Learner, Feedback, Diagnosis, Achievement } learning

Hopefully, this shift in emphasis will reverse the tendency, mentioned earlier, of conventional systems to downgrade learning. In a study of student perceptions of junior college instructors, Mc Cully (42) found that the most frequently received response was that effective instructors "arranged to give individual help as needed." Certainly this need will more likely be met under the above arrangements than in a conventional classroom.

6. Implementation of the solution

6.1 User Survey In the early 1900s Guy Wilson, a school superintendent, asked the people in his small town, "What mathematics do you use?" and he used this information as a basis for the local curriculum. (52) This was a user survey. Kipps (35) suggests that basic and remedial mathematics classes should use realistic problems for motivation. Accordingly, an extensive user survey was made early during planning to determine:

(a) the mathematics that students passing this course were expected to be able to know in subsequent courses.

(b) applied problems related to these areas to be used in the drill program.

In addition, the planners sought general support from those colleagues who would be involved in working with the students who graduated from the program. In retrospect, Parker's Guidelines for Inservice Education (49) were followed in conducting the Users survey. An attempt was made to show that the changes being suggested were significant to the users (guideline I). They were involved in the problem (II) and opportunities were developed for interrelating of participants by holding an informal problem-centered meeting (III). Initial suggestions were sought and findings summarized for the group (VI, VII). Great care was taken to maintain an atmosphere of encouragement of innovation (VII) and the necessity for evaluation (IX) was continually stressed.

Out of this survey came support and encouragement, a set of behavioral objectives for required learnings, and sample problems related to specific user areas - biology, botany, economics, math, physics, chemistry, technical courses, geology, psychology, business education, and nursing.

6.2 Development of Behavior Objectives and Tests

Specific behavioral objectives were developed from the usersupplied lists in accordance with the recommendations of Mager (40) and Cohen (16). Core objectives were developed first. Diagnostic and evaluative tests were then developed from these objectives. During the fall 1969 semester these tests will be validated, revised and retested during the spring 1970 semester.

Objectives for the supplementary units will be written from user lists during the fall 1969 semester and tests created on the basis of these objectives will be validated during the spring 1970 semester.

6.3 Developing Programmed materials It is clear from student comments that the programmed materials presently in use are not satisfactory. The students enrolled in this course vary from 18 years to over 60 years in age while available programmed materials present the subject matter at a 4th to 6th grade level. A survey of existing programs indicates that (a) they are almost invariably linear in format, (b) they are boring to adults, (c) they "talk down" to adults. Accordingly, it was decided that original programs would be written for all units.

Core programs will be ready for initial use during fall 1969. These programs will be revised on the basis of test data and in the light of the expressed behavioral objectives (54) and retested during spring 1969. Hopefully, final versions will be available by fall 1970. The author, an experienced programmer, will train at least one other member of the mathematics faculty in programming techniques.

6.4 Anticipated Problems In accord with systems planning techniques an attempt has been made by members of the mathematics faculty to anticipate some of the problems that will arise once this system is in operation.

6.4.1 A computer-based method of testing will eventually be developed.

6.4.2 Since grades will not be used in evaluation, there will be a need for faculty orientation to the program. A first effort in this direction was made in the original user survey. Future faculty orientation devices include periodic bulletins from the mathematics department, meeting with division chairmen and department heads to explain the new system and a meeting with the counseling staff to explain the new system and discuss its impact on their work. The faculty meetings will be partly information transmitting in function, but mainly an attempt to build a favorable attitude toward the program.

6.4.3 Student comments in the past indicate that interpersonal relations play a major part in making a course of study acceptable, therefore considerable attention must be paid to developing methods of using the open math lab concept to meet these needs. Present plans include having background music and free coffee in the math lab and choosing lab assistant who work at making themselves available for student consultation. It may also be possible to foster a study group plan whereby students work together part of the time in a mutually supportive way.

6.4.4 Ultimately, a study skills center will replace or supplement the operations so that students may enter the program at any time (rather than only at the semester beginning) and study any core or supplementary units independently. Instructors in any course in the college should be able to use any unit of the program as an independent study assignment, sending students to the study skills center for diagnostic testing and assignment to appropriate self-instruction.

6.4.5 There is a strong possibility that other instructors may wish to follow this model in developing other courses. Prime candidates are introductory physical science, elementary algebra, remedial English, and introductory business courses.

7. <u>Experimentation</u> The structure of this course will permit instructors to test various instructional materials and strategies under conditions allowing better control and evaluation than are possible in the conventional classroom. For this reason, a number of formal experiments are planned. It is hoped that the course will become a permanent laboratory for the evaluation of instructional practices.

7.1 Barlett (4) found that when an instructor in a mathematics course spent part of his time teaching study habits, the student learned more than when all of the instructor's time was spent teaching. This study seems to suggest that it might be profitable to attempt to develop an instructional sequence on study skills for mathematics, hopefully of value in traditional as well as individualized instruction.

7.2 Underlying all learning in mathematics are certain skills of reasoning, classification, analysis, synthesis, symbolization, etc. which are not normally taught in any formal way. It is our belief that many of these basic thinking skills can be learned, or at least sharpened and enhanced, by formal work. One experiment would attempt to develop tests of these skills and a series of exercises, problems and situations for teaching, providing practice, identification and generalization of these skills. The final criteria of effectiveness of the instructional materials would be their efficiency in producing improvement in a student's performance in the formal work of the mathematics course.

7.3 The paper-pencil programs of the first generation of the course will eventually be replaced, at least experimentally, by a multimedia approach. This would include the use of audio tapes, visual materials and realia. If and when available, computer assisted instruction will also be used. Each possibility will be evaluated on its ability to effect positive changes in the pertinent indicators of instructional effectiveness: (a) drop out ratio, (b) percentage of students reaching preset criteria on validated tests, (c) student attitudes, (d) amount of student time required for a given unit.

7.4 There is a need to study the possible facilitating effect of a team approach to using programmed instruction. Students working in pairs or small groups may exhibit improved performance. In particular, any group cohesiveness developed may reduce the drop out ratio. It may also be possible to selectively choose students who would respond best to group treatment by using some sort of need-affiliation test.

7.5 The identification of high drop risk students is a problem of special importance in the open door community college. There is a need to identify these students and to develop special procedures designed to reduce their drop probability.

8. Conclusions and Implications It should be emphasized that the systems approach is one of many approaches to the design and development of instructional systems. The systems approach, developed in response to technological needs, cannot be expected to work as well in educational systems without modification and experimentation. There is a need to take a closer look at what Stanford Optner has called

"man-dominated systems" as opposed to the "machine-like systems" of business and technology. (48) Educational, and especially instructional systems, are non-linear, highly complex, people-oriented, tradition-hobbled organizations in which the mission is less easily specified and there is less general agreement on evaluation. There is nevertheless a possibility that the systems approach can be modified to become an exceptionally effective tool in educational planning.

The systems approach is an excellent device for forcing supervisors, teachers, and other educational planners to ask the big questions, to see the big picture. Russell Ackoff, a pioneer in the systems approach, suggests (1) that it is profitable to regard this method as "a philosophy...an attitude of mind toward the relation between man and his environment...a method appropriate to the analysis of activity." Certainly, at the least, the systems approach must be considered a new technique of instructional design and supervision.

One necessary consequence of using system methods in instructional design is that it leads one fairly directly to a confrontation between technology and education. Many teachers and some supervisors tend to ignore the very real need for utilizing the best of modern technology in the humanistic enterprise that is education. Kenneth Norberg (47) has stated the situation clearly:

> "The first requirement is to recognize that the machine exists...that technology is now a fact in education. The other is to make sure that the positive force of technology is openly and responsibly directed by democratic instructional policies that are timely, clear and explicit, and not by obscure pressures and counter-pressures reflecting confusion, fear, or the desperation that comes when overdue decisions are forced by the sheer weight of circumstance. ...a humanized technology can free the teacher...and amplify the force of his creative and distinctly human efforts."

There is a tendency for one not educated in science to become first defensive, then frightened, as areas of knowledge he does not command begin to impinge upon his sphere of operations. This reaction must be avoided. Science and technology should be seen as instruments of man's power and progress, "devised for the malleable adaptation of man to his environment and the adjustment of his environment to man. If the human species is to remain successful, this instrument must be used more and more to control the nature and the rate of social and technological change as well as to promote it." (30) Educators certainly have the central role in seeing that these instruments are well used.

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