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ABSTRACT

This paper discusses the application of computers for higher education and describes a philosophy and initial application of an accountability system that can aid in coping with the problems of occupationally related schools. Discussed are: (1) the role of computers in systems application; (2) the need for systems related information: the rationale, the yields of an accountability process, and the characteristics of an accountability design; and (3) the design model and how it operates, including a generalized educational management system, system objectives, the sequential-access file entry subsystem, the generalized simulator, the automated instructional management system, the guidance model, the institutional management information system, and the program management information system. System charts conclude the paper. (AF)

SYSTEMS APPLICATIONS IN HIGHER EDUCATION[1]

A Paper Presented at the

American Educational Research Association

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Acknowledgment is made to the United States Office of Education for its support of projects relating to several concepts and components of the systems described herein. In particular, the reader desiring further specifics with respect to the Automated Instructional Management System is referred to materials filed with the United States Office of Education, Washington, D.C., relating to Research Contract #OEC-0-8-080157-3691(010). Additional information will be available in June 1971, dealing with the results of the Investigation of the Effectiveness of a Computer Management System Designed to Improve Learning Through the Individualization of Instruction, the subject of the above contract and to relevant papers such as those prepared by Barbara Weinschel, Director of Statistical Services at New York Institute of Technology. Materials on file at USOE, Washington, and at the Naval Academy, relating to U.S. Naval Academy Contract, #N00600-68-C-0749, "Development of a Multi Media Physics Course for the U.S. Naval Academy," Annapolis, Maryland, also contain additional information relative to the use of the system. One specific application of the simulator is delineated in the Final Report, Project #RFP OE-68-4, Contract #OEC-0-8-089026-3310(010), published at the University of Toledo, "Educational Specifications for a Comprehensive Elementary Teacher Education Program," submitted by A Consortium of the State Universities of Ohio to the U.S. Department of Health, Education and Welfare.

I. OVERVIEW:

A. The Role of the Computer in Systems Application

The greatest future impact of the computer upon higher educational patterns exists in its capacity to manage total systems. Analyzing well defined systems, the computer can guide the learners, professionals, and agencies involved in higher education to methods maximized to attain their goals. Sophisticated system-related information processing should result in more efficient decision-making processes, more relevant instructional management tools, and increasingly effective manpower-solving procedures. Such potentials can be used to affect present-day higher education, principally by providing guidance, accountability and evaluation measures for the various constituencies concerned with the education process. Once operative, useful information will become available as to what works or what does not - where gains occur and where they do not. The criteria must be such as to be useful and acceptable to the users of the system - not those imposed "a priori" by systems designers.

II. THE NEED FOR SYSTEMS RELATED INFORMATION

A. Rationale

The pressures on the total educational system are intense. The ever increasing number of learners demands new arrangements, additional services and teacher training. The question of effectiveness of the various programs is paramount.

Evidences of major stress are legion. Elementary schools are plagued with less than satisfactory levels of achievement for the heterogeneous groups of pupils they serve. Schools are faced with the problem of adding to their already overburdened operations a vastly expanded post high school education as the minimal career requisite of an increasing segment of the population. The pressures are critcial, and concern for educational excellence in rural, suburban, and urban institutions is notable. Despite this, there exists the incongruous situation of educators tolerating a large number of high school and college dropouts, and the even larger number of student failure patterns or extremely low attainment levels throughout the academic experience.

To this waste may be added a lack of relevant occupational training, mis directed career and curriculum guidance, and the arbitrary academic behavioral objectives fixed by tradition rather than realistic needs. Inflexible and inappropriate instructional pacing is often dictated by administrative convenience rather than the actualities of student performance. Frequently little, if any, use is made of successful innovative educational practices, models, and methodologies - due to a lack of information and professional know-how. The usual educational establishment is bereft of sufficiently rapid feedback on which to base corrections for deficiencies on the basis of any combination of the following: inadequacy of environment, resources, and methodologies; mismatch of teacher and learner; insufficient prerequisites and preparation; poor learner attitudes; or the innumerable other tangible and intangible factors which influence the effectiveness of the learning process. It is of little surprise that talent and funds are eroded by inefficiency. Educational planners hope the sophisticated capabilities of modern technology can reverse the pattern.

B. Systems Related Information Yields - The Accountability Process

Adequate systems related informational systems contain potential for guidance and accountability measures. In turn, the educational accountability process for education suggests the capacity, within specified education environments, to delineate responsibility for the success or failure of students to one or more of the operative factors bearing on the education process.

The present national commitment to better educational opportunities for all young Americans is having an unprecedented impact on the educational establishment. The urgency of the goal is viewed as a testimonial to the scope of our failure.

Already the proposals are beginning to mount: more remediation, more tutorials, more in-service training programs, more advanced technology, more demonstration projects - in short, more money for more of the same things we have been doing for the past ten years. Obviously, some very important questions will have to be answered before we can in good conscience buy our way out of another educational crisis.

The urbanologists, social scientists, psychologists, and educators point to a multitude of factors that affect classroom performance: diet, crowding, racial balance, methods, environment, family life, architecture, learning tools. The implication of this outlook is that we can somehow solve our educational problems through some yet to be developed technique of socio-psychological antisepsis.

We are not prepared to characterize all our efforts in education to date as total failure. Our problem is that we do not know where or whether we have failed or not. We have poured millions of dollars into hundreds of programs and collected mountains of unusable data. A larger investment will only generate more undecipherable data because we do not have the capacity to relate the data from one system to data from another among the myriad of systems tests administered in our schools.

A massive, computer-based information system effort to identify those means which provide the most usable information and to develop a national evaluation system that will best relate the best procedures is one way out of the current crisis. Urgent needs in the areas of health and housing and poverty do not afford us the luxury of across-the-board random experimentation. Sound principles of systems utilizations dictate that we stop bending all our efforts to assembling data and that we begin the task of genuine assessment.

A workable educational accountability and evaluation system must provide information for each one of its prospective users; an individual must be supplied with evaluation data that is explicity relevant to the particular facet of the educational endeavor he wishes to examine. Clearly, not everyone perceives the educational enterprise from the same perspective. In essence, an accountability information system which is not flexible enough to supply a wealth of information, to different groups, in formats they will accept, is simply not usable.

A malleable system design, a readily accessible data base, and information for evaluation of education on any dimension relevant to the users of a specific system are essential for complex explorations of the educational process. These requirements necessitate, then, that the information system must be broad-based, be free of the attitudinal and value biases of its designers, and yet be sufficiently flexible to be responsive to the attitudinal and value biases of its users.

Simple information, such as a comparison of individual types of student achievement against a national norm, has been accessible for some time. Evolving technologies, however, have facilitated the growth of information systems capable of more sophisticated evaluations. With such a system, complex new endeavors are possible; one could, for example, look at amalgamations of variables which previously were not subject to direct evaluation due to confounding effects. Now one can begin to record effects of environmental and strategic variables, in combination, on the people being served by a given educational enterprise. The results of such a systematic data analysis do not imply any superlative or mandatory pedagogical procedure, but they do provide guidelines on the effects of specified combinations of variables on performance in the educative process.

An information system such as that described above can serve to establish evaluative baselines that are currently lacking in the educational profession. Evaluation is impossible without such guides; an information system can supply the criteria for evaluators seeking to explore educational processes.

An educational program is about to be evaluated. What is to be the criterion of judgment? Will it be the length of learning time? The cost per pupil? In times of war, rapid military training in some areas are critical. Then, assuming equivalencies of learning and retention, it is time as opposed to money that assumes an evaluative priority. Similarly, the ratio of pupil-expended time to pupil successes to dollars spent might be the major criterion for evaluation of an educational program (perhaps the attrition rate is high because the length of time required for completion of the program is too lengthy to meet the pressing needs of an active student). Again, in any specific case, what is to be considered too much time or too much money? At present, these judgments are often based on the intuitive perceptions of an evaluator. An information system, however, could provide a baseline. The baselines generated by an information system will not serve as overnight cures to educational ills, but will supply clues to what can be considered adequate performance in specified educational situations.

If it is asserted that teachers, as professionals, be held accountable for an excess of "mortality cases" within the schools, it becomes necessary to stipulate the baselines for their guidance. What can the average teacher accomplish with a class of specified number, age, sex, racial, religious, and socio-economic characteristics found within a given environment? From total operating systems, the information system can provide the knowledge of baselines structured under specific conditions that will facilitate evaluation and accountability in the teaching profession, and in other educationally related occupations.

C. Characteristics of the Accountability Design

Inherent to the projected design is the belief that it is not enough to provide an academic education to a small proportion of our most apt high school graduates nor is it enough to provide the more marginal student with an opportunity to sink or swim in a college environment, for all too often this merely allows another experience in failure. What appears to be needed are new instructional techniques which are sufficiently powerful so that they enable a much broader range of students to cope more successfully with diverse curriculum than has been true in the past.

Two continuing broad phases must characterize the systems evolved. The first is to develop an educational format which is appropriate to the needs of a relatively heterogeneous student body - and to do this through an instructional management program, employing resources and guidance growing out of modern educational methodologies. The second phase involves implementation of the model, making it responsible to the needs of users.

Clearly, the aims and activities are ambitious and difficult to obtain. Hope of success rests largely on the belief that by instructional management through systems analysis, an operational program which realizes significantly greater efficiencies than currently attained is possible. As soon as such a model can truly be made applicable to a much wider range of students (the regular, the professional in need of upgrading or updating, the advanced, the geriatric, the pre-school, etc.) then its significance for all education would increase materially. Further, if the system proves inherently self-improving, and is flexible enough to include interaction with environments not always directly considered as influencing education (industry, labor, community, etc.), then new dimensions in education and training may be anticipated.

The model envisions providing several desirable outcomes:

1. A generalized self-improving model for instructional management applicable to a heterogeneous population in diverse environments.

2. A test bed for the model applicable to high school and post high school populations, including academically and economically disadvantaged youngers in occupationally related programs.

3. A sharper focus on unanticipated needs for 1. and 2. above, resulting from empirical feedback following implementation.

4. A design model which can be a basis for a total system applicable to the general needs of education.

5. A design model which can test alternative routes of higher education, in consortiums with public and private sectors not normally fully utilized, to advance efficiency and reduce costs of higher education.

6. A design model which can serve as a basis for the development of accountability and evaluation guidelines against which there may be established higher standards of efficiency for given dollar expenditures.

7. Provide guidelines for performance contracting and independent educational accomplishment audit.

Accountability in a system presupposes both obvious and subtle components. It demands that both the system interactions and its component operations be made available for scrutiny, so that verification of outcomes is possible. It implies that the outcomes be related to the objectives to determine the extent of achievement. It suggests that dynamic forces be operated to correct deficiencies and improve the system. It insists that its system interact with the environment because even in minimal interaction the environment includes the observer to whom the accounting is provided.

III. THE DESIGN MODEL AND HOW IT OPERATES

A. The Generalized Educational Management System

A system plan which incorporates the power and flexibility required for accountability and which is applicable to a wide range of educational situations will be described briefly. The designs referred to are those evolved by the Advanced Systems Laboratory of the New York Institute of Technology, Old Westbury, Long Island, as part of its continuing research into the structure of relevant educational accountability and evaluation measures. To this end, a major effort of the laboratory's cadre is concerned with the development of a Generalized Educational Management System (GEMS). Conceptually, GEMS is based on three components capacities: 1) an advanced data file access/retrieval file handler capability; 2) a simulator availability; and, 3) an adaptive feedback mechanism.

The total system represents the synthesis of a variety of subsystem which have been conceptualized, developed, and to varying degrees implemented at the Institute and elsewhere. As outlined in Figure I (a), (b), GEMS includes the following subsystems:

SUBSYSTEM	APPLICATION
SAFES	Information Handling and Data Retrieval
AIMS	Instructional Management
ULTRA	Educational Guidance
IMIS	Educational Administration and Library Management
PROMIS	Educational Planning and Evaluation
ETC.....	..... other models

B. System Objectives

The systems objectives of GEM are designed to:

1. yield machine independence to the maximum possible extent (i.e., the system can be adapted to a wide variety of machine configuration

2. create, maintain and access a large data-base relevant to student curricular, pedogogical, and administrative aspects of a given scholastic environment;

3. create, maintain, and access sub-files containing meta-data (data processed from main data-base, having high information content and low noise);

4. provide printed analysis of past, current and future student progress throughout the scholastic environment;

5. generate an adaptive feedback loop through which the system can modify its multiple-model simulator to reflect current conditions within its sub-files;

6. allow experimental modification of system parameters so as to forecast the probable outcome of contingent decisions;

7. provide a mechanism for externally initiated investigation of the data-bank for evaluation and experimentation;

8. generate linkages for input of modules into system;

9. develop mathematical skeleton of simulation mechanism;

10. employ one multiple-model simulator to generate pertinent information; and

11. crystallize and incorporate foundations for time-shared and teleprocessed implementation.

C. The Sequential Access File Entry Subsystem

The file handler requisite is embodied in the Sequential Access File Entry Subsystem (SAFES). It provides an open-end data storage and retrieval medium with multiple levels of indexing. This subsystem is self-allocating; i.e., upon being provided with information relative to the nature of the input data, it will allocate the appropriate file spaces and indices. SAFES will create and maintain both direct access (disk) and sequential access (tape) files in any number and of any length as well as provide for all data transmission within the system. SAFES provides the communications and data environment in which each of the subsystems operates. Any number of simulation models can be driven by SAFES from which they are supplied with raw data as well as reduced data.[1] When functioning in a large-scale, time-shared, teleprocessing environment SAFES will create and maintain files in any variety of storage media; monitor the usage of any file or sub-file; reorganize any file or sub-file to maintain maximum access efficiency; and, make optimal use of physical storage media.

D. The Generalized Simulator

A generalized simulator, which effectively becomes a unique computer language, is used to develop models of a wide range of educational environments. The basic structure of a Generalized Educational Decision Simulator (GEDS) is presented in the accompanying diagrams (Figures 2 and 3). This structure is created and specified as educational process information is fed into the system. Upon specification, the simulator reduces to a model of an aspect of the educational environment.

Fundamentally, the simulator is a variable decision structure, the lattice of which outlines the components (rational and alternative) of decision processes.

In keeping with the principle of modularity and flexibility, the decision structure is a tree configuration of x levels and y alternatives per decision. The criteria for each decision evolves from specific constraints of selected student history or performance parameters. These constraints may be absolute; i.e., numeric constants or ranges, algorithmic, or based on statistical probability levels relative to an analysis of class data. Such a device is comparatively rigid in that it cannot be easily modified to reflect changes in student data or course strategy. This is overcome by incorporating into each decision process a probabilistic weighting factor developed either instrinsically or by a student data analysis. As a result, the likelihood of a single path being chosen in a given decision process can be increased or decreased without reprogramming.

From the above description, it is obvious that the simulator is highly flexible, and capable of being adapted to a changing educational environment quite easily.

The feedback mechanism provides the device for accomplishing this adaptation, using mathematical pattern recognition as its basis. In essence, the process consists of analyzing the student data bank with the object of detecting and classifying patterns of academic behavior. Once these patterns are known, categories are established by specifying constant relationship between student parameters. An individual student is then evaluated by comparison with each category until the most appropriate category is selected and a metric conformity is determined. Such a device, which becomes more certain as the number of categories and the population in each increases, is used to drive a reporting subsystem and to manipulate the weighting factors in the simulator. Hence, a truly modifiable system capable of improving with experience is generated. Due to the open-end nature of the file and the ability of the system to access all available data, the experience of time is ever cumulative and can be duplicated at will.

E. The Automated Instructional Management System

In its simplest and most elementary form, the systems analysis approach at New York Institute of Technology which constituted the initial phase of structure of the Automated Instructional Management System (AIMS) consisted of carefully specifying three sets of conditions:

1. Desired outcomes or objectives of the system;

2. A detailed audit of the characteristics of the system, the system inputs, before they are operated upon or affected by the system;

3. An explicit description of relevant means-ends relationships and methods for assessing efficiency and/or efficacy, i.e., effective ways

in which systems resources may be organized to provide pathways to desired objectives.

Then, the appropriate phases relating to instructional management required development of specifications and/or codifications of:

a. Goals (curriculum objectives expressed in behavioral terms delineating precisely the substance of the educational program, the skills and knowledge to be learned);

b. Students (as inputs to the system, with profile structure, academic levels, proficiency attainment and all other relevant data relating to the selection and subsequent education);

c. Curriculum, course and instructional content (software and programs designed to accomplish specifications of (a) above);

d. Instructional strategies - combination of methods, media and organization required to conduct the learning program;

e. Assessment, tests and procedures for evaluation;

f. Instructional decision-making and prescriptions;

g. Feedback and restructure mechanisms;

h. Organization and facilities (personnel, facilities, faculty and equipment required to support other sub-systems).

The objectives of the Automated Instructional Management Sub-system are to provide self-adapting mechanisms which will aid in the evaluation of student progress; provide for prescriptive measures for remedial or enrichment material· allow empirical validation and optimization of course organization, content, strategies, and media; provide a record-keeping and communication function for the pupil, the teacher and the school; and, provide continual feedback to improve functional effectiveness of the system.

In addition to the linkages to the data base, including all file maintenance functions (SAFES), AIMS consists of a report generation subsystem coupled to a heuristic simulator with an adaptive feedback element. The goal for this subsystem is to provide for the use of the pedogogue a wide range of information processing tools for the analysis and evaluation of student progress and curriculum.

Coupled to the file handling capabilities of SAFES, AIMS includes supporting input-output options which allow it to:

1. perform and report item analyses of student test questions;

2. receive data on student performance and background history as well as course structure;

3. provide for multiple formats for input data; i.e., without reprogramming, the system can be adapted to a wide range of input formats;

4. produce any number of selected output reports which tabulate data relative to individual student performance profile, class performance profiles, and course validation;

5. permit the selection of students from the main data-base whose parameters conform to certain specified constraints and perform

any of 25 statistical operations on selected parameters of the selected students.

It is again emphasized that the design characteristics of SAFES permit it to be used as a general data manipulative device capable of providing an information environment in which any number of process simulators, of which AIMS is one, may effectively operate. This is the core concept of the accountability system.

The system specifications previously listed for the Generalized Educational Management System are likewise applicable to AIMS. As typical specifications representing needs in two other areas, pedagogy and behavioral psychology, the selected examples which follow may be of interest. The items have been chosen out of a range utilized in an application of AIMS at the United States Naval Academy, Annapolis, Maryland.

1. Typical Pedagogy Specifications:

a. Produce a listing of all students registered in the program; provide options at user choice so listing can be arranged alphabetically, in the order of the student I.D. number, as a single list, or divided into the separate class sections.

b. Produce a complete listing of the answer matrices for all tests; include the MBO[3] reference and a brief description of the MBO; the remedial prescription is also to be listed for each wrong answer by noting book number, page number, and problem number of the assignment.

c. Produce an individual student test print-out; in a format allowing the report to be given directly to the student after a test has been processed; include, in addition to the identifying heading, the truth value of each answer choice; in addition to remedial assignment, a personal message of encouragement or censure is to be included depending upon the student's grade; also, include a direction to report to the laboratory for a special remedial lesson if necessary.

d. Provide an individual student rating for homework as totals, or recaps of the number of A, B, C, D, and E ratings that were assigned to each of the homework problems by the homework markers over a given period of time.

e. Provide individual homework rating scores, student and section, give the number of A, B, C, D, and E grades issued to each student in each section for one particular homework assignment, where each letter is assigned a weight and the total score is converted to an average per centage.

f. Format a student profile, the form giving a summary of all the test scores and homework scores, as well as the current average, of each student in each section; provide update capacity after each entry so as to provide a running profile of each student's performance.

g. Structure histograms, the frequency distribution bar graph that shows the number of students that received each of the test scores assigned, to summarize the total performance record on any individual test for quick visual analysis of the entire student population.

h. Provide item analysis so as to maintain a record of the number of students that chose each of the answers that were presented in the multiple choice format of the test, with flagging to indicate the areas that need investigation.

i. Provide parameter flagging, with output devised to assist the investigator in examining the item analysis. Certain parameters are to be selected to determine answers chosen by more than 90% of the students, distractors chosen by 0% of the students, and distractors chosen by more than 25% of the students.

j. Determine final grade by variable selection of the computer marked, multiple choice objective test scores, homework grades, hand-graded tri-semester tests, and the final, hand-graded examination made, averaged, and weighted to arrive at a term mark.

k. Calculate and list indices and deviations for the group and individual as follows:

Group:

Capability Index
Performance Index
Performance Deviation
Problem Achievement
Post Test Achievement
Net Achievement
Achievement Deviation

Individual:

Capability Index
Performance Index
Absolute Performance Deviation
Relative Performance Deviation
Problem Achievement
Post Test Achievement
Net Achievement
Absolute Achievement Deviation
Relative Achievement Deviation

l. Calculate and list mean indices as follows:

Cumulative Mean Problem Achievement
Cumulative Mean Post Test Achievement
Cumulative Mean Net Achievement

m. List MBO's in each lesson to contain the following:

1) Each EO in the study guide which requires more than one trial selection to achieve the correct response.

2) Each EO in the worksheet for which the criterion question is incorrectly answered.

3) A remedial prescription for each of the items in A and B in the form of a reference to three standard textbooks and the pages where the material contained in the EO may be found.

4) Each TO which is not satisfactorily met in the Post Test.

5) A remedial prescription for each TO as prescribed above.

n. For those students who attain relative performance and relative achievement indices of +20 or more, provide a congratulatory message

message and an optional assignment of enrichment material in the form of textbook readings, advanced films, and/or advanced audio tapes.

o. For those students who attain a relative achievement index of +30 or more, provide a congratulatory message and an optional assignment as indicated above; and, in addition, include a statement that he has attained tutorial status and may be assigned to assist other students in the group.

p. Provide an item analysis based on study guide and worksheet performance of the group which enables the instructor to organize his group multiple media instruction (GMI) session for the week.

q. Provide an item analysis based on homework problems and post test which further contributes to instructional decision for the GMI session.

r. Structure skill category analysis for each student which enables the instructor to select specific weaknesses to be attacked by tutorial assistance.

s. Provide a media category analysis for each student which enables the course designer as well as the instructor to select remedial media and enrichment media for individual student use.

t. Divide each group into quartiles based on net achievement in each lesson.

u. For each quartile display the percentage of students who:

1) Needed more than one try before arriving at the correct answer to each study guide criterion check.

2) Answered each worksheet question incorrectly.

3) Received A, B, C, D, and E on each homework problem set.

4) Answered each post test question incorrectly.

v. For each quartile display the percentage of students who scored well or poorly on questions dealing with each of the four media categories.

w. For each quartile display the percentage of each of the skill levels correctly handled by the students.

2. Typical Behavioral Psychology Specifications

a. Produce a matrix which shows the relationship between TO, EO, learning or skill category, media type and each individual question.

b. Provide for selection and/or extraction of students into experimental groups based on characteristics reflected in their data.

c. Provide a management system capability for at least 1200 students.

d. Provide for the maintenance of a student background data file including:

Past Academic History
Student Interest Profile
    Edwards Preference
Aptitude Profile
    SAT Scores
    Achievement Scores
    Reading Level

e. Provide for collection of student timing information.

f. Allow information input from:

Mid-term exam
Final exam
Topic or lesson
Pre-test
Post-test
Monitor of classroom performance
(or analogy)

g. Provide capability to perform following statistical analysis on selected groups of students:

Analysis of Variance
Item Analysis
Kuder-Richardson Analysis
Correlation of Wide Spread Classes
T-Test of Means and Differences
Linear Regression Analysis
Pearson and Rank Correlation
Covariance Analysis
Multiple Regression Analysis

h. Develop mathematical basis for empirical simulation model for student guidance and forecasting performance.

F. Additional Evaluative System Characteristics

The simplified schematic of Figure 4 indicates essential requirements of an educational environment. Basically, we begin with students to be educated, structure varied environmental arrangements to prepare students to function successfully in post academic situations, and, then evaluate successes and failures, with varied criteria, to see what modifications are necessary for the totality being examined. As an example, evaluators of technical programs are concerned with the ability of graduates to be accepted, function, adjust and progress in the industries or society offering opportunities for which they have been prepared by the educational environment. All the elements encompassed within the environment, including pupils, facilities, teachers, courses, resources and other relevant factors, are adjusted when the total process does not yield the broad objectives set for the educational system under scrutiny. Thus, if an automotive technology program failed to produce industry acceptance or retention for the majority of its students, the entire program would be scrutinized rather than any single component.

Figure 5 shows salient elements of the Adaptive Feedback System and Figure 6 represents a component of the Automated Adaptive Feedback System applied to a course. Again, it is emphasized, the criteria for measurement of effectiveness are those selected by the users. Someone might select as a principal criteria the upward shifting of the "normal" achievement curve, plotted against delineated objective measures, for successive offerings of a program. (Figure 7) Another individual might select reduction of student attrition by curriculum modification as the principal criteria. (It has been alleged that 10% of course content has been responsible for 90% of attrition and failure in certain occupationally related skill areas in some military training centers.)

The impact of important elements affecting educational systems are sometimes underemphasized, or unstudied, possibly because of the complexity of their inclusion. Educators require a system provision to yield meaningful information which will assist in decision-making under stressed political situations. The usual inadequacy of information for this critical function is an important reason for the reluctance of individuals and communities to stand accountable for their programs. A potential simulation model of the communities concerned, with computer analyses techniques equivalent to the voter profile approaches characterizing election forecasting, is shown in Figure 8. The interrelationship to instructional process subsystems is amplified in Figures 9 and 10 which give further evaluation approaches to given educational situations.

The purpose of each component described above is to produce those quantifiable measures, individual or composite, which determine the effectiveness of the instructional system. While different system users may weigh the information produced in terms of their priorities, the baselines produced would always be quantitative and specific.

G. The Guidance Model

The guidance model, ULTRA, illustrates the accountability system further as it operates at New York Institute of Technology. ULTRA, occupationally oriented at Tech, is a model which can be applied to the guidance and control of a student through any educational environment. Operating within a central information system such as SAFES, enough flexibility exists so as to allow ULTRA to provide basic guidance information as well as supervised management of students involved in elementary, secondary and collegiate education. The purpose of ULTRA is for each student to receive the education, that is, environment, courses and curriculum, which will qualify him for the career objective selected by his interests and potential abilities as disgnosed, discussed, predicated, and interpreted by the combined attributes of man-made examinations, computer-oriented methodologies, and man-machine interpretations, with final human decision-making approval. ULTRA has, as one of its fundamental objectives, the organization of obtainable pathways by means of which each individual may expect a high probability of realizing the predicted match of his potential with the occupational, scholastic, and curriculum opportunities available to him. The resulting procedures can guide those concerned with the learning process through the major steps of optimized educational decision-making with respect to occupational guidance. The ULTRA schematic (Figure 11) shows varied routes available either for student guidance assignment or achievement of desired educational results. The computer, when used in a guidance management process, focuses factors as:

1. the translation of desired end point job skills in terms of student performance which the training is to bring about;

2. establishment of prerequisite entry level skills;

3. detailed task analyses which stipulate testing measures to verify performance;

4. predictive measures to develop criteria of performance coupled to recommendations for the kinds of instruction, strategies and guidance which will best overcome each learner deficiency;

5. cost effectiveness measures, to provide a means of evaluating "success" in terms of dollar cost, pupil time expenditures, or other pertinent criteria;

6. capacity to provide information sufficient to operate a complete manpower management system encompassing the school and community resources.

As part of ULTRA, the computer serves researchers as an aid in the creation of individually oriented programs for students who desire technical careers, including those whose success in conventional programs is questionable. Students in ULTRA are admitted, interviewed, and tested. The resulting data are sent to a computerized information center where a personal profile is constructed for each student. The profile encompasses records of ability, skills, knowledge, and a prediction of the student's future performance. Guidance counselors design a student's individual program on the basis of his profile, interview, and computer recommendations.

Students with the immediate capacity for college work are enrolled in programs leading to the two-year associate or four-year bachelor's degrees in various specialized technical fields. Others are referred to a diagnostic center where they undergo further examination. On the basis of test results, they enter two or four-year programs combining regular courses and remedial studies to overcome academic weakness. Students indicating marked deficiencies are enrolled in an intensive pre-college program prior to the pursuit of college-level courses. Those unable to undertake college work are placed in an "alternate skills" program combining jobs in cooperating industries with off-campus studies. The "alternate skills" program enables future transfer to college-level academics.

One paramount aspect of project ULTRA is the continuous assessment of individual progress. Test scores, learning rates, and acquired skills are constantly recorded and fed back to the teaching staff by the computer. An instructor need not wait until the conventional midterm or final for an over-view of his students' progress. Such intensive assessments allow staff members to refine predictive techniques and alter a student's curriculum where necessary. Work-study students can, thus, be transferred to college and advanced training. A student with a poor chance for success in a given program may be channeled into a program where success is more probable. Project ULTRA retains

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H. The Institutional Management Information System

The Institutional Management Information System (IMIS), another of the GEM subsystems, performs the function of central administration and library management on an institutional level. However, the institution may be defined as an elementary or secondary school, a vocational institution, a school district, a small college, a university, or even a state-wide educational network. This diversity of application is attributable to the principle of modularity and the innate flexibility of SAFES. Program modules having varied functions can be inserted into or extracted from the system without affecting the integrity of the totality. SAFES will then modify the data environment to accommodate the new function.

Within the province of central administration are the functions of grade reporting, admissions, registration, scheduling, student accounting, plant and equipment maintenance, inventory control, payroll, general accounting, purchasing and the library functions of cataloging, circulation control and information retrieval.

I. The Program Management Information System

In addition to the administrative systems operative under GEMS, a number of simulation devices can be used in augmenting the system to provide management information in specific areas. One such simulation device developed by the Advanced Systems Group is PROMIS (Program Management Information System).[5] PROMIS is a Planning, Programming, Budgeting simulator designed to provide information on the cost of projected implementations of educational programs. In addition, when provided with allowable variations in program elements, it will produce a range of optimal and sub-optimal program implementations based solely on cost analysis. Although capable of accepting a wide range of input information, when a modified PERT input is provided, greatest information yield is attained. This system can be applied to generating cost projections and optimum implementation patterns for a wide variety of programs such as an analysis of a model elementary teacher training program, projected curriculum changes involving new or reallocated teaching staff, with consequent impact upon facilities, building and space allocation proposals.

IV. CONCLUSION

It has been the intent of this paper to describe a philosophy and initial application of an accountability system which can aid in coping with the problems of our occupationally related schools.

The very nature of educational effectiveness is complex and goes beyond simple indices such as the relationship of cost to productive output. The problems confronting researchers attempting to quantify and measure the intangible qualities of education are formidable, but not unsurmountable.

The totality of all relevant questions relating to accountability cannot be answered by any single model. Any selected model is only an abstraction of selected factors and characteristics of an environment, embodying a stated opinion as to probable relationship. Yet the process has validity, for the model, be it good or bad, is a tangible structure capable of being tested. Its closeness to the world of reality can usually be precisely determined for when it operates well it forecasts probable occurrences accurately and when it fails it can be modified, retested and reevaluated. Empirically, the pattern can be repeated until basis of effectiveness exists wherein the effectiveness of change in any of the model's components can be evaluated against the indicators important to the use of the model.

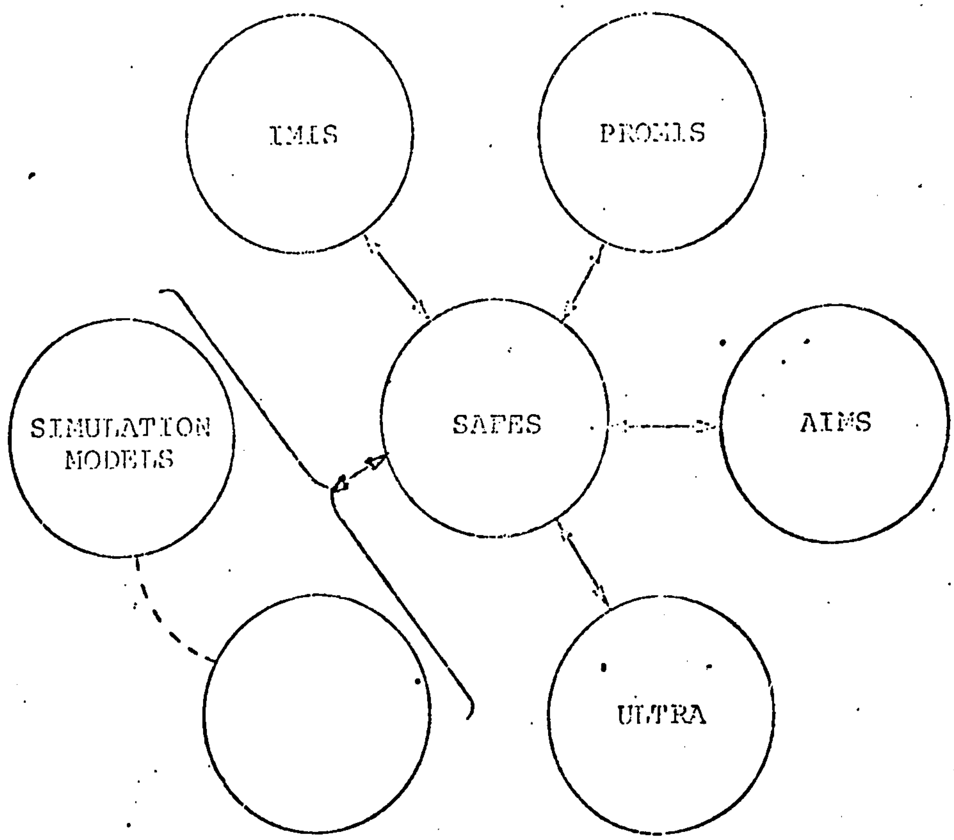


FIG. 1 a CONCEPTUALIZATION GENERALIZED EDUCATIONAL MANAGEMENT (GEM) SYSTEM

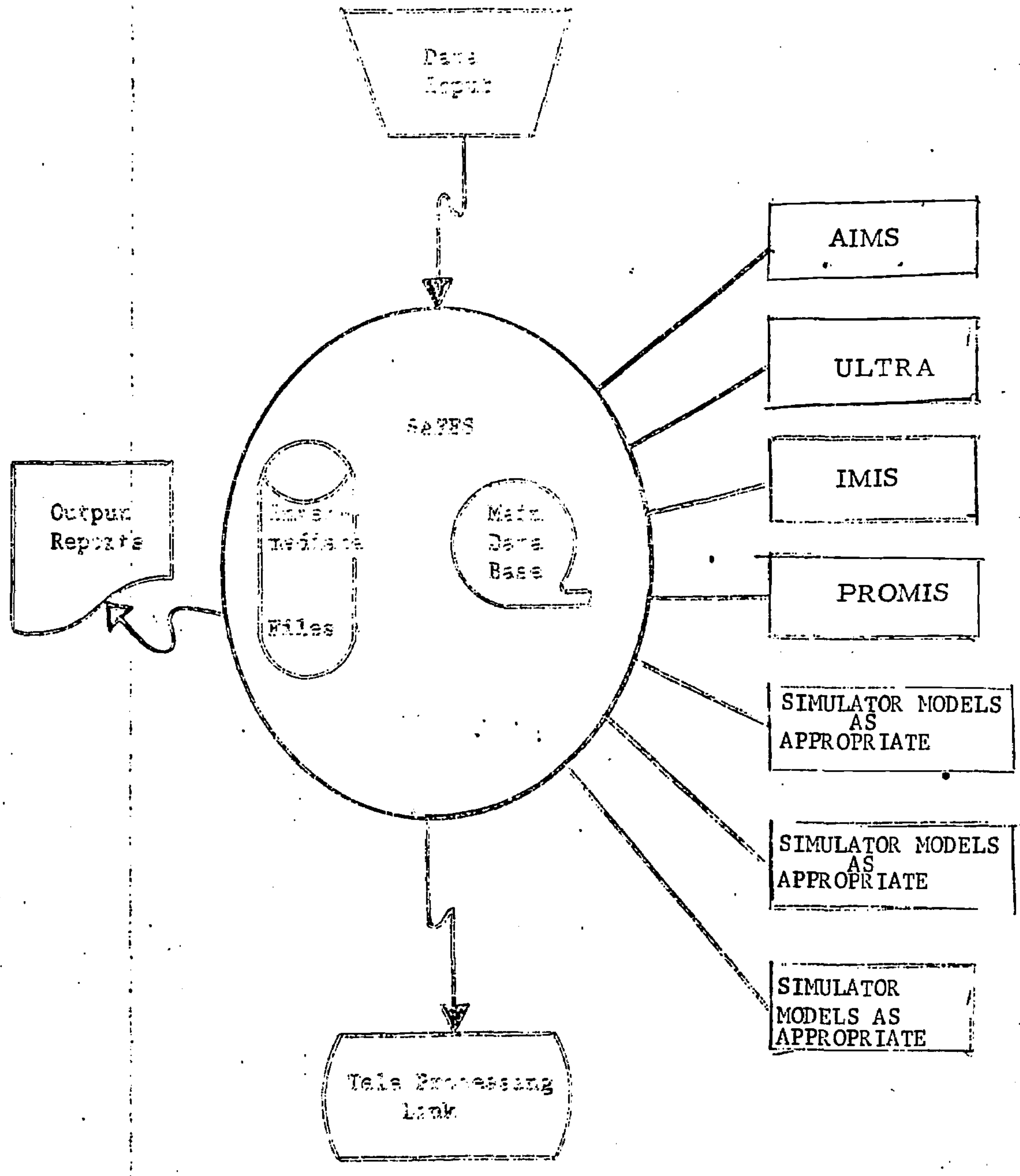
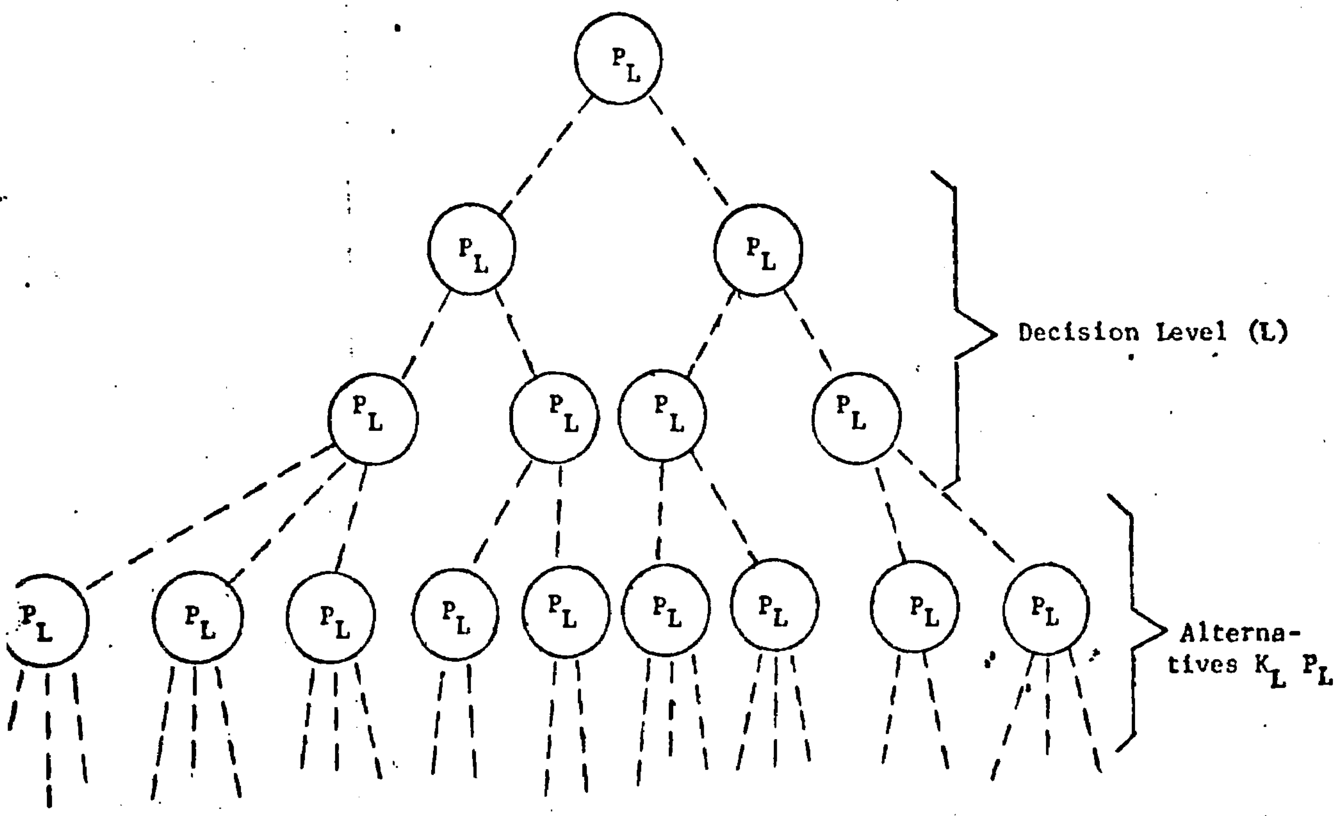


FIGURE 1 b) SCHEMA, GEM SYSTEM OPERATIONALLY



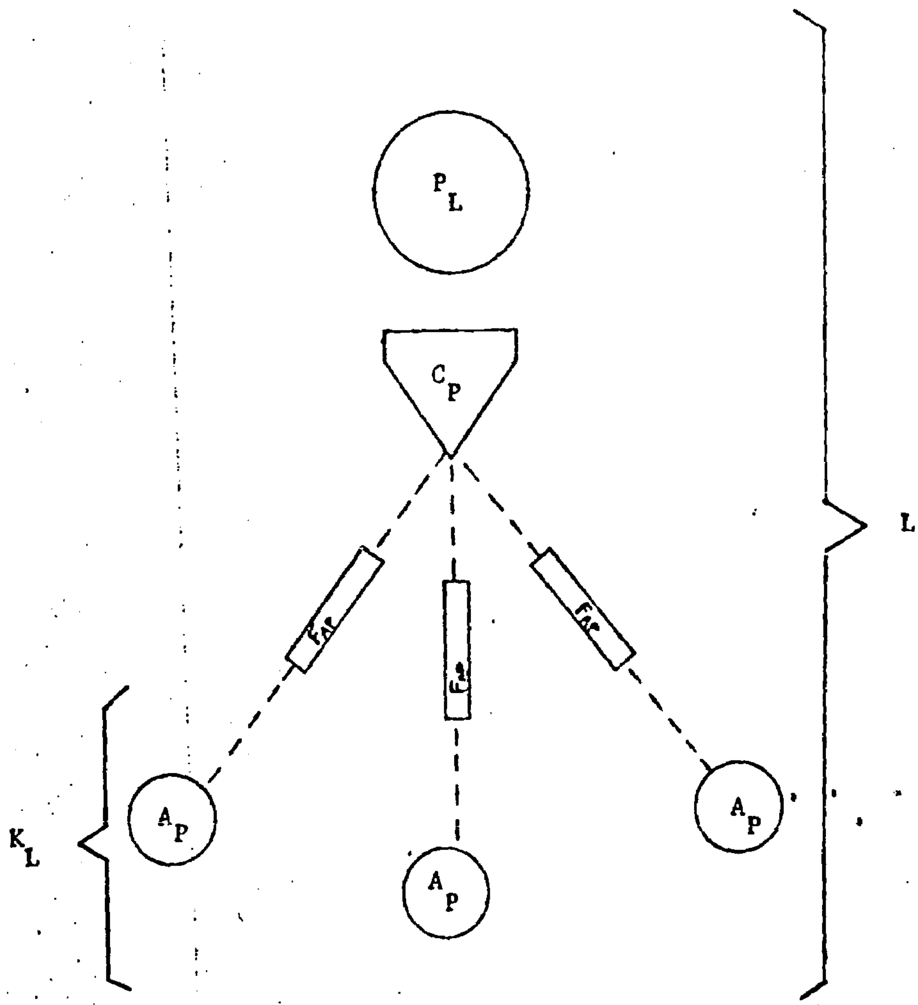
<u>GENERALIZED DECISION STRUCTURE</u> <u>(GEDS)</u>

Capable of being configured by parameter specification.

P_L Decision Point

K_L Alternatives per decision

FIGURE 2.



P	Decision Point
C^L	Decision Criterion
F^P	Probabilistic Weighting Factor
A^{AP}	Decision Alternatives
L^P	Decision Level
K_L	Alternatives Per Decision

where

A_P = 1, 2, 3, ..., N
C_P^P = f(student parameters)
P_L^P = f(L.K)

EXPANDED VIEW OF DECISION LEVEL

FIGURE 3.

SALIENT ELEMENTS OF THE PROPOSED ADAPTIVE SYSTEM

1. (YRS. NO. 1, 2, 3) — STUDENT DIAGNOSTIC TEST BATTERY, MEASURING ATTITUDES AND APTITUDES

2. (YRS. NO. 1, 2, 3) — CLEARLY DEFINED AND MEASURABLE OBJECTIVES FOR EACH UNIT, COURSE, AND CURRICULUM

3. (YR. 3) — PREDICTIVE CAPABILITY (EQUATION) FOR OPTIMAL STUDENT MANAGEMENT

4. (YRS. NO. 2 3) — MULTI-MEDIA PRESENTATION OF SUBJECT MATTER INCLUDING CAI

5. (YRS. NO. 2 3) — VALIDATED TESTS AND EXAMINATIONS WHICH MEASURE STUDENT ATTAINMENT OF OBJECTIVES

6. (YRS. NO. 1 2, 3) — RECORD KEEPING FOR:
   - STUDENT
   - TEACHER
   - COURSE AND CURRICULUM
   - SYSTEM

7. (YRS. NO. 2, 3 — CONTINUED EVALUATION OF SUBSYSTEMS:
   - STUDENT
   - PREDICTIVE EQUATIONS — RELATING TO INSTRUCTIONAL STRATEGIES
   - COURSES AND CURRICULUM
   - TEACHER
   - RECORDS
   - SYSTEMS

8. (YRS. NO. 2 3) — CONTINUAL FEEDBACK OF FINDINGS TO IMPROVE SUBSYSTEMS EFFECTIVENESS WITH RESPECT TO SYSTEMS OBJECTIVES

FLOW DESIGN: AAF SUBSYSTEM AS KERNEL OF EXTENSIVE FEEDBACK SYSTEM

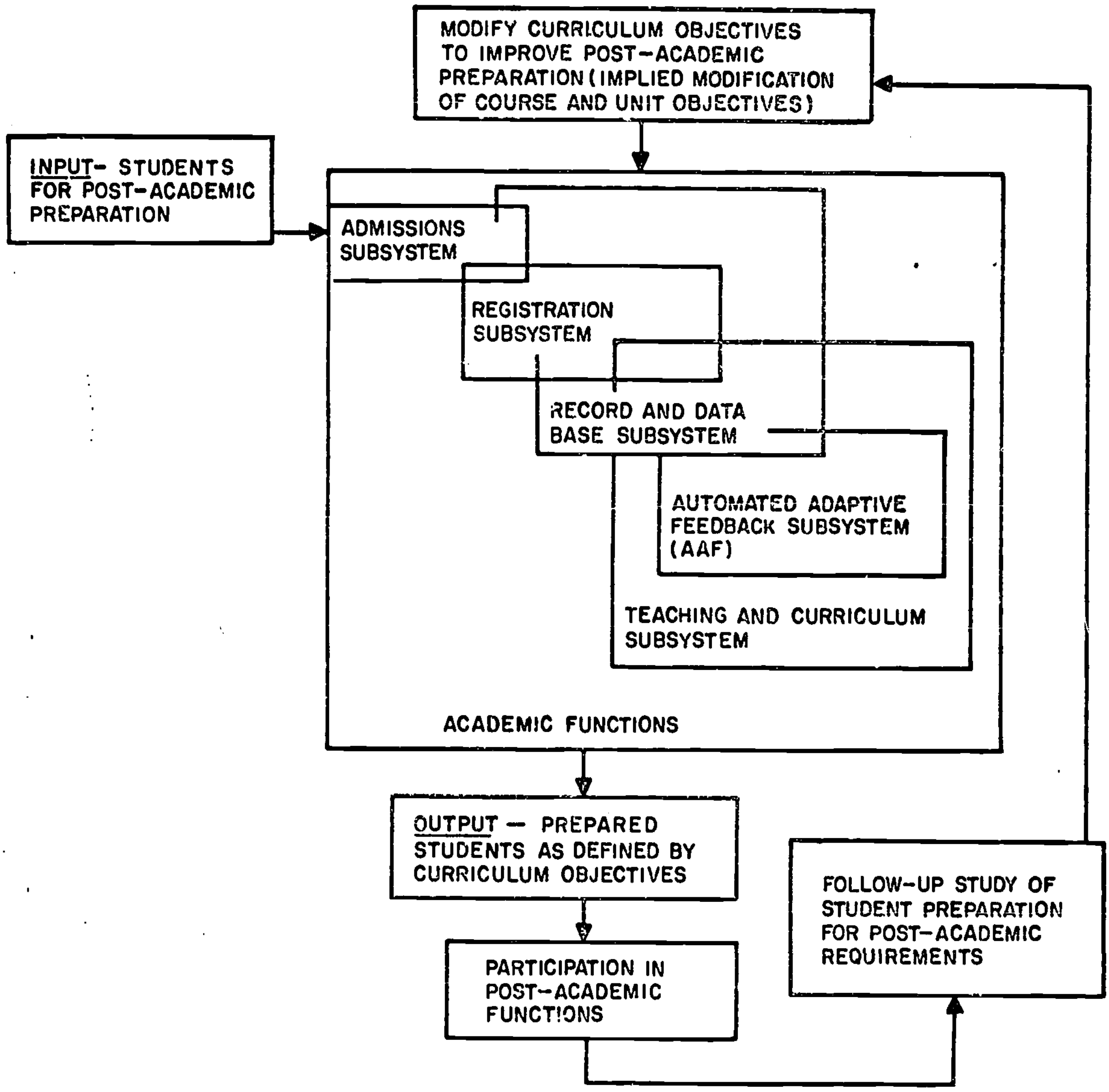
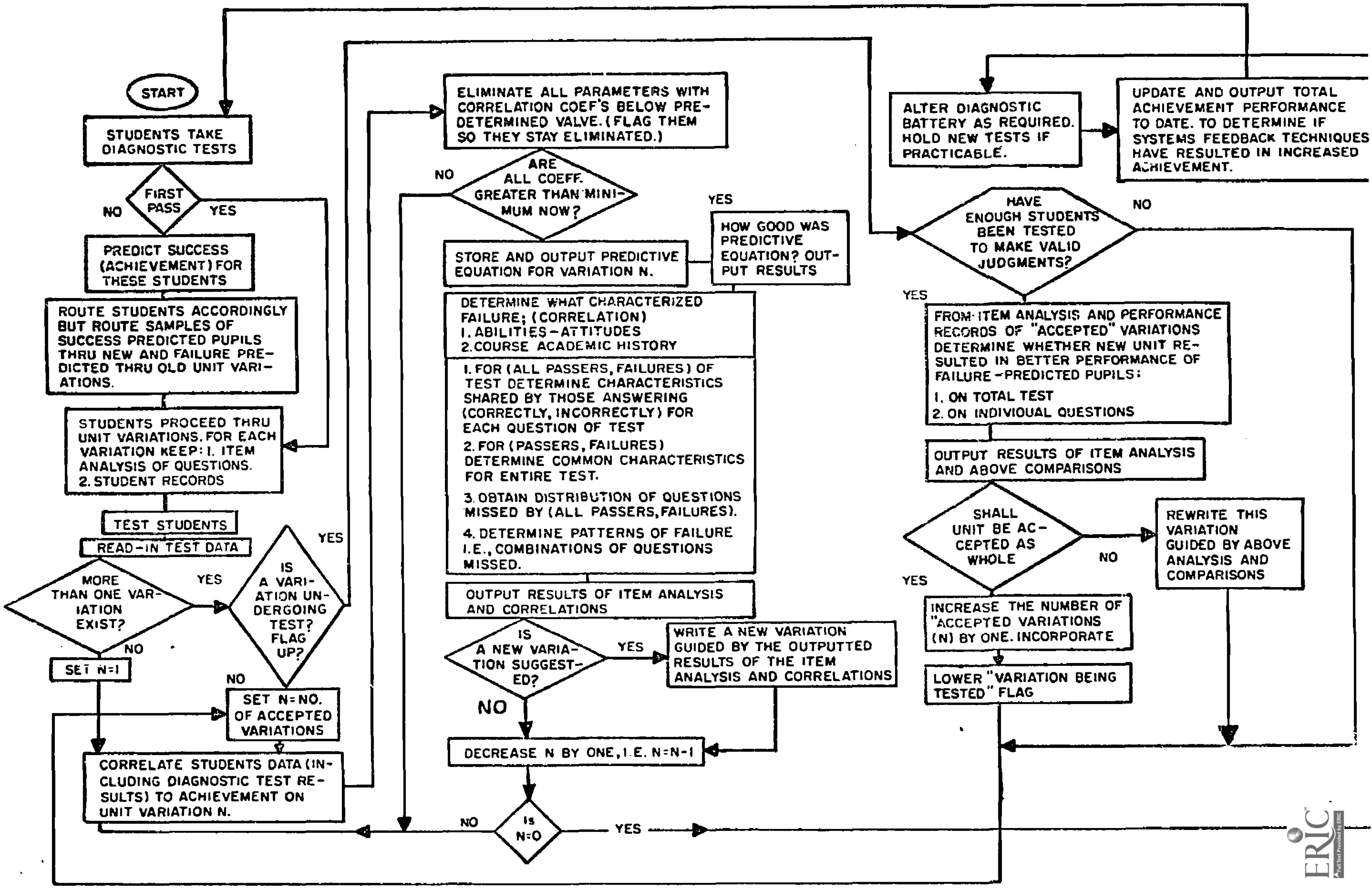


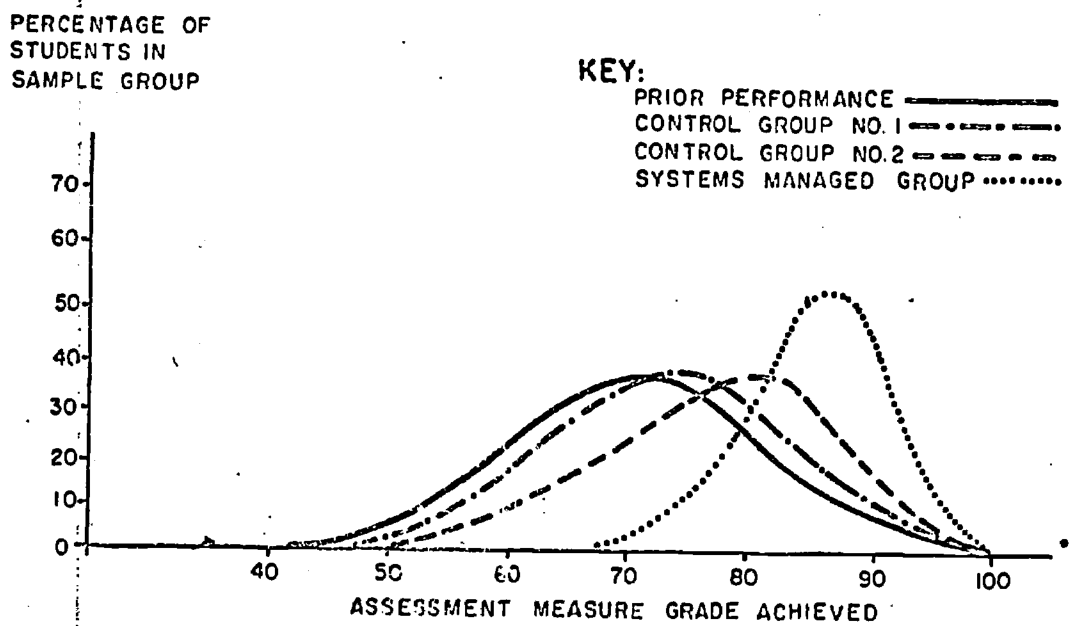
FIG. 4

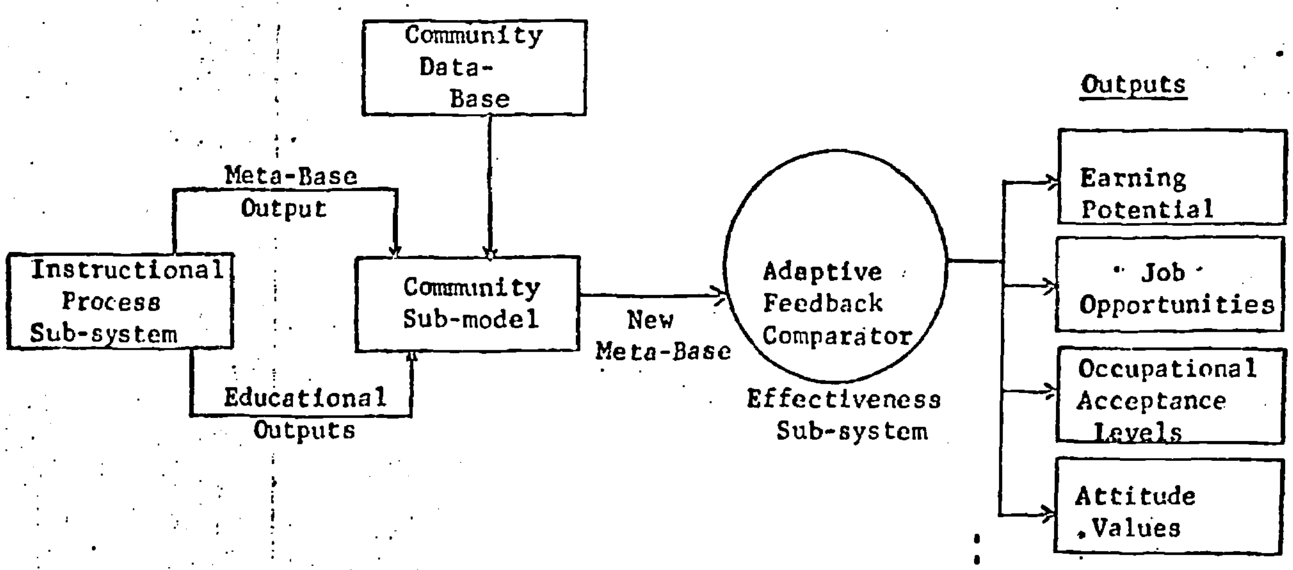
PRELIMINARY FLOWCHART OF AUTOMATED ADAPTIVE FEEDBACK SUBSYSTEM



TYPES OF CHARTS TO BE PREPARED FOR GRAPHIC DEMONSTRATION OF STUDENTS PERFORMANCE, etc. THESE EXAMPLES ARE PURELY HYPOTHETICAL AND DO NOT REPRESENT ACTUAL DATA.

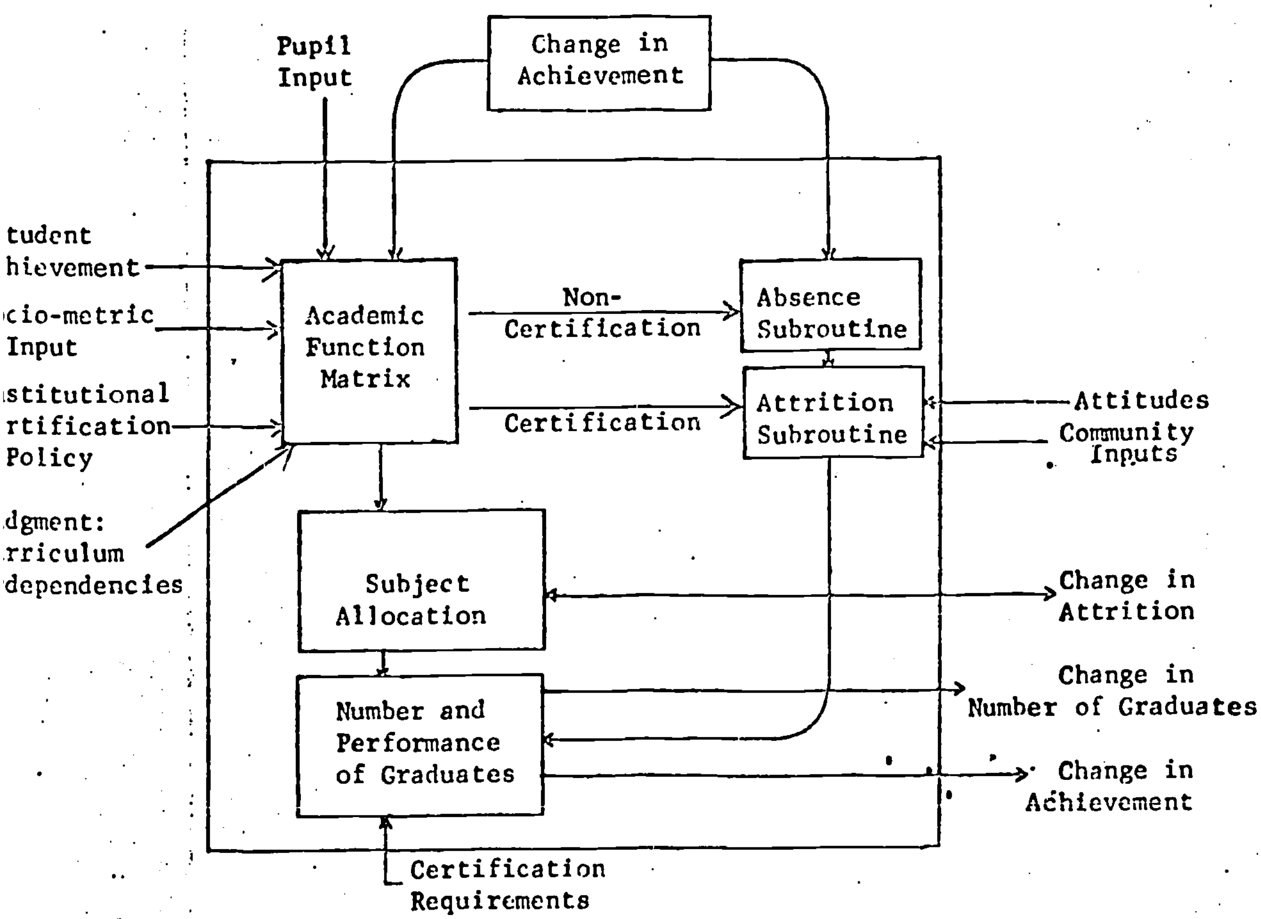
I. OVERALL COURSE OBJECTIVE ACHIEVEMENT, GRADE DISTRIBUTION





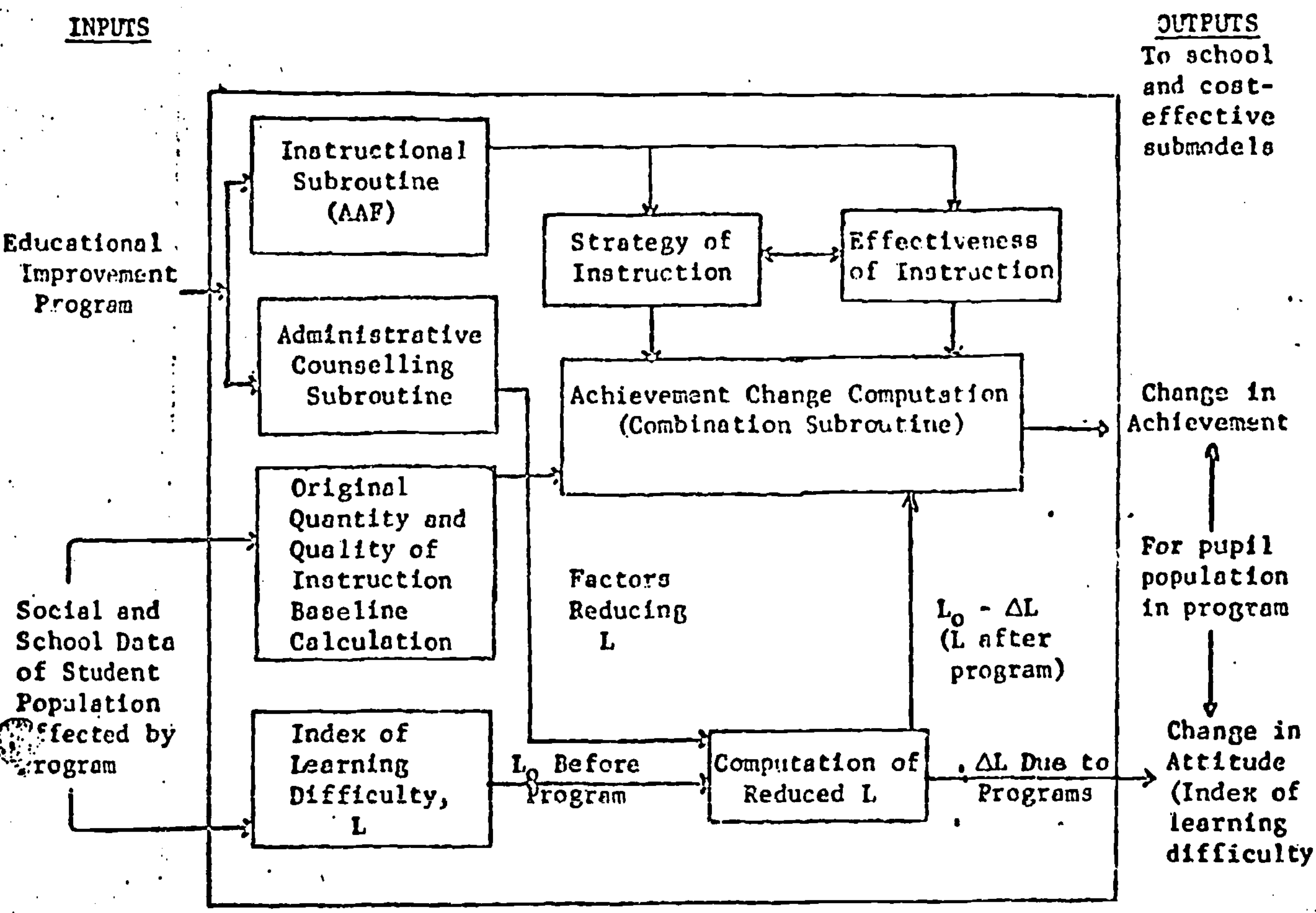
COMMUNITY SUBSYSTEM

FIGURE 8.

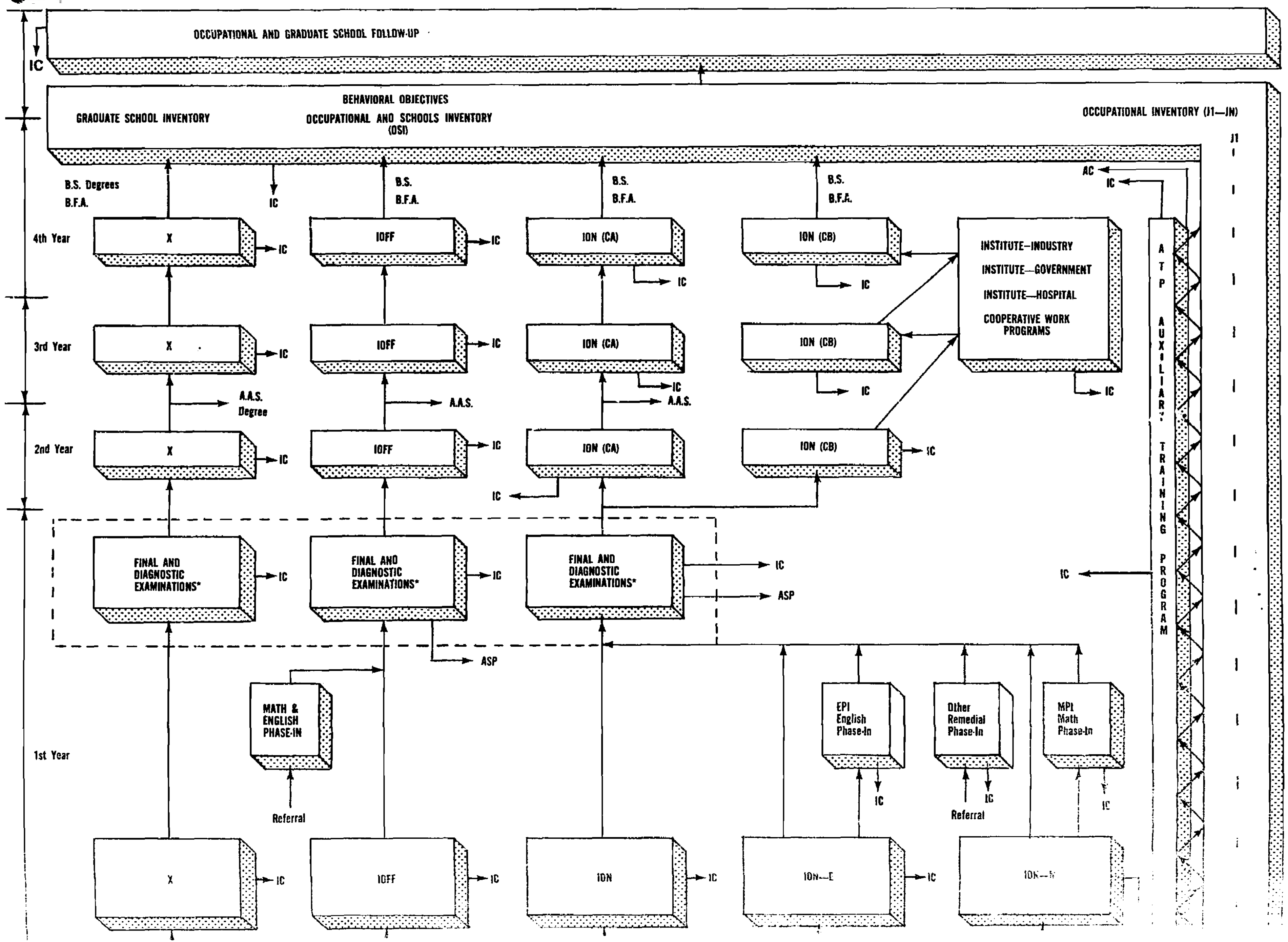


INSTRUCTIONAL PROCESS SUBSYSTEM

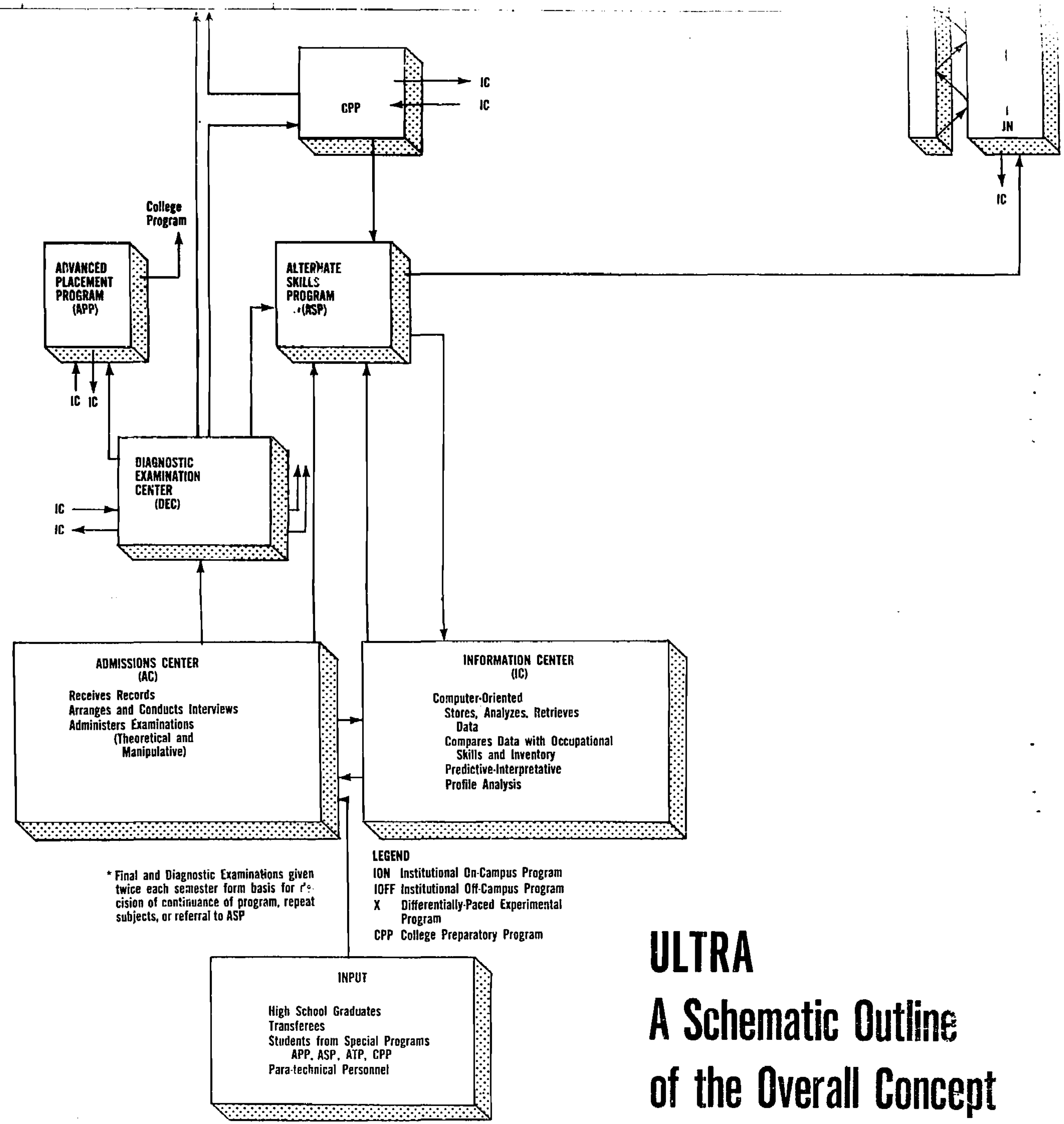
FIGURE 9.



INSTRUCTIONAL PROCESS INPUT SYSTEM



OCCUPATIONAL AND GRADUATE SCHOOL FOLLOW-UP
GRADUATE SCHOOL INVENTORY
BEHAVIORAL OBJECTIVES
OCCUPATIONAL AND SCHOOLS INVENTORY (OSI)
OCCUPATIONAL INVENTORY (J1—JN)
J1
B.S. Degrees
B.F.A.
B.S.
B.F.A.
4th Year
3rd Year
2nd Year
1st Year
X
IOFF
ION (CA)
ION (CB)
INSTITUTE—INDUSTRY
INSTITUTE—GOVERNMENT
INSTITUTE—HOSPITAL
COOPERATIVE WORK PROGRAMS
A.A.S. Degree
A.A.S.
AC
IC
ASP
ATP AUXILIARY TRAINING PROGRAM
FINAL AND DIAGNOSTIC EXAMINATIONS*
MATH & ENGLISH PHASE-IN
Referral
EPI English Phase-In
Other Remedial Phase-In
MPI Math Phase-In
ION
ION—E
ION—M



* Final and Diagnostic Examinations given twice each semester form basis for decision of continuance of program, repeat subjects, or referral to ASP

LEGEND

ION Institutional On-Campus Program
IOFF Institutional Off-Campus Program
X Differentially-Paced Experimental Program
CPP College Preparatory Program

ULTRA
A Schematic Outline of the Overall Concept