AN EVALUATION OF THE INSTRUCTIONAL SYSTEMS APPROACH IN HIGHER EDUCATION

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Chas. F. Schuller
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ABSTRACT

AN EVALUATION OF THE
INSTRUCTIONAL SYSTEMS APPROACH
IN HIGHER EDUCATION

by Gregory Louis Trzebiatowski

The purpose of the study was to critically analyze the systems approach to instructional development in order to determine the overall potential of this approach in higher education, and to discover which operational and theoretical areas need further development.

The methodology was primarily one of descriptive and critical analysis of the instructional system approach in higher education. Existing systems literature was analyzed, interpreted, and related to higher education needs and extrapolated in terms of two early attempts at Michigan State University to develop university level courses with instructional system development (ISD) procedures.

SUMMARY AND CONCLUSIONS

The instructional systems approach to curricular planning seems to have great potential as an instructional planning technique. Its two greatest contributions are the capability to identify key instructional decision points and a management/planning methodology which permits educa-

tors to take optimum advantage of what is known about the art of teaching. This potential, however, is largely unrealized because a comprehensive instructional system theory which is capable of producing a "true" instructional system has yet to be developed. Because of the need for an instructional system theory, the following recommendations which can guide its development are summarized below.

Theoretical Concerns

1. Instructional system theory should be developed within the framework of a social system theory. It should not develop within an industrial-military training system theory because of the philosophical differences between training and education.

2. Training oriented system design experts should not be permitted to make instructional decisions.

3. Strategies of instruction, including those that are technologically oriented, must undergo extensive development before their potential can be realized.

4. The various strategies of instruction must be unified to form a workable theory of instruction which can operate within the parameters of an instructional system theory.

As a result of the analysis of Michigan State University's instructional system field trials, a number of operational problems which merit further study were noted. These are summarized into two groups; those which should be resolved before instructional system development begins and those which are of concern during ISD.

Concerns Prior to ISD

1. The validity of the course. The course which is being considered for ISD should be both internally and externally valid.

2. The role of the instructor. It should be determined prior to ISD which of the several possible roles the course instructor will assume. He should be involved in all phases of ISD to insure maximum personal growth.

3. The availability of primary technology. The availability of an established network of primary instructional technology seems to be a prerequisite to the development of an IS.

4. A priority policy. A central administrative unit of the university should establish a policy regulating priorities for course development through ISD.

5. The question of utility. An extensive study should be conducted on the cost of input versus the desirability of output in ISD.

6. Training the ISD team. A thorough training program should be developed to train the instructor and the interdisciplinary team in system design procedures.

7. <u>Public relations</u>. An active public relations program should be established to inform the university faculty, students, and other interested individuals of ISD activities.

Problem Areas within ISD

1. The determination and statement of IS goals.

2. The collection and use of input data.

3. The analysis of the objectives and behaviors which constitute the instructional system's requirements.

4. The selection, implementation, and evaluation of instructional strategies.

5. The storage and retrieval of instructional materials according to the behavioral objectives which they are designed to accomplish.

6. The production of instructional materials which are designed to fulfill specific behavioral objectives.

7. Simulation of the newly synthesized instructional system.

8. The collection and evaluation of feedback systems which will permit the redesign of instructional systems.

AN EVALUATION OF THE INSTRUCTIONAL SYSTEMS APPROACH IN HIGHER EDUCATION

By

Gregory Louis Trzebiatowski

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CHAPTER I

THE PROBLEM

The Need for the Study

Pressures to improve instruction in higher education are being felt from many directions. Societal pressures such as population growth; the growth of knowledge, especially in science and technology; and the rising aspirations of the individual coupled with America's increasingly important role as a world leader are demanding that more individuals go to college to learn more, and at a higher level of sophistication, than ever before in our history. Pressures within higher education are demanding that college faculties devote an ever increasing proportion of their time to research and government service, leaving less professional time to be devoted to curricular planning and classroom teaching.

The pressures to improve instruction in higher education cannot be relieved by simply adding more staff, because America's institutions of higher learning, particularly the state-supported institutions, face a problem which is rapidly growing more acute--the shortage of capable teachers for an increasing student population. The dimensions of the problem are difficult to estimate, since there are a number of variables involved, but even the most optimistic estimates leave little question that higher education will face a critical shortage of teachers within a few years.

The shortage of qualified teaching faculty was dramatized by Frederic W. Ness, President of Fresno State College, California, in his recent article in the Saturday Review, when he said, "At present there are some 338,981 students enrolled in graduate programs in American colleges and universities, with roughly 15,000 completing the doctorate annually. The national demand for doctorates, however, is from three to six times this number, by the most conservative estimates; and when a Ph.D. is not available there is often nothing to do but settle for the second best."[1]

The results of the Carnegie Foundation for the Advancement of Teaching Study, The Flight from Teaching,[2] shows that the problem is further complicated by university professors being lured away from teaching by higher salaries and higher prestige into research and government service.

The alternatives for dealing with the college teacher shortage problem are few. Limiting enrollments is one

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[1] Frederic W. Ness, "The Case of the Lingering Degree," Saturday Review, XLIX (Jan. 15, 1966), p. 65.

[2] The Carnegie Foundation for the Advancement of Teaching, Flight from Teaching, Reprint from the 1963-1964 Annual Report (New York: The Carnegie Foundation for the Advancement of Teaching, 1964), p. 4.

alternative, but this can hardly be an acceptable solution in light of the American tradition of opening educational opportunities to everyone. The realistic alternatives are a decline in the quality of education, or changes in the strategies of instruction and administrative arrangements which might better utilize the available teaching and learning resources.[3]

Instructional Systems as an Alternative

Some educators who are keenly interested in the problems of improving instruction in colleges and universities have suggested that instructional system development is one of the more promising alternatives currently being explored.

Before describing instructional systems and discussing models for their development, it is necessary to consider in general what is meant by system, a much-defined term, and one which has meaning in every form of organized research and learning.

General systems methodology permits a system to be defined broadly as any grouping of components which operates in concert or related fashion with the purpose of

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[3]Committee on Utilization of College Teaching Resources, Better Utilization of College Teaching Resources, (New York: Fund for the Advancement of Education, 1959), p. 8.

accomplishing a specified goal or set of goals. Educators are familiar with phrases using the term system; e.g., school system, educational system, grading system and closed-circuit television system. Instructional systems are those systems which are made up of instructional components; i.e., teachers, pupils, texts, etc., which interact to accomplish specific educational goals.

As early as 1956, Hoban, in his keynote address at the Second National Audiovisual Leadership Conference at Lake Okaboji, proposed an instructional systems approach to audio-visual communication.[4] Using Shannon and Weaver's Communication Model[5] as a base, Hoban developed an audio-visual communication system which was designed to increase the overall effectiveness of instructional communication.[6]

Educational researchers have long been interested in the adaption of systems analysis to the problems of improving instruction in higher education. Systems analysis refers to the specific analytical technique for observing the operation and organization of an operating system in

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[4] Summary Report of the Second Lake Okoboji Audio-Visual Leadership Conference held at Iowa Lakeside Laboratory, Lake Okoboji, Milford, Iowa, August 19-22, 1956, Sponsored by the State University of Iowa and NEA Department of Audiovisual Instruction, p. 8, (Mimeographed).

[5] Claude E. Shannon and Warren Weaver, The Mathematical Theory of Communication (Urbana: University of Illinois Press, 1949).

[6] Hoban, 13.

order to develop a logical and complete description of the functioning system.

At a symposium on the state of research in instructional television and tutorial machines, Carpenter, using more formal systems terminology than Hoban, outlined the general requirements of "man-machine systems approach" to the solutions of complex operational problems like those of education, and including the media sub-systems.[7] He felt that an instructional system design applied to the problems of education would provide "A conceptual framework for planning, orderly consideration of functions and resources, including personnel and technical facilities such as television, the kinds and amount of resources needed, and a phased and orderly sequence of events leading to the accomplishment of specified and operationally defined achievements."[8]

The growing recognition of the system concept in education is found in recent discussions by Finn,[9] Bern,[10]

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[7]C. R. Carpenter, New Teaching Aids for the American Classroom, Wilbur Schramm (ed.), (Stanford: Institute for Communication Research, 1960, Reprinted in 1962 by U.S. Department of Health, Education, and Welfare: E-34020), p. 75.

[8]*Ibid.*

[9]James D. Finn, "Technology and the Instructional Process," AV Communication Review, Vol. 8, No. 1 (Winter, 1960), pp. 5-26.

[10]Henry A. Bern, "Audiovisual Engineers?," AV Communication Review, Vol. 9, No. 4, (July-August, 1961), pp. 186-194.

Glaser,[11] VanderMeer,[12] and others. The importance of this concept is illustrated by Hoban's more recent statement: "If we are to cope adequately in educational media research and in the implementation of research finding, use of the system concept is intellectually and practically inescapable."[13]

Educators have frequently stated the need for more research and development in instructional systems. Carpenter, for example, suggests both the potential of and the need for rigorous study of instructional systems in his statement that, "the development of a model of the component operations of a higher order man-machine system focused on learning and intellectual development has not yet been done with the necessary rigor and thoroughness."[14]

Norberg, while developing a rationale for the use of the new media in higher education, commented on the need for diligent study and hinted at possible resistance by

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[11]Robert Glaser (ed.), Training Research and Education (Pittsburgh: University of Pittsburgh Press, 1962).

[12]A. W. VanderMeer, "Systems Analysis and Media - A Perspective," AV Communication Review, Vol. 12, No. 3 (Fall, 1964), pp. 292-301.

[13]Charles F. Hoban, "The Usable Residue of Educational Film Research," New Teaching Aids for the American Classroom, Wilbur Schramm (ed.), (Stanford: Institute for Communication Research, 1960, Reprinted in 1962 by U. S. Department of Health, Education, and Welfare: OE-34020) p. 110.

[14]Carpenter, p. 84.

many professional educators to the adoption of the system concept when he said: "No doubt a good deal remains to be done by way of elaboration and justification of the system concept in education. To many professional educators this notion, borrowed from engineering and industry, may seem harsh and even ominous in its implications for the management of instructional processes. Even so, there is something firm and indisputable in the idea that instructional planning in modern educational institutions cannot be conducted on a piecemeal basis and without some effort toward a rational and efficient deployment of human and technical resources."[15]

The importance of the system concept as an approach to curricula planning is indicated by the United States Office of Education's funding of instructional system development studies.

One of the studies funded by the United States Office of Education in the area of instructional systems is nearing completion at Michigan State University. This study, directed by Dr. John Barson, which is entitled "A Procedural and Cost Analysis Study of Media in Instructional System Development", covers the period from 1963-1965, and

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[15]Kenneth Norberg, "The New Media in Higher Education: A Rationale," New Media in Higher Education, James W. Brown and James W. Thornton, Jr. (eds.) (Washington: National Education Association, 1963), p. 16.

focuses on an investigation of the development and use of the newer media in instructional systems.

The three purposes of the Barson Study are: (1) the descriptive analysis and evaluation of instructional system development activities at MSU during the period, 1963-1965; (2) the measurement of costs associated with instructional systems development; and (3) the development of hypothetical models of instructional system development (ISD).

Purpose of the Study

The purpose of this study is to critically analyze the systems approach to instructional development in order to determine the overall potential of this approach in higher education, and to discover which operational and theoretical areas need further development.

The findings of this analysis will be reported by:

1. A general conclusion concerning the potential of a system approach to instructional development in higher education;

2. Identifying and recommending the areas which need further theoretical development before the system approach can be applied to instructional development in higher education;

3. Describing the principal prerequisites which must obtain for successful instructional systems develop-

ment in higher education and for its field testing;

4. Identifying the instructional system procedures which are most in need of further study and development.

Methodology

The methodology of this study is primarily one of descriptive and critical analysis of the instructional system approach in higher education. Existing systems literature will be analyzed, interpreted, and related to higher education needs and extrapolated in terms of two early attempts at Michigan State University to develop university level courses with instructional system development procedures.

Review of Pertinent Literature Research studies and scholarly writings related to system development are analyzed and interpreted and their relevance to the problem discussed. Current system theories in operations research, systems engineering, and instructional training system development for business management and military and industrial training are reviewed, but only a few are reported because, while the terminology used in operations research and system engineering are similar or in many cases the same, the variables which are crucial in an instructional system either are not considered or are given different emphasis in non-educational fields. Throughout the review of the literature, particular attention is paid to those sections of the works reviewed which would assist in making an evaluation of the potential of systems approach in education.

Analysis of ISD Field Trials As a part of Michigan State University's Instructional System Development Project, a model for instructional system development was produced and field tested on two university level courses, one in theatre arts and the other in electrical engineering.

In order to gain insight into the potential of the systems approach to curricular planning, the procedures used in the two field trials are carefully analyzed and evaluated. The analysis and evaluation are accomplished by analyzing extensive data on the events which took place during the field trials and by applying standard system development procedures to their evaluation.

The data on the procedures used in the field trials were collected from two major sources: first, all of the documents produced by the ISD Project, and second, 83 1/2 hours of audio tapes which were recorded during the field tests. While listening to the tapes, the procedures used in the field trials were critically evaluated for deviations from the procedures prescribed by the specialist model for instructional system development. Deviations from the prescribed role by any of the specialists were carefully noted. Problems of communication between the personnel involved and problems of information feedback were also noted. The basic system development procedures used to guide the evaluation of ISD procedures were derived from the systems literature.

<u>Organization of the Study</u> The evaluation of the systems approach to instructional development planning begins with statements of: the problem, the purpose of the study, the methodological approach and key definitions. Chapter II includes a review of pertinent systems literature. Chapter III is designed to acquaint the reader with the various types of models and their importance in ISD. The third chapter also includes a review of the Specialist Model for ISD as it was generated by the MSU Instructional Systems Development Project. The review of the Specialist Model serves as an example of a typical ISD model and prepares the way for its later analysis. Chapter IV outlines seven sequential steps which are basic to the design of any system. These seven steps are used in a later section of the chapter to critically analyze the Specialist Model and the procedures which were used during the field trials. The final chapter undertakes to summarize the conclusions, discuss their importance and make final recommendations.

Definition of Terms

To avoid semantic problems and to aid understanding, certain key terms used in this study shall be defined here before proceeding. The systems concept, borrowed from military training and industry, brings with it a number of terms that have different interpretations from general usage and are included in this section for that reason.

System General systems methodology permits a system to be defined as any grouping of components which operates in concert or related fashion with the purpose of accomplishing a specified goal or set of goals. The components are dynamically interrelated. Dynamic interrelationship implies that the components of the system are capable of changing not only the performance of the system as a whole, but of affecting the performance of one or more of the other components. All systems are composed of subsystems; that is what a dynamic part would be. Systems are usually components of other systems and as such are considered subsystems. Systems can sometimes be differentiated one from another only through very subtle differentiation or definition.

Instructional System An instructional system is a complex consisting of several or all of the following components: learner(s), instructor(s), material(s), machine(s), technician(s), given certain inputs and designed to carry out a prescribed set of operations. This set of operations is devised and ordered according to the most recent and pertinent evidence from research and expert opinion so that the probability of attaining the output specified behavioral changes in the components is maximal.

Educational Media Generalist An educational media generalist is a professional educator with specialized competencies in the application of instructional technology to the teaching-learning process. Areas of concern, with respect to instructional technology, include administration, teaching, research and development, production, and curriculum planning.

Educational Media Specialist An educational media specialist is an educator primarily concerned with the selection of the form, or mode of representation, and transmitter, or media-instrumentation, to be used in the transmission of teaching examples to the student.

Environment Environment is the set of all entities which surround the system whose action may affect the system, and may be affected by the system. It also is referred to as the suprasystem.

Information Information is defined for the purposes of this study as stimuli, or energy forms, that convey pragmatic meaning. That is, information signifies something that is potentially subject to common identification by both the transmitter and the receiver of the information. As such, information is distinguishable from noise or uncoded stimuli which are void of intended denotative or connotative properties.

Filter A filter is a factor (man, man-made, or environmental) which consciously or by its state of being, acts to admit certain system elements to the system process, keeping others out.

Noise Noise refers to those conditions which interfere with the communication of an item intended as information.

Component A component is a dynamic part or element of a system. Instructional systems contain many elements, such as instructional personnel, technicians, media, and learners.

Boundary A boundary is the line forming a closed circle around selected variables, in which there is less interchange of energy (or communication, etc.) *across* the line of the circle tha~~t~~n *within* the delimiting circle. The delimiting circle forms the parameters of the instructional system.

<u>Inputs</u> Conditions or entities from the system's environment which act on the system, thus affecting the system's functioning and influencing the outputs.

<u>Outputs</u> Outputs are the sending of observable phenomena representing the acts of a system into the environment. This involves energy exchange across the system's boundary.

<u>Feedback</u> Feedback is the return of output to the system in order to reach the objective of the system and maintain organizational structure.

<u>Open System</u> An open system is a system that can be changed, or is adaptive, and which engages in energy and information exchange, both with its component subsystems and with other systems which comprise its environment. An open system must be capable of receiving inputs and of producing outputs.

<u>Efficiency</u> Efficiency is a ratio relationship between energy inputs to a system and the outputs from that system.

<u>Instructional Model</u> An instructional model is an idealized conception of the teaching-learning process.

<u>Media</u> Media are the in-between or intermediate part or parts in a communication network that transmit the message from the source to the receiver. These parts may be the voice of the lecturer, the image of a photograph or other graphic, the print of the textbook, the electronic impulses of the television, radio, or public address system or a combination of several of these. In instructional system thinking, the term "media" is usually interpreted to represent the means used to connect the teacher and the students.

Summary

In order to improve instruction in higher education many educators are advocating the use of the systems approach to curricular planning. They feel that if instructional planning is better organized and more technologies of instruction are incorporated into the instructional program then the combined pressures of rapidly increasing enrollments, insufficient teaching faculty, and the absence of adequate funding will not decrease the quality of instruction in higher education.

It is the purpose of the study to evaluate the potential of the systems approach to instructional planning in higher education. The evaluation will be based upon a careful review of pertinent systems literature and by analysing the first attempts to redesign university level courses using an instructional systems development model.

CHAPTER II

A REVIEW OF THE LITERATURE IN INSTRUCTIONAL SYSTEM THEORY

Systems: A Conceptual Tool

The word system is derived from the Greek "Systema" meaning "to place together." Peach describes a system as an "aggregate of two or more physical components and a set of disciplines or procedures by means of which they function together."[1] The entities or components, either conceptual or physical, of a system can be described as activity performers, information processors, and activity controllers. The control of these components is the function of the system's communications network and of its decision-making structure. The decision-making structure, through the communications network, guides the actions of the system's goal or purpose. The interdependence of the system's components is the result of the content of the system and the structure by which the content is arranged.

As a means of looking at reality, the systems concept uses interdependent components, which serve as activ-

[1] Paul Peach, What Is System Analysis?, SP-155 (Santa Monica, California: System Development Corporation, March 4, 1960), p. 1.

ity performers, controllers, and information processors, and a communications network and a decision-making structure. As Finan explains, "A system is a way of conceptualizing experience, according to which the components of an organized grouping interact to achieve a designated purpose."[2] Kennedy reinforces the definition of a system as a conceptual device when in his discussion of the concept "system" he states, "The definition of a system is in a sense arbitrary and depends heavily on *a priori* definition of a task or problem."[3]

Careful examination of other definitions of system shows a conflict of views on the basic nature of a system. One posture is exemplified by Beer when he states that "Systems are constructs of the human mind, and intuitive method of looking at nature."[4] A second position concerning the basic nature of a system is that "the ultimate system embraces the universe." As Eckman states, "it is obvious that any real systems study can only encompass a

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[2]John L. Finan, "The System Concept as a Principle of Methodological Decision," *Psychological Principles in System Development*, ed. Robert M. Gagne (New York: Holt, Rinehart and Winston, 1962), p. 517.

[3]John L. Kennedy, "Psychology and System Development," *ibid.*, p. 15.

[4]S. Beer, "Below the Twilight Arch--A Mythology of Systems," *Systems: Research and Design*, Proceedings of The First Systems Symposium at Case Institute of Technology, ed. Donald P. Eckman (New York: John Wiley & Sons, Inc., 1961), p. 14

portion of the Ultimate System, and therefore, that every system being studied is but a portion of a larger system."[5]

The apparent paradox can be resolved by analyzing the operation of the human mind. We cannot conceive of concepts in isolation. Concepts are understood in relationship to other concepts. These other concepts are related to others _ad infinitum_, until the entire universe is a system of interlocking parts.

This picture of the universe is far more subtle than our minds will operationally allow. We seize on patterns to explain causal relations. We say X interacts with Y, which is why Z occurs, and Y is related to X; but this relationship extends to encompass every other unit in the universe.

If all systems, with the exception of the universe, are systems only by definition and are created for purposes of conceptualization, then careful definition and delineation of what is to be included within the boundaries or parameters of a defined system is extremely important. It is important because if variables which are significant to the problem; i.e., the system undergoing study, are not included within the parameters of the system--or irrelevant variables are included--then efficient and effective study of the problem is made more difficult and in some cases

[5] _Ibid._, p. ix.

impossible. Educators embarking on a course redevelopment program using instructional system development techniques must consider the crucialness of parameter definition and the division of the system into component subsystems, for as Beer warns in his discussion of the mythology of systems, a system cannot sustain arbitrary division without ceasing to be the system that it is.[6]

In a social system such as education, there is great danger of destroying the whole by arbitrarily dividing what we have no business dividing, since the variables involved in the teaching-learning process are at best hazy.

It is interesting to note that educators, who are frequently criticized for using too nebulous terms, are being asked to adopt a new conceptual tool--the systems approach--because it is more rigorous and exact; yet we find in the key construct--system--a strong possibility of confusion. There are at least twenty published definitions of the word system. Since a system may be operationally defined at almost any level or to any degree of complexity, it is sometimes difficult to determine how much is included in a reference to a particular system. To add to the confusion, aggregates of systems are referred to as suprasystem, and the divisions of a system are called subsystems. In light of the confusion which may result from simple definition

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[6] Ibid., p. 14.

and explanation of the term "system," the next section of this review will explore the characteristics and properties of systems.

Properties and Characteristics of Systems

In reviewing the literature on the properties and characteristics of systems, two works were judged to be outstanding because of their comprehensiveness and thorough treatment of the topic. The first is an article by A. D. Hall and R. E. Fagen, entitled "Definition of System."[7] Both men are systems engineers in the Bell Telephone Laboratories. The second outstanding work is an earlier thesis presented by L. von Bertalanffy, entitled "An Outline of General System Theory."[8] Both articles are abstract and rather heavy reading, but are complete and exact in their treatment of general system theory. It is evident by their use of the same examples that other more recent authors have also reviewed the works mentioned above. Griffiths,[9] for

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[7]A. D. Hall and R. E. Fagen, "Definition of System," General Systems Yearbook, First Yearbook of the Society for the Advancement of General Systems Theory, ed. Ludwig von Bertalanffy (Braun-Brumfield, Inc., 1956), p. 18-28.

[8]Ludwig von Bertalanffy, "An Outline of General System Theory," The British Journal for the Philosophy of Science, Vol. I, No. 2 (August, 1950), p. 134-165.

[9]Daniel E. Griffiths, "Administrative Theory and Change in Organizations," Innovation in Education, ed. Matthew B. Miles (New York: Teachers College, Columbia University, 1964), p. 429.

instance, used the same example in 1964 for illustrating equifinality that Bertalanffy[10] used in 1950.

In order, later, to make a transition to instructional systems, more time will be spent dealing with the properties and characteristics of systems in general.

Characteristics of Systems: When dealing with a concept like system which is difficult to define explicitly, it is sometimes helpful to identify the major characteristics of the concept.

A system is a set of entities which interact dynamically according to a set of relationships or disciplines to achieve a designated purpose or goal. A completely staffed instructional television facility could be considered a system. The entities are the men and machines needed to achieve the system's goal, which could be a video-taped instructional television program.

The entities which, together with their properties, make up the system may be seen as natural or man-made. Natural systems are those found in nature and are described by the astronomer, physicist, chemist, biologist, physiologist, etc. The television facility just mentioned is a good example of a man-made system.

[10]Bertalanffy, The British Journal...., I, p. 158.

The entities of a system are made up of a variety of parts. Thus any entity in a system would be considered a subsystem; or for another purpose, an entity could be redefined as a system of a lower order. Still using instructional television as an example, three general subsystems can be identified: script production; graphics and scene production; and program production. Any of these subsystems can be examined more carefully and seen to have subsystems of its own; e.g., the script production subsystem can be redefined as a system with the production of an instructional television script as its goal. The script production subsystems--several subject matter experts, a writer, an editor, and a producer--must interact dynamically according to a set of relationships; that is, script production and writing techniques, to produce the output or goal.

All entities have properties and these properties are specifications of the entities. A script writer, for example, has certain skills or properties which differentiate him from, say, a television producer.

The connections between entities are called relationships. There are two kinds of relationships: static, which do not change with time; and dynamic, which change with changes in time. In a given television system the relationship between camera lens and video tape recorder is a static relationship. The relationship between a writer and a subject matter expert could be considered dynamic.

Generally, when a human is involved, either with another human or with a machine, a dynamic relationship exists.

The environment is the set of all entities which surround the system; whose action may effect the system, and in turn may be effected by outputs of the system.[11]

The boundaries of a system are the regions which differentiate or separate a system from its environment. As discussed earlier in the section on the system as a concept, it is very difficult, particularly in a social system such as higher education, to separate a system from its environment. Hall and Fagen in their discussion of environment comment on this question.

> For a given system, the environment is the set of all objects a change in whose attributes affect the system and also those objects whose attributes are changed by the behavior of the system.
>
> The statement above invites the natural question of when an object belongs to a system and when it belongs to the environment; for if an object reacts with a system in the way described above should it not be considered a part of the system? The answer is by no means definite. In a sense, a system together with its environment makes up the universe of all things of interest in a given context. Subdivision of this universe into two sets, system and environment, can be done in many ways which are in fact quite arbitrary. Ultimately it depends on the intentions of the one who is studying the particular universe as to which of the possible configurations of objects is to be taken as the system. 12

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[11] Hall and Fagen, "Definition of System," General Systems Yearbook, p. 20.

[12] Hall and Fagen, "Definition of System," General Systems Yearbook, p. 20.

Throughout their discussion of the definition of environment, the Bell Telephone Laboratory scientists do not offer any concrete suggestions for successfully making the separation between the system and its environment. They conclude by emphasizing the difficulty and importance of the problem by stating: "The general problem of specifying the environment of a given system is far from trivial. To specify completely an environment one needs to know all the factors that affect or are affected by a system; this problem is as difficult as the complete specification of the system itself."[13]

In the process of characterizing systems, an imposing problem has been identified. The problem of separating systems from their environment will be dealt with in greater detail later in the study.

Properties of Systems

A system is composed of several properties which relate to its function, its operation and its nature; some of which contribute to the probability of its success or failure as a workable system.

A system is referred to as a multisystem if it has other systems (subsystems) as its entities or elements.

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[13]Hall and Fagen, "Definition of System," General Systems Yearbook, p. 20.

The partition of systems into subsystems and subsystems into systems of a lower order is referred to as the property of hierarchical order.

A system is <u>open</u> if it has <u>input</u>; i.e., the sending of entities in the form of matter, energy or information from the environment into the system; and <u>output</u>; i.e., the sending of entities from the system into the environment. A <u>closed</u> system, on the other hand, cannot communicate with its environment. Systems become progressively more closed as larger portions of the system's environment are included within the system's boundaries; i.e., as a system moves up the hierarchical order it becomes more closed. For example, a university, under the direction of a board of regents, is more closed in its communication with its environment than a lower order system like the university's instruction system under direction of an academic vice-president.

A system is said to be <u>regulated</u> if it has feedback. All open systems are regulated systems since they receive feedback or output which is used by the system to guide it toward its designated purpose or goal. Student and alumni surveys are one formal technique for collecting feedback.

A system is <u>adaptive</u> and compatible with its environment if exchanges of outputs lead to the continued survival of the system. To continue the university example, the addition of new curricula, such as a School of Packaging, and the elimination of obsolete courses, is an adaptive property of a university system insuring its continued survival.

A system has <u>independence</u> if a change in at least one of its entities effects that entity alone and does not cause changes in the system's action. The less a university department is changed by the loss of a professor, the greater is that department's independence. A system that has total independence of all its entities or components is considered to be degenerate. A system becomes degenerate if there is no wholeness; i.e., all its subsystems are completely independent of one another. A degenerate school would have no relationships or regulations connecting and governing its subsystems. Such a school would be unstable and very likely soon cease to exist.

A system is in <u>progressive segregation</u> when changes in the components of a system tend toward independence of the components and in <u>progressive systemization</u> when changes in components tend toward greater wholeness. A system is in a steady state if progressive segregation and progressive systemization occur simultaneously and continue through time.

<u>Action of Systems</u>

A great deal can be learned about the actions of a system by studying the effects of various kinds and amounts of input into the system. Similarly, close examination of a system's output also reveals valuable information about its actions.

The action of a system is affected by the amount of its input. If the amount of input is high, some of it will be omitted or ignored. A system receiving high input will filter it and react only to certain of its categories. When input becomes excessive, the system will ignore it entirely or employ some means of cutting off the input.

If the input potential is high, a university, for example, controls the student input by limiting enrollment, thus omitting part of the input; or it may filter the potentially excessive input by raising the entrance requirements. If input fluctuates in intensity, the system will delay output during peak loads and catch up during input lulls. A high continuous level of input lowers the precision and quality of the system's output. Finally, a continuously increasing input produces a strain in the system which, if the strain becomes too great, can lead to a catastrophic collapse of the system. A continuous increase in a teacher's load, for instance, puts a strain on the school and decreases the quality of the school's product. If the strain becomes too great, the teachers might resign from their positions, resulting in the collapse of the school.

A system which does not feed back some of its output decreases in stability until it degenerates. Feedback, which is essential to the survival of any open system, must be provided for in the design of instructional systems to insure wholeness, stability, adaption, and continued existence of the system. Feedback is also needed to insure that the system continues moving toward its objective.

Knowledge of the characteristics, properties and actions of systems may not be sufficient for the application of the concept "system" to the solution of educational problems. A brief review of Bertalanffy's General Systems Theory will add necessary background information needed in any discussion of instructional systems theory.

General Systems Theory as developed by Ludwig von Bertalanffy is a theory applicable to all sciences concerned with systems. According to Bertalanffy "there exist--<u>general system laws</u> which apply to any system of a certain type, irrespective of the particular properties of the system or elements involved."[14] If education or aspects of it can be considered a system, then Bertalanffy's General System Theory provides a framework within which educational systems can be examined and instructional system theory can be developed.

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[14]Bertalanffy, <u>The British Journal</u>...., I, p. 138.

General System Theory

Ludwig von Bertalanffy wrote that in many fields of scientific research there were trends towards generalized theories containing universal principles or general system laws which would apply to any system of a certain type. He proposed a new basic scientific discipline called "General System Theory".[15] Unlike many theories which are based on assumptions of linearity and the additive combination of elements or components, General System Theory is founded on principles of non-linearity and complex inter-relationships among the components which make up the system. Attention is focused on the behavior of the system as a whole.

When von Bertalanffy began to expound and expand his General System Theory, he was attempting to make a contribution to science in general. His contribution was not to any specific discipline, but to all disciplines. It was a <u>general</u> system theory, a system of systems, a class of classes; a <u>metatheory</u>.

Founded in Lotka's general system laws in the field of biology[16], the General System Theory as developed by von Bertalanffy applied, or should apply, to all the systems of a given class. As Bertalanffy says,

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[15] Bertalanffy, The British Journal...., I, pp. 134-165.

[16] Alfred J. Lotka, <u>Elements of Physical Biology</u>, (Baltimore: Williams and Williams Co., 1925).

> Thus, there exist models, principles, and laws that apply to generalized systems or their subclasses, irrespective of their particular kind, the nature of their component elements, and the relations of "forces" between them. It seems legitimate to ask for a theory, not of systems of a more or less special kind, but of universal principles which are valid for "systems" in general.
>
> In this way, we come to postulate a new discipline, called General System Theory. Its subject matter is the formulation and derivation of those principles which are valid for "systems" in general. 17

This critical point of generalized, but not specific, principles is one to keep in mind. In it is the key to the concept of General System Theory as von Bertalanffy saw it. His supporter, Kenneth Boulding, says,

> It (General System Theory) does not seek, of course, to establish a single, self-contained "general theory of practically everything" which will replace all the special theories of particular disciplines. Such a theory would be almost without content, and all we can say about practically everything is almost nothing. 18

And in the previously mentioned article, von Bertalanffy pointed out that the aims of General System Theory were to establish certain general principles, which he then elaborated:

> a. There is a general tendency towards integration in the various sciences, natural and social.

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[17] Ludwig von Bertalanffy, "General System Theory," Currents of Modern Thought, Vol. II, (1955), pp. 75-82.

[18] Kenneth E. Boulding, "General Systems Theory - the Skeleton of Science," Management Science, Vol. II, (1956), p. 197.

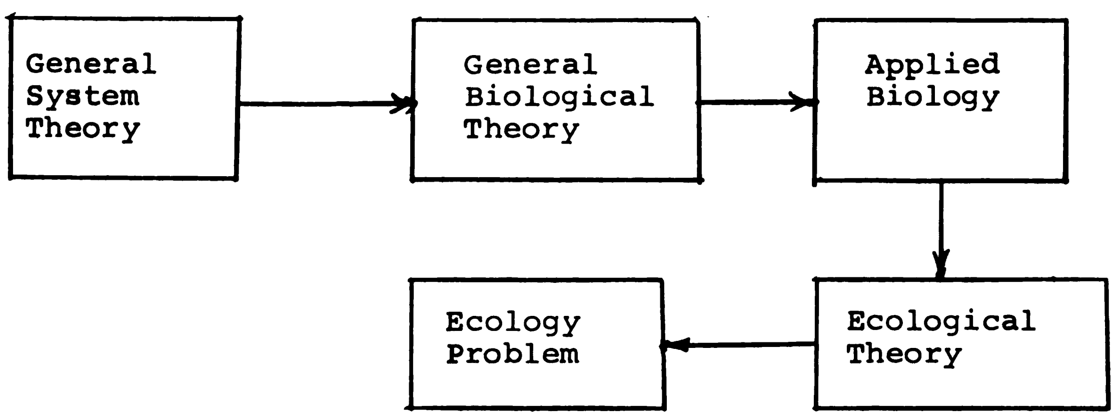
b. Such integration seems to be centered in a general theory of systems.

c. Such theory may be an important means for aiming at exact theory in the nonphysical fields of science.

d. Developing unifying principles, running "vertically" through the universe of the individual sciences, this theory brings us nearer to the goal of the unity of science.

e. This can lead to a much needed integration in scientific education. 19

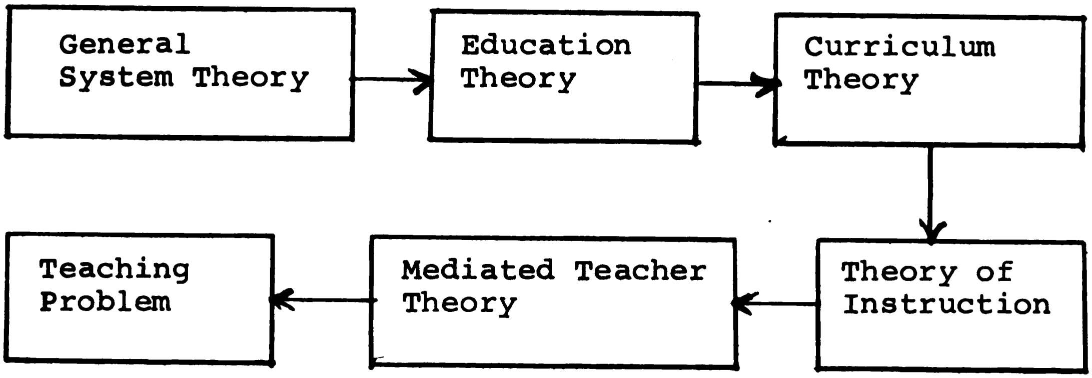
In working terms, a General System Theory is not applicable to problems of a specific nature.[20] A graphic example below shows the relation of a general theory to a problem in a specific discipline.



[19]Bertalanffy, Currents of Modern Thought, p. 76.

[20]C. James Wallington, "The Meaning of General Systems Theory: A Paradox." (Los Angeles: University of Southern California, Department of Instructional Technology, 1966) (Typewritten).

Similarly, in the field of education,



While there may be elements or sections of a General System Theory which can be utilized to compare systematic organization of different processes, there is no claim to a one-to-one "fit" or match between general and specific theories. This is especially true in the behavioral sciences where the specific theories tend to be extremely cumbersome and fragmented.

One of the major reasons that the behavioral sciences, especially education, are finding it difficult to bridge the gap between General System Theory and specific social science theories is that General System Theory is incomplete at the present time. The Theory was developed using the constructs and principles found in the natural sciences, particularly biology. While the general framework exists for the behavioral sciences to build upon, the principles and constructs needed to explain phenomena in the social sciences do not, as yet, exist in General

System Theory terminology.

Even if a great deal of work remains to be done in the way of development of General System Theory, the idea of attempting to extract universal system laws from as large a portion of the universal system as possible is an appealing one.

The concept of a universal system speaks eloquently for the fallacy of the division of the study of nature into disciplines. It is not surprising that the systems concept should be a focal point for the convergent development of a number of disciplines. These disciplines are bringing with them sophisticated methodology for the analysis and synthesis of systems. The next section of this review focuses on the contribution of systems engineering, operations research, information theory, and systems analysis to the growing body of systems research.

The System Disciplines

Information Theory

If a system is to function successfully and achieve its objectives, information is needed to direct and control the system. Information theory has contributed a great deal to the understanding of this information management problem.

From the engineering standpoint, information theory had its beginnings in papers published in 1928 by Hartley[21] and expanded by Shannon.[22] Information in this classical sense is highly mathematical and is concerned primarily with the amount of information that can be communicated over a system consisting of a Source-Transmitter-Channel-Receiver-Destination. Information is defined in terms of electronically generated signals. Substantive areas of theory include information sources, content, rate of transmission (in quantitative terms), channel description and transmission capacity, noise source, degree and degradation effect of noise. Although information networks in instructional systems are still described in Shannon's terminology, most of the mathematical and quantitative aspects of his theory have been deleted.

Information theory has had a significant influence on the development of the systems concept. Information is the glue that holds a system together. In Ackoff's words,

> The effectiveness of an organization depends in part on its having "the right information at the right place and at the right time". 23

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[21]R. V. Hartley, "The Transmission of Information," <u>Bell System Technical Journal</u>, Vol. 17 (1928), pp. 535-550.

[22]Claude E. Shannon, "A Mathematical Theory of Communication," Bell System Technical Journal, Vol. 37 (1948), pp. 379-423.

[23]R. L. Ackoff, "Systems, Organizations, and Interdisciplinary Research," <u>Systems: Research and Design</u>, p. 33.

Ryans, in his explanation of system, stresses the importance of information in three respects. First, the interaction of the system elements is dependent upon a common information network. Second, the function of the system is dependent upon the control of the flow and transmission of information. Third, the system can be characterized by the way it processes the available information.[24]

A limiting factor in the application of classical information theory to educational systems is that it assumes the existence of a static system. Engineering-oriented information theory is most useful in fixed information systems involving electronic circuitry, such as radar or television. In these cases the elements are discrete and manipulable and therefore subject to operational prediction with engineering precision. In any communication system where a man is one of the elements, learning can occur. Learning alters the probability formulas, and this in turn negates the predictive properties of the mathematical model.

The second limitation in the application of information theory to educational systems lies in the definition of information. The term lends itself to very broad definitions. For instance, Ryans defines information as "any

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[24]David G. Ryans, System Analysis in Educational Planning, TM-1968, (Santa Monica, California: System Development Corporation, July, 1964), p. 3.

state or property that is capable of being communicated."[25] Information is considered by the electronics engineer to be synonymous with energy. It may also be regarded as signifying a state or property that is potentially subject to common identification by its source and its destination. Information theory focuses on the electronic definition of information where the measure of information contained in a message is a function of the number of distinct physical messages that could have been sent and the probability associated with the selection of each message. The measure makes no reference to content, significance or meaning of the message.

A third limitation of information theory is in the use of the term "noise." Information theory considers only one kind of noise, that which masks the signal and thereby lowers the probability of its being received as sent. However, in human communication a second kind of noise can exist: this second kind of noise is "semantic noise." Barrow and Westley describe semantic noise as noise which competes with the receiver's attention, thereby lowering the probability that the message will be received as sent.[26] A speaker's use of words which are not a part of the lis-

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[25] _Ibid._, p. 6.

[26] L. Barrow and B. Westley, _Television Effects_, (Madison, Wisconsin: University of Wisconsin Television Laboratory, 1958), p. 63.

tener's active vocabulary is one form of semantic noise. In this instance, the listener's attention is diverted from the speaker's message in an effort to decode or extract meaning from the unfamiliar word. Each such diversion lowers the probability that the message will be received as sent.

In spite of the fact that the theorist in human communication must consider many things as variable which classical information theory considers as constant, there is much in information theory which is useful to instructional system development, particularly since the introduction of a number of ramifications and adaptions of classical information theory by behavioral scientist George A. Miller.[27] Published in 1951, his text is now considered a classic.

Miller and others associated with him have considered information from both the semantic and pragmatic points of view, thus making concepts like channel capacity, coding, message design and redundancy useful to the behavioral scientist in non-quantitative manner. The usefulness of information theory to the behavioral scientist is clearly expressed in this statement by Wilbur Schramm:

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[27] George A. Miller, Language and Communication, (New York: McGraw-Hill Book Company, Inc., 1951). Reference is to entire work of 298 pages.

> The concepts of information theory have an insightful quality, an intuitive sort of fit when they are applied freely to mass communication situations. 28

However, the primary contribution of information theory to the system concept in particular has been through its influence on system engineering and system analysis. The concept of the mathematical modeling of information flow was a key element in the development of system simulation techniques. System simulation is one of the major techniques of both system engineering and system analysis.

System Engineering

System engineering began in the 1930's. The Radio Corporation of America's work in developing television broadcasting services led them into research in the engineering of automatic control system for electro-mechanical devices. This research was the conceptual basis for system engineering. During the 1930's and 1940's, as equipment systems became larger, engineers became more concerned with the interaction of equipment in machine complexes. The unique set of problems involved grew beyond the scope of the traditional engineering fields; the new interdiscipline of system engineering was born.[29]

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[28]Wilbur Schramm, The Process and Effects of Mass Communication, (Urbana, Illinois: University of Illinois Press, 1960), p. 83.

[29]Leonard C. Silvern, Systems Engineering in the Educational Environment, A Position Paper given for the

The primary influence of systems engineering on the system concept is in the organization of men and machines. The system concept uses a team of specialists in an effort to optimize the output of complex man-machine operations. In an instructional system some of the team members might be specialists in the subject matter, in evaluation, in learning psychology, in instructional media, and in educational sociology. The approach is scientific and emphasizes the "whole system" rather than the component approach.[30] Some of the tools of system engineering are cybernetics, game theory, simulation, information theory, servomechanism theory, linear programming and queuing (waiting-line) theory. Some of these tools; e.g., simulation, are useful to the educational system designer without a great deal of modification, while others such as servomechanism theory, either do not apply to educational system problems or must be substantially modified before they can be used.

As pointed out earlier, the development of system engineering is convergent toward what has been defined as the system concept. System engineering has been trading methodology with both operations research and system analysis

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STEMS Project, (Washington, D.C.: U.S. Office of Education, March, 1963), p. 5.

[30]Robert H. Roy, "The Development and Future of Operations Research and Systems Engineering," Operations Research and Systems Engineering, (Baltimore: The Johns Hopkins Press, 1960), p. 23.

to a point where it is difficult to distinguish between them. As Roy states, "The differences between operations research and systems engineering lie more in the people who do the work than in concept, philosophy, or procedure."[31]

System Analysis

System analysis has been used as a catch-all phrase. Many use the term interchangeably with the conceptually broader terms "system engineering" and "operations research." While this usage may not be far wrong in current application, it is historically inaccurate because systems analysis did have a separate development.

The key to system analysis methodology lies in the definition of the term analysis. Analysis is from the Greek *ana* + *lyein*, meaning to loosen up or to separate. Combining the words system and analysis suggests a process in which a whole system is broken down into the greatest number of constituent parts or elements which still maintain a meaningful relation to the whole and to each other.

The popular use of the term system analysis implies the related, though converse, process of system synthesis. The term is derived from the Greek *syn* + *tithenai*, meaning "to place with." The process is one of combining elements

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[31] *Ibid*.

into a meaningful relation in such a way that the product is a whole system. However, system synthesis is not necessarily a corollary of system analysis in that it may involve the combination of previously non-related elements. In other words, synthesis is a process of invention, innovation, or design;[32] whereas analysis is essentially a process of breaking down a whole into its components.

About 1950 the scientists of the Rand Corporation began using the term "system analysis" to describe their work in the design and analysis of data systems. By 1955 the term system analysis was closely associated with the analysis of data for the programming of digital computers.

System analysis is still closely associated with computer programming. However, techniques peculiar to it, such as flow chart analysis, and its natural connection with the methodology of system engineering and operations research, have made it a good general analytical tool for system development. Mood describes the current position of system analysis as similar to "God, country, and motherhood--almost everyone is in favor of it."[33]

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[32] Paul Peach, What Is System Analysis?, SP-155, (Santa Monica, California: System Development Corporation, March, 1960), p. 13.

[33] Alexander M. Mood, Some Problems Inherent in the Development of a Systems Approach to Instruction, Prepared for Conference on "New Dimensions for Research in Educational Media Implied by the 'Systems' Approach to Instruction", conducted by Center for Instructional Communications of Syracuse University, April 2-4, 1964, (Pacific Palisades, California: Operations Research Society of America), p. 1.

System analysis techniques are of primary value in the analysis of the communication networks which exist within almost all systems. Such sophisticated techniques as flow chart analysis, simulation and symbolic modeling are used in the analysis of communication data as it flows through the system.

Operations Research

Operations research, another of the systems disciplines, has been described as a scientific method for studying the immediate future. It was born out of the strategic and logistical problems of World War II. The thousands of variables connected with modern warfare require a high-power methodology to provide a basis for decision making. The technique developed proved to be of general value for the optimization of the functions of any system. A current definition of operations research is stated by Ryans:

> Operations research generally is thought of as the application of mathematical tools and techniques to the scientific study of organizations and operating systems, with the goal of providing those in control of the system under consideration with optimum solutions to problems relating to equipment organization, procedures, etc. 34

This definition, while it does not sharply separate operations research from other scientific management tools, does

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[34] Ryans, TM-1968, p. 2.

indicate the scope and purpose of operations research.

The success of the operations research procedures is dependent upon the ability of the model to forecast values of the uncontrolled variables. One of the most useful tools developed by operations research for this purpose is operational gaming. The method of operational gaming is to synthesize the key variables into a close proximity of the actual operational environment, and then to collapse the time dimension. This allows for the realistic manipulation of the controlled variables. The method provides a controlled trial and error approach to system optimization.

One of the graphic means of mapping the predicted variables is a technique called PERT (Program Evaluation and Review Technique). PERT acts as a framework for ordering and evaluating predicted variables into a plan for realizing a system's objectives. The PERT approach allows for the early identification of future problem areas and unpredictable events so that feedback for operational gaming will provide the optimum system strategy for dealing with these variables.

Like operations research in general, PERT was born of the strategic and logistic problems inherent in managing complex man-machine systems. In its first application PERT provided the framework for scheduling and coordinating the 11,000 subcontractors contributing to the Naval Fleet Ballistic Missile Program. The development of the Polaris

Underwater Missile System two years ahead of the predicted schedule is due largely to the use of the PERT technique. PERT has since proven to be a system development tool of general value for planning and controlling a system and for providing intersystem communications.

While each of the system disciplines has a unique history of development and a specific design methodology, all are drawn together by a general research design methodology. The following section will compare and contrast system research methodology with the more traditional scientific method.

The Design Approach of System Research

The methodology of system research is the product of the convergent development of system engineering, information theory, system analysis, and operations research. System research methodology has also borrowed techniques from psychotechnology, semantics, communications, economics and many other fields. This wholesale borrowing suggests a hodgepodge of methods wrapped around a loose theoretical core. The suggestion, however, is not justified.

System research is not developing in a come-what-may fashion. The theoretical core consists of some very definite concepts about the basic nature of the universe. This strong conceptual base is the point of attraction for the convergence of the system disciplines. The techniques employed in system research are the product of a synthesis of the techniques of the contributing disciplines. Better understanding of system organization is being achieved by utilizing the analytical power of system analysis.

The product which is emerging from the combination of the various system disciplines is a universal approach which is analogous to the scientific method in many respects. Hopkins draws this parallel in the following terms:

Scientific Method	System Research
1. Observe facts.	1. Gather facts on which to base system objectives.
2. Describe observations.	2. Formulate objectives from the facts.
3. Analyze facts observed.	3. Analyze, quantify, and organize, and relate requirements to the state of art techniques.
4. Search for relationships.	4. Subsystemize requirements according to functional groupings.
5. Formulate general laws and hypotheses.	5. Formulate, design, and construct model to produce required system behavior.
6. Deduct predictions from hypothesis.	6. Establish criteria for testing model.
7. Test prediction experimentally.	7. Operate model and measure results.
8. Adapt or reject hypothesis.	8. Adapt or reject modeled design. 35

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[35] R. C. Hopkins, A Systematic Approach to System Development, FN-4176, (Santa Monica, California: System Development Corporation, August, 1960), pp. 18-23.

In spite of these similarities there are significant differences between the traditional scientific method and the system approach. In the first place their basic objectives differ. The intent of the system approach is to produce or forecast an efficient system. The purpose of the scientific method is to build a conceptual framework that represents the logical relations obtained within a given range of phenomena. The system approach is interested in the arrangement of the components in a manner that tends to constrain action toward a specific end. The scientific method seeks understanding by measuring the correspondence between a set of observations and a set of concepts.

Finan details the basic differences in approach between the system and the scientific methods:

Scientific Method	System Approach
Formulating Problem	
Transpose problem to controllable environment. Limit variables to conceptual dimensions.	Study problem in operational environment with live variables.
Use of Analogies	
Use symbolic idealizations of observations as explanatory model.	Use empirical summary of results as a forecast formula.
Use of Hypothesis	
Link hypotheses to model, if experimentally corroborated attribute causal effect.	Use hypotheses to suggest content of forecast and criterial terms, and to interpret observed relation between terms.

Variability of Observations	
Validity dependent on controlling all relevant experimental conditions other than the one being manipulated.	Fidelity dependent on representing whatever source of variability may operate within the criterial situation.
Unit of Analysis	
Select unit to demonstrate behavioral uniformity.	Select unit for producing or forecasting a particular operational system.
Criteria for Acceptable Inference	
Demonstrate model relationships by statistical hypothesis testing.	Forecast to criterion by statistical estimation techniques.
Extension of Findings to New Situations	
Generalize by demonstrating the extinsiobility of the model dimensions.	Generalize by inference from populations and guessed inter-class relationships.
Utilization of Research	
Results yield abstract predictions which may have implications adaptable to operational systems. [36]	Results yield forecasts which are a direct and immediate basis for action.

The key difference between the scientific method and the system method can be found in the final step of both methods; that is, in the scientific method the research findings lead, hopefully, to a greater and more comprehensive theory,

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[36] John L. Finan, "The System Concept as a Principle of Methodological Decision," Psychological Principles in System Development, (New York: Holt, Rinehart and Winston, 1962), p. 518.

and in the system method the research findings yield a direct and immediate plan of action.

Education can benefit from both methods. However, until recently only the scientific or theory-building methodology has been utilized to any great extent in educational research; today, a growing number of educational researchers are becoming interested in applying the system methodology to educational problems. The following section will review literature pertinent to the development of instructional systems.

The Potential of Instructional Systems

Introduction

The introduction of new instructional strategies which utilize the so-called "new media" has created a number of problems for educational planners. The use of such educational innovations as instructional television, self-instructional programs, language laboratories, and independent study carrels as major components in the instructional process has greatly increased the complexity of education.

The problems which result from the introduction of complex innovations can be grouped into several broad categories. The first category can be labeled "problems of communication." Education, like almost every other area of human activity, has always had communication problems;

but with the increased use of instructional technology, effective communication has become vitally important to efficient classroom operation. The constant communication between the television teacher and the classroom teacher which is necessary for the effective use of instructional television would be an example of the increased need for communication in the classroom.

A second area of concern is administrative. As the educational process increases in complexity, the classroom management and decision-making problems become proportionately greater. As an example, consider the adoption of the language laboratory. The relative advantages and disadvantages of the language laboratory as an instructional strategy must be carefully weighed and a decision made. If the language laboratory concept is adopted, then a number of other closely related factors must be considered. Problems concerning the laboratory equipment design, the selection of professional and technical personnel, repair and maintenance of the electronic equipment, the selection of language teachers trained in the audio-lingual method of language teaching, curriculum development and instructional material selection; scheduling of the laboratory for formal class meetings, for individual student use, and for other uses not related to language instruction (e.g., the teaching and practice of business skills such as dictation); and finally, financial aspects--all of these must be taken into account. When considered with these problems in mind, the adoption of the language laboratory is a vastly more complex proposition than equipping a competent language teacher with an adequate number of textbooks and scheduling the course into a standard classroom.

The third area in which the introduction of educational innovations has created problems for educational planners is in the area of curriculum and instruction. The gradual but steady adoption of instructional and curricular innovations over the past decade has begun to break the traditional pattern of classroom instruction. The transition from traditional patterns is far from complete, but is becoming more so as each technologically-oriented innovation is introduced.

Instructional television was one of the first of the technological devices to force a change in the traditional pattern of classroom instruction. For the first time in the history of education the classroom teacher was asked to share his role of instructional strategist with another teacher. In the case of instructional television it was the television teacher.

Instructional media and materials, such as films, filmstrips, charts and graphs, still pictures, disc recordings and audio tapes, have been used in the classroom for instructional purposes for many years. These materials have always been used as an "aid" to instruction. The decision whether or not to use these supplementary materials has been left to the classroom teacher. The order of presentation and the emphasis given these materials was also left to his judgment.

With the introduction of instructional television, however, this pattern of media and material utilization was broken. If ITV is to be used successfully, the classroom teacher must integrate his classroom activities with the activities of his television counterpart. The integration of instructional activities with a mediated teacher is necessary for the successful utilization of language laboratories, programmed instructional materials and other well organized systems of instruction.

The changed role of the teacher; i.e., from the sole instructional strategist to one who shares in planning the instructional strategy, is not entirely the result of the introduction of instructional technology into the classroom but is also due to the new curricular programs which utilize instructional media as an <u>integral</u> part of the instructional system. The CHEM (Chemical Education Material Study) curricula, for example, has as an integral part of the course twenty-seven instructional films which are designed not to aid or supplement classroom instruction, but actually to do the teaching.

The changing role of the classroom teacher is particularly interesting and important topic. It will be examined further in relation to the main concern of the study; i.e., the design of instructional systems.

As the adoption of instructional innovations increases the overall complexity of the instructional process, a number of educators and behavioral scientists have been advocating that the system approach be used to solve instructional planning problems. The literature pertaining to the research and theory of instructional systems development can be readily divided into the same categories as the instructional planning problems discussed above. The problem areas which have been identified are administration, communication, and curriculum and instruction.

Instructional Administration and the System Approach

Educational administration is a broad term which needs to be limited before using it in a discussion of instructional systems. In a broad sense, administration concerns itself with the management of educational affairs. For this purpose, some of the tools of the systems disciplines are directly transplantable to educational systems. As an example, the support services of educational systems are like burden services anywhere. Such administrative functions as scheduling, attendance keeping, accounting, budget analysis and control, supply services, and other segments of institution management are readily adaptable to computerized systems and other tools of scientific management. Educational management systems are a concern of this study only in so far as they relate to instructional systems.[37] Attention will therefore be limited to the administrative problems of instructional systems.

One of the earliest published references to the use of the system approach as a possible means of solving administrative problems was an editorial by James D. Finn in Teaching Tools, a now defunct instructional materials magazine.[38] Finn did an excellent job of explaining the system concept although he did use the military in his examples. After chiding the school administrators for being overly occupied with the bits and neglecting the whole, Finn suggests that school administrators adopt the system approach currently being used by modern (1956) military and industrial management. He defines an audio-visual program at the school level in system terminology. His definition, however, seems to limit a school's audio-visual program to the role of a logistical support system rather than an integral part of the instructional program, as it is now considered. This point was evident when he stated that:

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[37] For a current summary of the administrative aspects of educational management systems see: John W. Loughary, Man-Machine Systems in Education, (New York: Harper and Row, 1966).

[38] James D. Finn, "AV Development and the Concept of Systems," Teaching Tools, Vol. 3 (Fall, 1956), pp. 163-64.

> ...an audio-visual program--and this is the heart of our argument--is a clear-cut _system_. The _system_ begins with the production of materials--films, pre-recorded tapes or even a classroom bulletin board--and ends with the recovery or replacement of the materials. It is a man-machine system. Involved, within the school situation, are people--teachers, administrators, students, clerical and technical help; materials, machines, other systems (delivery, for example), and outside institutions--dealers, producers, distributors, to name some of the larger units.
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> ...The concept of an audio-visual _system_ would also reduce the ridiculous lack of coordination which results in building classrooms with no light control on the one hand and investing in projectors and materials on the other. If there were no other fact in existence to establish that present day administrative theory and practice is an atomistic, old-fashioned, outmoded business, this fact would do it. If, instead of considering buildings in the category of "buildings" and audio-visual materials and devices in the category of "curriculum materials," administrators were, for five minutes, to consider the audio-visual program as a _system_, obviously lighting, ventilation and even proper bulletin board and chalk board space would be related to the problems of teacher use of these materials. Buildings would be built with the _system_ in mind. 39

Finn concluded with a statement that still applies to most educational media specialists:

> Professional audio-visual directors are also not without fault in this matter. In many cases, perhaps for very good reasons, but true nevertheless, the audio-visual director thinks and operates in an atomistic fashion as opposed to the fact that he should be managing a _system_. His _system_ extends from the producer to teacher and class back to producer again. But he spends his time with booking forms or equipment repair or previewing committees--operating all the time in a piecemeal fashion.

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[39] _Ibid._, p. 164.

> The audio-visual movement is relatively young. It is also geared into the technological world of the future--a world of interlocking, complicated systems of men and machines. It cannot be administered under a theory useful for the production of buggy whips. We need a new audio-visual systems theory; we need it NOW. 40

The potential contribution of the system approach to school administration was re-stated by Finn a year later (1957) when he said, "The new management concepts--systems, operations research, the use of the theory of games, etc.--all have much to offer school administrators."[41]

In the next half-decade other educational researchers and theorists began to see the potential of the system approach. One of the first to follow Finn's lead was a Penn State University professor of psychology who has done extensive research on film and television. Professor C. R. Carpenter, speaking at a symposium on the state of research in instructional television and tutorial machines in November, 1959, suggested a system approach to teaching and learning. He feels that the system approach "may prove to be helpful in integrating the 'new' media, including television, into our schools and institutions of higher

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[40] Ibid.

[41] James D. Finn, "Automation and Education: 1. General Aspects," Audio Visual Communication Review, Vol. V., No. 1, Winter, 1957), p. 357.

education."[42]

Carpenter succinctly outlined the general requirements for employing the new approach when he stated:

> The general requirements are known for employing this higher order "man-machine systems approach" to the solutions of complex operational problems like those of education and including the media sub-systems. They are the following:
>
> 1. Achievement or performance goals are defined. 2. These goals are then translated into sub-systems of general and specific functions. 3. The means of executing these functions are specified, and components of the systems are defined to include human capabilities, machines, materials and their interaction in the system. 4. Distinctions are made between those functions which can best be performed by persons with known competencies and those which can best be performed by instrumentation and materials with known characteristics. 5. Schedules and sequences of events are so planned that all components of the system, sub-systems and functions operate as required and in an orderly manner. The designed system, when tested and retested, may have its components changed or re-ordered to maximize the performance of the system as a whole in accomplishing projected goals or objectives.
>
> A systems design for an educational enterprise would provide: A conceptual framework for planning, orderly consideration of functions and resources, including personnel and technical facilities such as television, the kinds and amount of resources needed, and a phased and ordered sequence of events

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[42] C. R. Carpenter, "Approaches to Promising Areas of Research in the field of Instructional Television," New Teaching Aids, A Symposium on the State of research in instructional television and tutorial machines, held 13 and 14 November, 1959, at the Center for Advanced Study in the Behavioral Sciences, under the auspices of the United States Office of Education and the Institute for Communication Research, of Stanford University, (Washington, D.C.: U.S. Office of Education, 1962), p. 75.

> leading to the accomplishment of specified and operationally defined achievements. A systems approach should provide a way of checking on the relation of performances of all components to factors of economy and should reveal any inadequacies of the several components, including the faults of timing and consequently of the entire system. 43

While Carpenter's statement certainly has wider implications, he does seem to have the administrator in mind. He seems to be suggesting that the system approach has great potential for handling administrative problems, particularly those related to the management of learning and the effective utilization of the newer electronic media.

Unfortunately Dr. Carpenter did not expand his paper beyond a statement of the potential of the system approach to educational planning. He left for others the task of detailing implementation procedures for the new approach. However, it must in all fairness be said that his paper on the requirements and potential of a system approach to educational planning is perhaps the best that has been written.

It is interesting to note the progression of ideas regarding systems in education. Finn's very early paper was largely general and did little more than emphasize the need for such an approach to administration of media and

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[43] _Ibid_.

related problems. Three years later, in 1959, Carpenter went beyond Finn by stating very ably the requirements and potential benefits of a system approach to educational planning. The next logical step would be an analysis of a school as a system and the construction of a model from the analysis. This is exactly what George S. Maccia has done.[44] While working at the Educational Theory Center in the Bureau of Educational Research and Service at the Ohio State University, he translated von Bertalanffy's General System Theory into an educational theory model.[45] Maccia's model, since it encompasses the activities of an entire school, is general and lacks detail. While this model appears to have little value to a practising educator, it does contribute a useful foundation upon which other education system theorists can build more complete theories.

Closely following the publication of Maccia's work was a DAVI task force position paper on the function of media in the public schools.[46] A significant part of this

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[44]George S. Maccia, _An Educational Theory Model: General Systems Theory_, Center for the Construction of Theory in Education, Occasional Paper 62-126, (Columbus: Bureau of Educational Research and Service, 1962), reference is made to entire work of 32 pages.

[45]_Ibid._, p. 8.

[46]National Education Association, "The Function of Media in the Public Schools," ed. Barry Morris, A Position Paper developed by a task force assembled by the National Education Association Division of Audiovisual Instructional Service, _Audiovisual Instruction_, (January, 1963), p. 13.

paper dealt with the problem of personnel deployment and patterns of organization and staffing for effective administration of media-oriented instructional systems. The members of the task force recognized the need for high-level coordination of instructional systems when they stated, "If a school system is truly serious in its effort to apply the full range of educational media to the tasks of increasing its productivity and enhancing the quality and diversity of learning, it must place this function at a level coordinate with business management and curriculum administration."[47] It was recommended that the coordination function be filled by a "media specialist"[48] who would serve as media director at the level of assistant superintendent in a public school system. His department might include such sections as:

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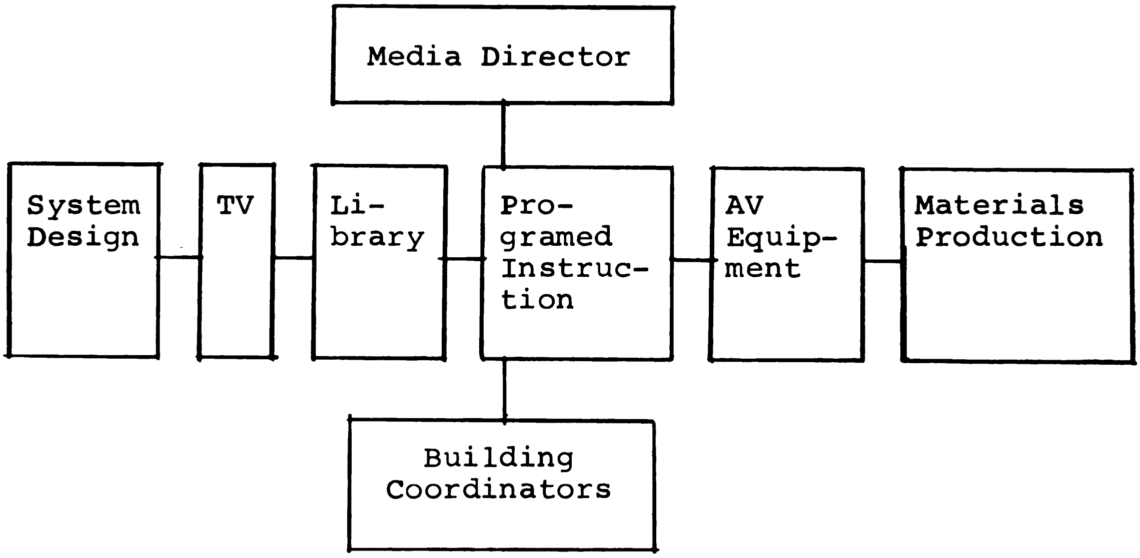
[47] Ibid.

[48] It would be more accurate to describe the person as a media generalist rather than a media specialist since this person would have responsibility for the administration and use of all instructional media.



While the ideas presented in this position paper were important and forward looking, the dissemination of the ideas is not wide spread. The document appears to be an "in house" publication, since it was published in the audio-visual field's practioner-oriented journal, Audiovisual Instruction rather than being published in one of the journals read by educational policy-makers: the boards of education and top-level administrative personnel. Perhaps the position paper was not primarily intended for school administrators. As Finn indicated in his editorial reviewed above, a great deal needs to be done to educate the more traditional, hardware oriented audiovisual director. In any case, the point seems clear that if the system approach to educational planning is to become a reality in education, then new administrative patterns and specially trained professional personnel will be necessary to implement the new approach.

Alternate methods of handling the introduction of systems approach to education have been suggested by a number of theorists representing several disciplines. Those dealing with the administrative aspects of the introduction of each innovation will be considered.

A broad theory of administrative change has been developed by the prominent educational administration theorist Daniel Griffiths.[49] His theory is intended to cover a wide spectrum of change which could include the administrative aspects of instructional system development.

It should be noted that Griffiths proposes his theory using General System Theory concepts. This use of General System Theory gives additional testimony to its versatility and growing popularity in educational circles.

The following selected quotations outline the major points of Griffiths' theory of administrative change.

> Since the tendency of organizations is to maintain a steady state, the major impetus for change comes from outside rather than inside an organization. Since organizations are open systems, they have a self-regulating characteristic which causes them to revert to the original state following a minor

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[49]Daniel E. Griffiths, "Administrative Theory and Change in Organizations," Innovation in Education, ed. Matthew B. Miles, (New York: Bureau of Publications, Teachers College, Columbia University, 1964), p. 430.

change made to meet demands of the supra-system.

Many organizations bring in outsiders as administrators, believing that change for the better will result. This apparently works in many cases, and the proposed theory can accommodate this observation. All organizations exhibit some form of progressive segregation or hierarchical order. The order makes it possible for change to occur from the top down but practically impossible for it to occur from the bottom up.

These ideas and others are now formulated as a series of propositions.

1. The major impetus for change in organizations is from the outside.

2. The degree and duration of change is directly proportional to the intensity of the stimulus from the supra-system.

3. Change in an organization is more probable if the successor to the chief administrator is from outside the organization, than if he is from inside the organization.

4. Living systems respond to continuously increasing stress first by a lag in response, then by an over-compensatory response, and finally by catastrophic collapse of the system.

5. The number of innovations is inversely proportional to the tenure of the chief administrator.

6. The more hierarchical the structure of an organization, the less the possibility of change.

7. When change in an organization does occur, it will tend to occur from the top down, not from the bottom up.

8. The more functional the dynamic interplay of subsystems the less the change in an organization.[50]

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[50]*Ibid.*, pp. 430-35.

The model outlined above could serve as a guide for implementing instructional system development procedures to be recommended in the conclusion of this study.

Instructional administrators, according to Churchman, can apply instructional system design development concepts from two philosophical positions.

The first position is essentially a divergent one of carefully studying and understanding each part of a system before expanding toward the whole. The second takes the opposite, convergent posture of studying the whole system first and then examining its parts. Churchman summarized these two opposing points of view when he stated that:

> Even as far back as the Greek philosophers, men construed two ways of thinking about the whole that makes up a system. One philosophy insists that the thinker begin with the simple parts, understand them thoroughly, perfect them if he can, and then begin building the parts together into an edifice that eventually becomes the entire structure. Modesty and diligence characterize this philosophy: one must work very hard on what one clearly understands and can feasibly change, before he goes off into more complicated and less tried pathways. One only earns the right to talk about wholes when one has been sufficiently trained in the parts. The opposite philosophy holds that we must begin with a concept of the whole; otherwise we shall never know how to identify the parts, much less how to improve them. Daring and creativity are the hallmarks here, as well as hours of contemplation and debate. Again, one must earn a right, but in this case the right to act. Before changes are introduced in the parts, what the overall goals should be must be thought through, as boldly as possible. 51

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[51] C. West Churchman, "On the Design of Educational Systems," Audiovisual Instruction, (May, 1965), p. 362.

The debate over which to consider first--the parts or the whole--will likely continue for some time, since within education there are those who support both positions. On the one hand there are those who see the improvement of education as a series of small steps: improved teacher selection, better building designs, improved testing and evaluation, etc. Each improvement is an independent step toward excellence. On the other hand, there are those who seriously question the whole educational system as it is presently organized. Most military-industrial system analysts, especially those interested in educational systems, seem to favor the analysis of as large a segment of education as is feasible before dividing the system into subsystems for further analysis.[52,53]

The issue may never be resolved. Perhaps both approaches are necessary. However, Churchman suggests an alternate approach which carefully avoids the question. He has labeled the approach "housekeeping." He notes "that housekeeping is intended to straighten out an existing

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[52]Leonard C. Silvern, "Systems Analysis and Synthesis in Training and Education," Automated Education Handbook, ed. Edith H. Goodman, (Detroit: Automated Education Center, 1965), p. 7.

[53]Ellis P. Myer, "Communication Difficulties in Total System Design," Monograph No. 1, The Automation of School Information Systems, ed. Don D. Bushnell, (Washington, D. C.: Department of Audiovisual Instruction, NEA, 1964), p. 133.

system; it leaves the overall goals invariant as it works on the parts that have gotten out of order. It does not raise the horrendous question, what is this system all about? Or, rather, it does not do this unless the task of housekeeping becomes so frustrating, or boring, or costly, that the question more or less asks itself."[54]

An example of housekeeping in a university setting might be a new more efficient system of processing student grades. The whole question of whether or not students should be assigned grades at all is avoided. The housekeeping approach takes present policy as a "given" and works to see whether the policy is being implemented effectively.

While the housekeeping approach to instructional planning will probably meet with little resistance from the present instructional administrators, it is not likely to introduce significant innovations into the existing instructional system. Griffiths' theory of educational change tends to support this contention. Perhaps we are patching up an antiquated DC-3 when we should be designing a supersonic transport.

Designing instructional systems involves more than administrative decisions regarding staffing patterns and organizational structure; more than a reliable theory of

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[54]Churchman, loc. cit.

administrative change, and a decision as to whether it is wiser to begin improving the system by starting with the whole and moving toward the parts or vice-versa. It also involves questions which are concerned with communication within and between systems.

Communication and Instructional System Design

As education increases in complexity, more specialists are needed to successfully meet educational objectives. Not only are more specialists being used, but many new specialties are becoming a part of our educational systems. With this increasing complexity and specialization, there is a concurrent increase in the complexity of necessary communication networks. Several examples will illustrate the point.

As the financial and record-keeping aspects of education become automated, educational administrators must communicate and interact with data processing specialists. As little as a decade ago this was not the case. Now classroom teachers must communicate increasingly with specialists in guidance and counseling, evaluation, curriculum, subject matter, health, special education, instructional materials and many others.

Literature related to ISD contains surprisingly little concerning the educational communication problem.

One possible explanation for this lack is that most of the systems-oriented scholars contributing to the growing body of knowledge on instructional system development began their work in industrial and military systems. Silvern, Churchman, Ackoff and Eckman are typical examples. Industrial and military systems, by in large, have characteristics not common to educational systems. First, industrial and military systems have very specific objectives or outputs; e.g., the manufacture of a particular product, or a weapons system with certain capabilities. Second, their output is usually not human. In cases where the output is human, as in a military training system, the human is product or process-oriented. An Air Force mechanic is trained to repair and maintain an aircraft. What happens to him as a "human" is not the primary concern of the training program. Third, in industrial and military systems the man-machine relationship is very close; for example, pilot-plane. The communication between man and machine is precise and exact. In many cases, the machine dominates the relationship and is capable of functioning properly without the aid of a human. This is especially true in space systems where computer communicates with computer.

In sharp contrast to industrial and military systems, educational systems--particularly the instructional subsystem, is human-oriented, has relatively loose objectives and is human-dominated. Instructional systems therefore have special and difficult communication problems which need to be defined and planned for.

The developers of any instructional system must consider the special communication problems which exist within education.

Although instructional system theory currently does not seem to recognize the importance of communication networks, particularly between humans, in ISD they are important to the successful operation of such a system.

It has been shown that the system approach to instructional planning has considerable potential for dealing with the administrative aspects of instruction and that it needs considerable development in handling instructional communication problems. The next and final section of this review attempts to determine the potential and present state of development of the instructional and curricular aspects of instructional system development.

The Curriculum Subsystem

Earlier in this review it was pointed out that systems are largely conceptual; i.e., they can be defined in whatever manner is most useful to the definer. It follows logically that a conceptual system is a heuristic device. It is useful for the insight it provides into a given area of concern; or, scientifically speaking, the amount of explanation, prediction and control to which it may eventually lead.

One area of concern in an instructional system is the determination of the curriculum or, defining curriculum in a rather narrow sense, determining what is to be taught, to whom, and at what level. It would be useful to treat this concern as a separate subsystem because it has inputs and outputs, definable goals, and operates within specified parameters. The central purpose of the curriculum subsystem is to produce plans, designs, or predispositions with which to build the instruction subsystem. Instruction can be seen as a separate subsystem which has its own boundaries, inputs, and outputs. The output of the curriculum subsystem is seen as one of the inputs into the instruction subsystem.

Before examining the instruction subsystem, a word of caution should be offered against accepting in toto the military-industrial training method of determining what to teach. Since the systems approach to instructional planning has its roots in systems engineering and operations research, and because industrial-military training systems are the systems most closely related to educational systems, curriculum system analysts may be tempted to adopt the industrial-military training method of determining what to teach. The industrial-military training directors whose work appears in educational publications are strongly advocating adoption of the task analysis method of determining what to teach. A single example will illustrate the point. Roger Kaufman, a training director at Douglas Aircraft Company, suggests in a book edited by a dean of a teachers' college that the content of programed materials be determined by "performing a task and training systems analysis to determine exactly what skills and knowledges the trainee (student) must have when he completes the course..."[55] Task analysis may be a part of curriculum determination, but any educator who has attempted to design a curriculum to prepare a child to become a "good citizen" knows it is difficult or even nearly impossible to analyze the "task."

The Instruction Subsystem

The instruction subsystem may be characterized as the environment within which systematic cues and stimuli are presented to a learner. The learner reacts and responds to the cues and stimuli. The curriculum subsystem represents the major source of stimuli for the instruction subsystem. The stimuli and cues may be presented to the learner through print, picture, voice or other means of sensory input.

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[55]Roger A. Kaufman, "The Systems Approach to Programming," Trends in Programmed Instruction, ed. Gabriel D. Ofiesh and Wesley C. Meierhenry, (Washington, D.C.: Department of Audiovisual Instruction, NEA, 1964), p. 33.

If the instruction subsystem may be characterized as the environment within which systematic cues and stimuli are presented to a learner, then, as Hoban clearly points out, "the central problem of education in <u>not</u> learning but the management of learning. Learning and the management of learning are <u>not</u> equivalent terms, any more than are learning and teaching. The so-called teaching-learning problem is subsumed <u>under</u> the management-of-learning problem" (underlining his).[56]

Programed instruction, as an instructional strategy, comes closest to Hoban's concept of management of learning since it involves the careful management of the cues and stimuli presented to a learner. This idea, programed instruction, seems to have some merit for the planning of instructional subsystems and deserves further examination.

One of the advantages of programed instruction which is frequently pointed out in the literature is that the student can progress at his own rate, perhaps finishing a normal 15-week semester's work in nine weeks. This race-track approach to learning disturbs many educators, and rightfully so, since education involves more than the brightest student being able to pick the fastest horse for

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[56]Charles F. Hoban, "Implications of Theory for Research and Implementation in the New Media," A Working Paper for the Conference on Theory for the New Media, March 11-15, 1962, Michigan State University, East Lansing, Michigan, p. 4.

a speedy ride through the curriculum.

The present emphasis on speed of completion is more in line with industrial training philosophy than with educational philosophy. There is an essential difference between the two philosophies: industry is not interested in the employee learning more than he needs to know for execution of specific tasks. Silvern's widely used manual on Methods of Instruction, written for use by Hughes Aircraft Company, points out this difference. In a discussion on the selection of content for training programs, Silvern states:

> Skills and knowledge which are necessary to be learned are called INDIRECTLY RELATED. With these, the trainee understands and is better informed about the "why" of his work and has certain secondary skills. However, these are not essential and, in many instances, may be omitted from technical training programs...Skills and knowledge which are useful and generally beneficial but not necessary or essential are called GENERALLY RELATED. Usually in technical training programs, generally related content is undesirable due to the time limitation of a program (underlining and capitalization his).[57]

Educational systems, through their instructional subsystem, are interested in having learners, especially the more talented ones, explore all the experiential possibilities within a given area of content. The essentials are just the beginning of education.

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[57]Leonard C. Silvern, Textbook in Methods of Instruction, (2nd edition, Los Angeles: Hughes Aircraft Company, 1962), pp. 67-68.

If the race horse concept is rejected, and programing is viewed as a means of determining when the learner is ready for cues and stimuli which would lead to in-depth experiences in a particular content area, then a learner's progress through the initial unit of the program would supply the needed cues for the teacher to begin branching the learner into other in-depth programed units. With this system, each student would terminate the unit of instruction at the same point in time but could possibly have had experiences vastly different from the other students'.[58]

The techniques of programed instruction seem to have potential application to the management of learning problems which are encountered in the design of an instruction subsystem, but the potential is as yet unrealized--a great deal remains to be done.

Summary

There is general agreement concerning the potential of the system approach to instructional planning, but there is little agreement by the authorities on systems with respect to the most effective and efficient way of implementing this new approach in educational planning. A dearth

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[58]Robert Heinich, "A System of Instructional Management." (University of Southern California: Department of Instructional Technology, not dated) (Mimeographed).

of research data was found in support of any particular position.

Significant gaps were found to exist in the theoretical constructs of existing systems theory. One of the haziest areas is that of definitions, beginning with the most important, the definition of "system", and moving down to the less important terminology. Many of the definitions used in systems theory are very difficult to define operationally, especially in an educational context.

One of the most significant findings of this search of the literature is the extent to which industrial training systems theory is inappropriate to education because of basic philosophical differences between training and education. Before this research was undertaken, it was believed that large portions of training systems theory could be adopted, without adaptation, into educational systems.

The next chapter will attempt to describe the specialist model for instructional system development as proposed by Michigan State University's Instructional System Development Project. The utility of models in theory development will be briefly examined in order to better understand the specialist model.

CHAPTER III

THE SPECIALIST MODEL

One of the major techniques used in the systems approach to problem solving is the use of models. With the exception of analysis, the development of a model of a system under study is perhaps the most important step in the systems methodology.

Models are important to the successful use of the systems approach, but they certainly are not unique to the study of systems. Toy-makers produce "models" by the millions. Teachers discuss the characteristics of the "model" student; while scientists are "modeling" a particular type of atomic reaction.

The above uses of the term "model" indicate respectively a copy, an ideal, and a process. The conceptual diversity demonstrated is perhaps sufficient justification for a brief examination of the concept "model", particularly since it is growing rapidly as a cognitive style in almost all areas of scientific endeavor. Therefore, before describing the Specialist Model as developed by Michigan State University's Instructional System Development Project, various aspects of models and model building will be explored.

Models

The term model has a variety of definitions each of which depends upon the function of the model being defined, but a broad definition which seems to encompass all aspects of the term is one offered by Page in his discussion of the tools and techniques of operations research. He states, "it (the term model) may be defined as any concept that gives insight or facilitates reasoning about the problem at hand."[1]

Model building has gained wide acceptance as a research tool. Scientists from diverse disciplines use model building as a means of gaining insight into their problems. The widespread use of model building as a cognitive style is commented on somewhat facetiously by Kaplan in the introduction to his chapter on models. He summarizes the introduction by stating that, "in short, models--to play on another meaning of the word--are much in fashion, though to say so is by no means to prejudice their scientific significance and worth. The words 'model' and 'mode' have, indeed, the same root; today, model building is science

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[1]Thornton L. Page, "A Survey of Operations Research Tools and Techniques," Operations Research and Systems Engineering, ed. Charles D. Flagle, William H. Huggins, and Robert H. Roy, (Baltimore: The Johns Hopkins Press, 1960), p. 125.

'a la mode'."[2]

The Function of Models. Models have gained wide acceptance in the scientific community because they are said to provide "meaningful contexts within which specific findings can be located as significant details."[3] The fact that they do so is both true and important, but it is not distinctive of models. Theory also serves to provide a context for the interpretation of data.

A function which is more distinctive of models is the organization of data. A theorist can organize his data more quickly and easily if he uses a model.

Models also serve to improve communications between scientists. Ideas which are recorded in some form of a model are likely to be communicated more quickly and more accurately than if they remain in the more abstract expository format.

Finally, models reduce complex problems to a manageable size, thus making it possible to examine individual segments without losing sight of the whole or losing sight of the relationship between segments. For educational planners, the ability to reduce complex problems to manageable

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[2]Abraham Kaplan, The Conduct of Inquiry, (San Francisco: Chandler Publishing Company, 1964), p. 258.

[3]Ibid., p. 268.

size is perhaps the most useful function of models.

Kinds of Models. Each discipline has its own special terminology to describe the types of models used in its particular area. Thus it is difficult to classify all of the kinds of models under one taxonomy. However, it has been suggested by Ackoff that scientific models have at least three connotations: (1) as a noun, representation in the sense of an architect's small-scale model of a building or a physicist's large-scale model of an atom; (2) as an adjective, a degree of perfection or idealization, like a model home or a model student; and (3) as a verb, to demonstrate or show what a thing is like.[4]

(1) As a noun, models are described by using such terms as replica,[5] physical,[6] copy,[7] scale,[8] etc. This noun connotation implies some isomorphic relationship with

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[4]Russell L. Ackoff, Scientific Method: Optimizing Applied Research Decisions, (New York: John Wiley and Sons, Inc., 1962), pp. 108-109.

[5]Carter V. Good, Essentials of Educational Research, (New York: Appleton-Century-Crofts, 1966), p. 7.

[6]Kaplan, p. 273.

[7]Leonard C. Silvern, "Systems Analysis and Synthesis in Training and Education," Automated Education Handbook, (Detroit: Automated Education Center, 1965), p. I C II.

[8]Marc Belth, Education as a Discipline, (Boston: Allyn and Bacon, Inc., 1965), p. 87.

the real-life object. If a model train is an exact replica of the original, then it is said to be an isomorphic model. The degree of isomorphism can vary, e.g., a shoddy effigy of a losing football coach has a relatively low degree of isomorphism, while a model train--exact in every detail including steam power--could be said to have a high degree of isomorphism. Silvern describes the degree of isomorphism in terms more characteristic of systems engineering. He explains that "if it is a very good copy, it is said to be a high-fidelity model; if a poor copy, a low-fidelity model. This means that the degree of faithfulness of the copy is a characteristic of the model...Normally, low-fidelity models are less expensive than high-fidelity ones and, for this reason, we see more of them."[9]

There are many advantages to be gained in using an isomorphic model. Some of these are that: (1) scaling to a more useable size increases accessibility and manipulability; (2) isomorphic models often are well suited to pedagogy--as exemplified by the planetarium, which can model the solar system; (3) they permit experimentation which is often cheaper, faster, and safer than the full scale original, e.g., using a model of an airplane in a wind tunnel to test the aerodynamic characteristics of a newly designed

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[9]Silvern, "Systems Analysis and Synthesis..."

plane; and, (4) they permit the testing of hypotheses as does computer simulation.

Another characteristic of models which applies to all three connotations (i.e., model as a noun, adjective and verb) is the concrete to abstract continuum. On the concrete end of the continuum are such iconic models as geophysical globes which strive to replicate the physical features of the earth. On the opposite end are symbolic models which represent not so much the features of an event or object as the structure of the relationships within an event. Symbolic models are often represented in the form of equations and are then called mathematical models. Approximately in the middle of the concrete-abstract continuum is the analogue model which represents the properties of real things in an analogous form, thus requiring an appropriate legend to interpret the information; e.g., the use of various shades of blue to represent water depths on a map. Such a map is an example of a fairly concrete analogue model: concrete because the map colors approximate the real thing. Role-playing and operational gaming are examples of more abstract analogue models.

(2) Models used in the second sense, as adjectives, are used to represent ideals or standards. Models of this type can be as concrete as a "model" home or as abstract as a set of mathematical equations representing a "model"

social behavior.

An ideal system can sometimes be used to improve upon an imperfect system. Each system can be represented by a model, but the models used will be of different types. For example, in the improvement of college student registration procedures, computerized student registration could be the ideal procedure and so modeled; stand-in-line registration procedures could be the existing system and the process modeled in a flowchart. The models representing the two systems, the ideal one and existing one, could then be studied and change or modification decisions made.

(3) The third connotation of model, that of a _verb_, describes those models which represent a process. The flowchart is a common example of this type of model. A pictorial flowchart of an automobile assembly line would represent a relatively concrete form of this type of model, while a computer simulation program of that assembly line represents an abstract form. The PERT technique (described in Chapter II) is a relatively new form of the process model. The advantages of using a process model are the same as those listed for the other two connotations; however, model building as a general cognitive technique also has some disadvantages which should be kept in mind.

Limitations of Models. Like any other technique created by man, models and model building are subject to shortcomings.

While these shortcomings do not negate the use of models, model builders should be aware of them.

Abraham Kaplan offers the most comprehensive discussion available of the limitations of model building in his book The Conduct of Inquiry. He points out the following shortcomings:

1. Undue emphasis on the manipulation of symbols often to the detriment of the content which the symbol represents.

2. Premature model building can distract the builder from further study of the subject matter.

3. Model building can trap the builder into oversimplification of the problem.

4. Overemphasis on rigor can waste valuable time.

5. Treating a model as though it were a map and forgetting that it does not correspond exactly to the subject matter which it represents.[10]

Theory vs Models. A final source of confusion for model builders is one which is discussed at length by May Brodbeck.[11] She maintains that the term "theory" and the term

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[10]Kaplan, pp. 275-288.

[11]May Brodbeck, "Models, Meaning, and Theories," Symposium on Sociological Theory, ed. Llewellyn Gross, (New York: Harper & Row, 1959), pp. 381-383.

"model" should not be interchanged. Since the main purpose of models is simplification and organization of the subject matter under study, the interchange of terms can lead to confusion. The confusion becomes particularly evident when highly speculative or untestable theories are referred to as models.

Most of the faults of models and model building seem to involve an overemphasis on the model itself, to the detriment of the subject matter which it represents. It would seem that if the model builder were to keep in mind that the model is a cognitive tool and not an end in itself, then models can be very valuable conceptual devices.

It can be concluded from this discussion of models that in spite of the dangers inherent in model building their use in instructional system development is almost a necessity since models serve three important functions in ISD, i.e. the organization of data, the improvement of communications and the reduction of complex problems to a manageable size.

The Specialist Model for ISD, which will be discussed in the next section, serves to illustrate a combined idealization and flowchart model. It also shows the complexities involved in the development of an instructional system and gives background information preparatory to the analysis of the field trials which were the first attempts to implement this model.

The Specialist Model

With the points discussed in the preceding section concerning the kinds, functions and limitations of models, we shall discuss a model designed for a specific educational purpose. The model is the Specialist Model for Instructional System Development.

The Specialist Model is being described in this section and will be analyzed in detail in the next chapter because it is one of the first attempts to apply the systems approach to educational planning; specifically, planning for the development of courses in higher education. The need for this type of planning has been discussed in Chapter I, but to summarize briefly, university faculties are faced with teaching a body of knowledge which is rapidly increasing both in quantity and in complexity. Although more faculty planning time is needed to develop new courses and change existing courses to keep pace with changing needs, less time is available for the purpose. This is because as universities become more diversified, faculty members are being asked to spend more of their time in non-teaching functions such as basic research and government service programs.

In order to keep the quality of the instruction high it has been suggested that specialists be employed to help the course instructors develop their courses and improve their teaching efficiency.

It has been further suggested that the systems approach be used as a planning technique to coordinate all aspects of the course development problem. While the systems approach has been used with great success in industrial and military management, it has not been used very extensively in education. Where the systems approach has been used, its methodology was not systematically applied; nor were the results carefully examined.

One of the first studies designed to research the broad area of instruction in higher education was Michigan State University's instructional system study. The study, funded by the United States Office of Education, is entitled "A Procedural and Cost Analysis Study of Media in Instructional System Development."

Although the study focused on an investigation of the development and use of the newer media in instructional systems, it had three purposes which were considerably broader than the use of media in instruction. These purposes were: (1) the descriptive analysis and evaluation of instructional system development activities at MSU during the period 1963-1965; (2) the measurement of costs associated with instructional systems development; and (3) the development of hypothetical models of instructional system development.

The first goal of the study, the analysis and evaluation of instructional system development activities at

MSU, was successfully completed by Miller.[12] He concluded that of the two departments which had well organized instructional programs, "neither department studied fit the definition of an instructional system except in a very general sense" (final page of abstract). The second phase, the cost analysis, failed to produce any significant results, largely because existing accounting procedures did not record the data needed to conduct such a study. The third phase, the development of hypothetical models of instructional system development, produced the Specialist Model, so named because a series of educational specialists are used in the process of instructional system development.

Using the system analysis methodology, this dissertation examines the Specialist Model and its first two field tests. The purpose is to complete a critical analysis of the broad concept of instructional systems in higher education without focusing on a particular area, such as media utilization. The results will give direction to the further development of the systems approach to educational planning, if further development seems feasible.

The Specialist Model is described below to clarify its purposes and procedures before it is analyzed in Chapter IV.

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[12] Elwood Eugene Miller, "Instructional Systems Development, Michigan State University: 1960-1963" (unpublished Ed.D. dissertation, College of Education, Michigan State University, 1965), entire work.

The Specialist Model developed by Barson and Gordon[13] is a combination of two types of models discussed above. First, it is an idealization in that it does not represent any existing set of instructional system development procedures, but proposes "ideal" instructional system development procedures. Second, it is presented in a modified flowchart format to show the process which is involved in the development of an instructional system.

The broad setting of the Specialist Model can be best shown perhaps through the "black box" approach. The output of the black box is an instructional system specifically designed for a particular university level course. The IS developmental procedures can be applied to any course in any department of a college or university provided the necessary resources are available. The purpose of the IS developmental system, as represented by the Specialist Model, is to produce an instructional system.[14] (See Figure 1.)

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[13] John Barson, _et al._, _A Systems Approach to Curricular and Instructional Planning_, A symposium conducted in Chicago at the annual meeting of the American Educational Research Association, February 10, 1965.

[14] "An instructional system is a complex consisting of several or all of the following components: learner(s), instructor(s), material(s), machine(s), technician(s), given certain inputs and designed to carry out a prescribed set of operations. This set of operations is devised and ordered according to the most recent and pertinent evidence from research and expert opinion so that the probability of attaining the output (specified behavioral changes in the components) is maximal." Above, p. 12.

The inputs to the developmental system are not well defined by the Model, but generally they consist of (a) goals--these cover the entire spectrum of goals from societal goals to university goals to student and instructor goals; (b) students--the learners subjected to the instructional system; (c) equipment; (d) research findings; (e) financial resources needed to operate the system; (f) the information related to the content of the course and the information related to instructional system development and other factors which are relevant. (See Figure 1.)

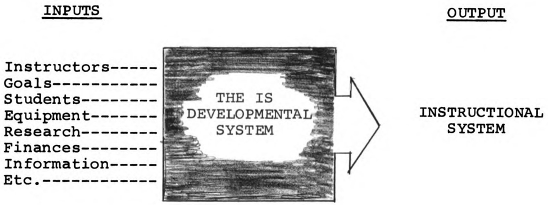

Fig. 1.--THE "BLACK BOX"

The interior of the black box, i.e., the IS developmental system, can be shown to be a process which takes place over time and thus can be indicated graphically on a flowchart. The time dimension of the process is variable and measurement of time at any point in the process development would be an ordinal level of measurement, i.e., the sequence of events can be labeled as to the order in which they take place, but unit values cannot be attached to indicate the amount of time elapsed during each event. One of the alternates which can be used to show ISD process is to make the flowchart in terms of functions performed at each stage of the process; in this case the functions performed by educational specialists in the development of an instructional system.

The Barson-Gordon Specialist Model for IS development calls for specialists to perform various functions.[15] The first function is to analyze the specific problem. This involves the interaction between a representative of the academic department, usually the course instructor,[16]

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[15]John Barson, John M. Gordon, Jr., and W. Russell Hornbaker, "Standard Operating Procedures for a Learning Resources Center: A System for Producing Systems," Audio-visual Instruction, May, 1965, p. 378.

[16]The term "instructor" is used here to refer to the person who teaches college-level courses regardless of his academic rank.

and a coordinator. The coordinator is a specialist in problem analysis and the collection of input data. The coordinator, with the help of the instructor, must determine through an analysis of the instructional problem if the existing instructional procedure needs a complete redesign or whether it would be adequate to apply the housekeeping principle and redesign only a segment which seems to be causing the problem. This decision is made with the aid of general input data, such as the financial restrictions placed on the course, student data, historical information concerning the course if it has been taught in the past, and the general philosophy of instruction held by the academic department. The collection and analysis of the input data helps determine the parameters of the new instructional system; e.g., financial limitations may restrict the initial phase of the course revision to the first semester of a two-semester course.

After the inputs have been collected and the specific instructional problems identified, the instructor consults the evaluation specialist. (See Figure 2.) The evaluation specialist builds up on the work already completed by the coordinator and adds to it by helping the instructor determine the course objectives and develop tests which will measure the entering and terminal behaviors of the students.

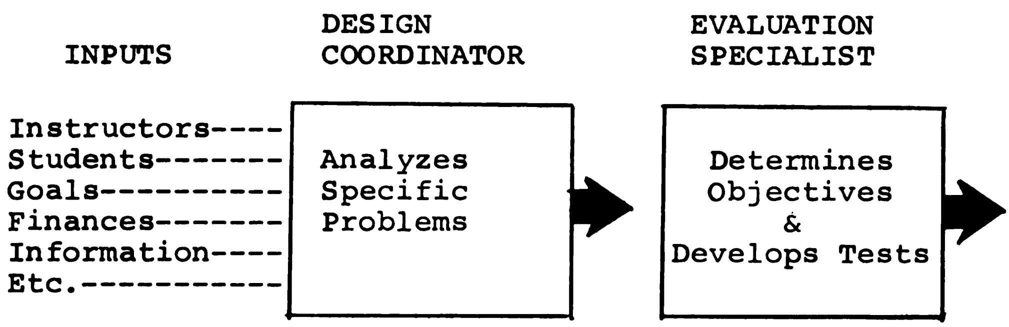

Fig. 2

Upon completing the specification of the course objectives and the development of the assessment instruments, the instructor consults the instructional specialist. This specialist is an instructional strategist who uses the course objectives to develop an instructional flowchart, which shows the order of presentation of the subject matter content. The order is determined primarily from the logic of the subject matter and the desired behavioral outcomes on the part of the learners.

The instructional flowchart breaks the content into logical units for instructional purposes. The instructor and the instructional strategist must determine the communication patterns to be used in teaching the units. The communication patterns, such as teacher-student, material-student, student-student, are chosen to maximize the possibilities of producing the desired behaviors.

The instructor, using his expertise in the subject matter, selects the most appropriate teaching examples which will illustrate the concepts being taught. The teaching examples can be presented to the student in a variety of forms. The instructor engages the services of still another specialist to assist him in the task of selecting the most appropriate level of representation.[17]

The educational media specialist is the person who helps the instructor make the selection as to which form or level of representation to use in presenting the teaching example to the student. (See Figure 3.) Form, or level of representation, is a term Bruner uses in explaining the features of a theory of instruction.[18,19] One of the features of his theory of instruction is concerned with the structure and form of knowledge. Knowledge, according to Bruner, can be represented in three forms: enactive, ikonic, and symbolic. Thus the selected teaching examples can be presented

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[17]"Representation" is used here to refer to (a) the strategies used by a learner to conserve his past and present experiences in the form of a model, and (b) the rules which govern the storage and retrieval of information from this model.

[18]Jerome S. Bruner, Toward a Theory of Instruction, (Cambridge, Mass.: The Belknap Press of Harvard University Press, 1966), pp. 10-11.

[19]Jerome S. Bruner, "On Cognitive Growth: I" and "II", Studies in Cognitive Growth, Jerome S. Bruner et al., (New York: John Wiley & Sons, Inc., 1966), pp. 1-67.

to the learner in three forms: enactive,[20] ikonic,[21] and symbolic.[22]

With the form selected, the media specialist chooses a transmitter, or media-instrumentation system to carry the teaching examples. The transmission system consists of all the materials and devices available for carrying the selected messages. Ideally, the educational media specialist[23] would base his recommendations on established

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[20]Enactive representation is acquired by learning patterns of responses and developing habits. Enactive representation of knowledge can only be taught through action or practice; e.g., as learning to ride a bicycle or learning touch typing. Words, diagrams and pictures are of relatively little value in this type of learning.

[21]Ikonic representation of knowledge depends upon visual or other sensory organization and upon the use of summarizing images. For example, the "learning" of a city by developing a mental map of its physical organization; i.e., the location of landmarks, streets, and freeways.

[22]The symbolic representation of knowledge is representation in words or language. The use of symbols and symbolic systems characterizes this mode of representation. Learning through the use of a language distinguishes symbolic representation from enactive and ikonic representation.

[23]It should be noted that the foregoing description of a specialist-based model for instructional system development prescribes a considerably more restricted decision area for the educational media specialist than is typically observed. A broad, generally accepted definition of an educational media specialist: An educational media specialist is a professional educator with specialized competencies in the application of instructional technology to the teaching-learning process. Areas of concern, with respect to instructional technology, include administration, teaching, research and development, production, and curricula planning. It should be noted that in reference to this model the above definition could better be applied to the educational media <u>generalist</u>.

principles of media effectiveness under the conditions specified, but practically these principles have not been established for most media and materials. In the absence of guiding principles, the instructor and media specialist must rely on their past experience.

An instructional materials specialist conducts a search for ready-made materials which are compatible with the transmitter selected and are in the form needed to demonstrate the teaching example. (See Figure 3.)

If none are found, media production specialists such as film-producers or graphic artists produce the selected teaching examples in the form desired.

The components of the newly designed systems are brought together and, with the help of a technical supervisor, the instructor conducts a trial run using a sample drawn from the intended student population. With feedback available from the trial run, the instructional system can be evaluated and modifications made. The redesigned instructional system is then ready for general use in the academic department for which it was intended.

The Design Setting. In addition to using unique course design procedure, the foregoing description of a hypothetical model for instructional system development requires a unique physical setting which will facilitate maximum efficiency of interaction between the persons working on

Note: 1. The instructor is included at all stages of development.
2. The instructor may begin at any point.
3. In actual practice areas overlap.

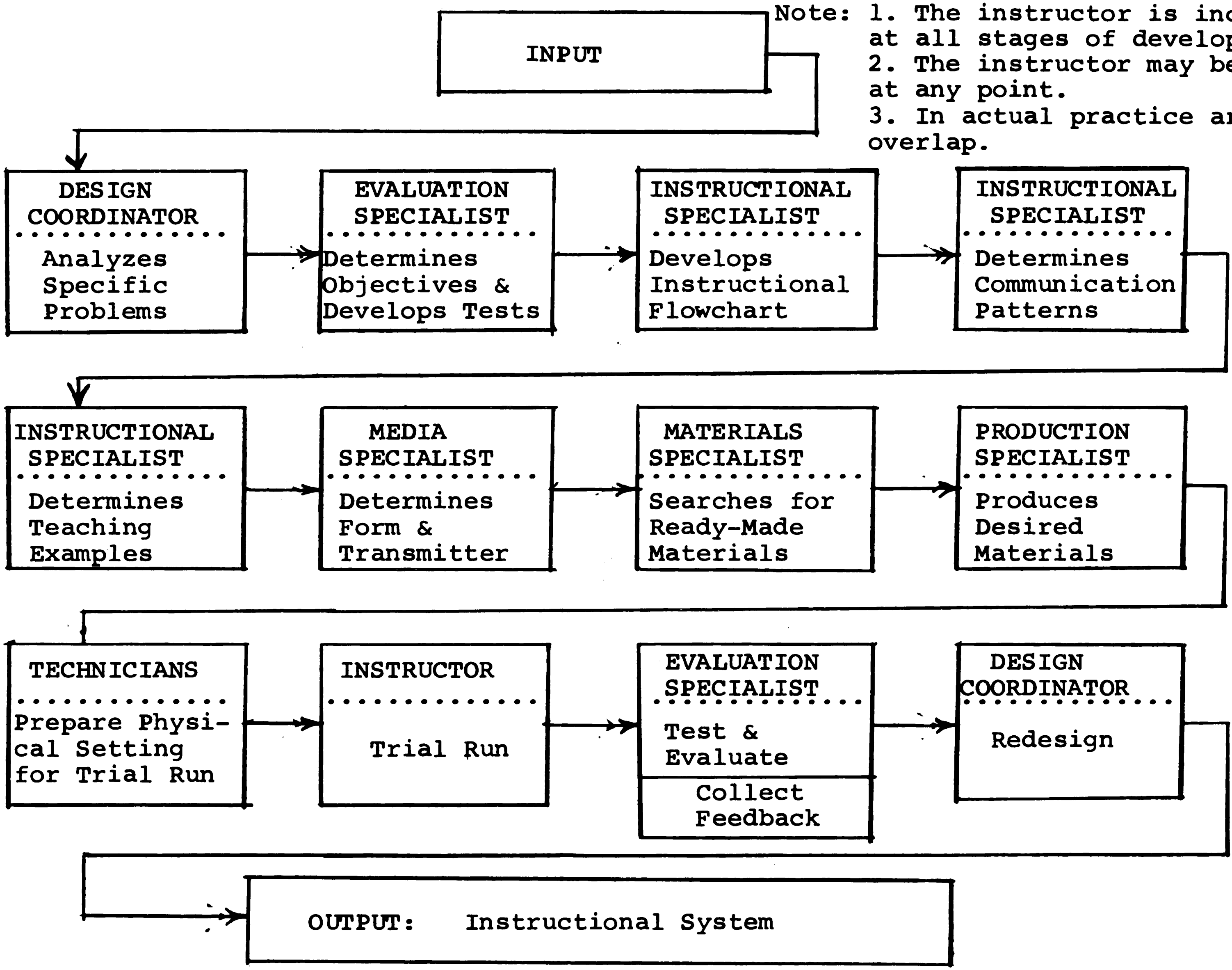

Fig. 3.--THE SPECIALIST MODEL FOR INSTRUCTIONAL SYSTEM DEVELOPMENT

the design of instructional systems.

The design of IS could be facilitated through the conception of a Learning Resources Center. A Learning Resources Center is a specialized university facility dedicated to the analysis of instruction and the development of instructional strategies, and has provisions for the housing and the production of supporting materials and devices. A Learning Resources Center would provide offices and meeting rooms for the personnel required in the design of IS. Instructional material production facilities would also be a part of such a Center. Facilities for conducting research on the effectiveness of the instructional system would also be provided. The specialists involved in the operation of a Learning Resources Center would be grouped as shown in Figure 4.

The hypothetical Specialist Model, described above, has been tested to a limited extent. Chapter IV will analyze these tests in depth.

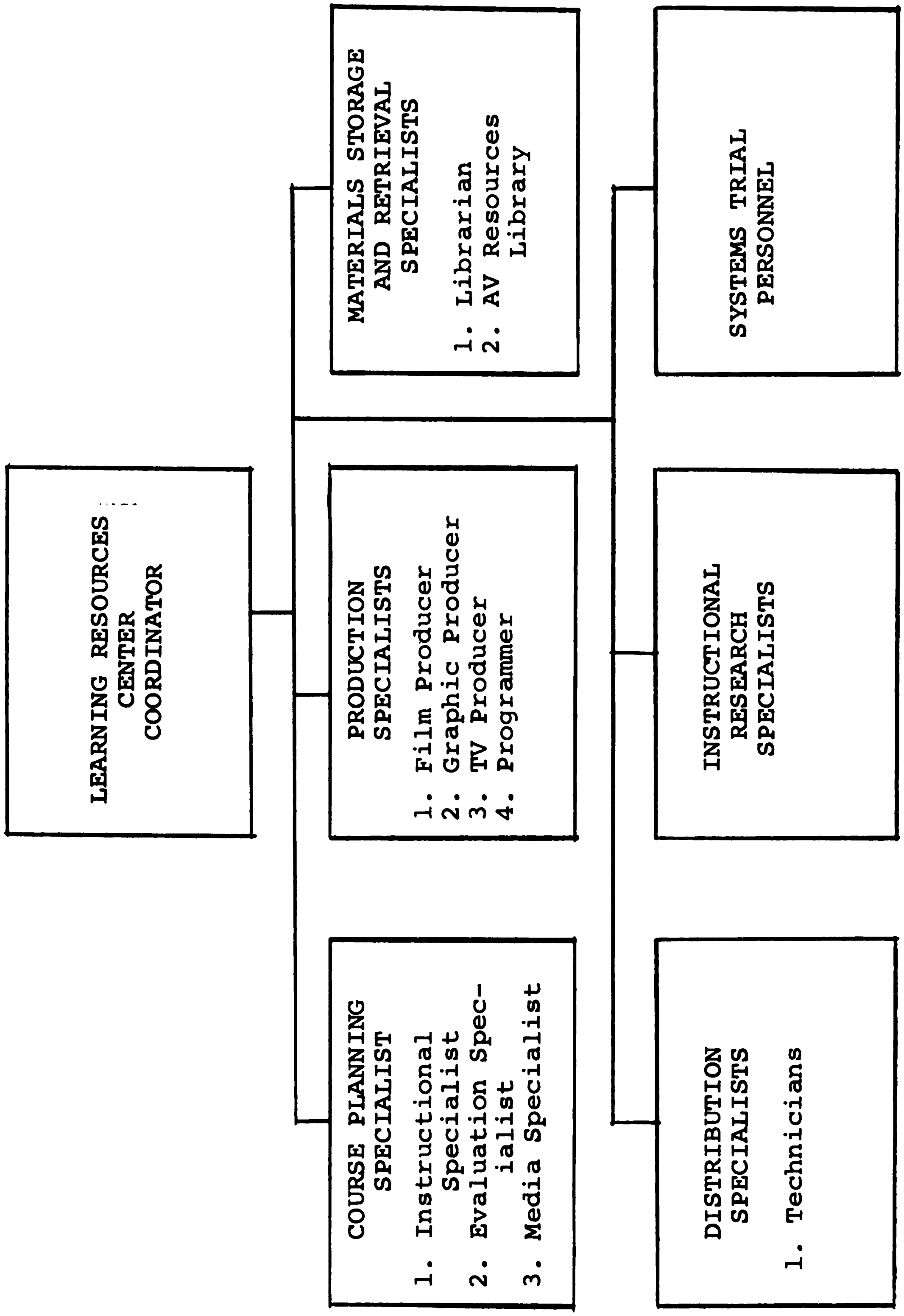
LEARNING RESOURCES CENTER COORDINATOR
COURSE PLANNING SPECIALIST
1. Instructional Specialist
2. Evaluation Spec- ialist
3. Media Specialist
PRODUCTION SPECIALISTS
1. Film Producer
2. Graphic Producer
3. TV Producer
4. Programmer
MATERIALS STORAGE AND RETRIEVAL SPECIALISTS
1. Librarian
2. AV Resources Library
DISTRIBUTION SPECIALISTS
1. Technicians
INSTRUCTIONAL RESEARCH SPECIALISTS
SYSTEMS TRIAL PERSONNEL

Fig. 4.

CHAPTER IV

AN ANALYSIS OF THE SPECIALIST MODEL FOR INSTRUCTIONAL SYSTEM DEVELOPMENT

The Specialist Model for Instructional System Development (ISD) which was described in Chapter III was tested to a limited extent by Michigan State University's Instructional System Development Project. As the final phase of the project, two field trials were undertaken--one in theatre arts and the other in electrical engineering. Earlier studies had been completed in which instructional units already operational were analyzed to see if they behaved according to systems principles. However, the M.S.U. field trials were one of the first known attempts in which a team of specialists set out to design an instructional system using the systems approach.

The purpose of the field trials was to observe the efficiency of the model's development procedures and to reshape these procedures based on the findings. No attempt was made to systematically evaluate the improvement in student learning, since the ISD procedures used were considered to be too tentative to evaluate the approach on the basis of a developmental trial.

The implementation procedures of the Specialist

Model for ISD calls for a team of specialists to work with the course instructor in the development of an IS. The team consists of a system design coordinator, an evaluation specialist, an instructional strategist, a media specialist, production specialists, and technicians. The specialists who participated in the two M.S.U. field trials were drawn from the existing staff of the University College Evaluation Services Bureau, the Instructional Media Center and the ISD Project.

Before the effectiveness of the ISD procedures used in the field trials can be analyzed, some standard system development procedures must be used as a basis of comparison. The following section outlines a basic procedure for system development.

Basic Guidelines for System Design

With extensive study of systems literature, a basic pattern of system design becomes evident. The terminology varies slightly from one system discipline to another; i.e., an operations researcher uses different terms than a systems engineer, but the basic approach to system design problems is fairly standard across the systems disciplines. This standardized procedure seems to hold whether one is designing a military weapons system, an industrial manufacturing plant, a military supply system or a business management decision-making structure.

The following outline lists seven major sequential steps which are basic to the design of all types of systems.[1]

Step 1: Determination of Functional Objectives

The basic purpose of this step is to pursue the question, "What is the system supposed to do and why?" This should result in a list of needs, uses, and purposes of the system being designed. The list should be as all-inclusive as possible within practical limits.

Step 2: Definition of the System; Its Inputs and Outputs

While this step may occur concurrently with Step 1, it has a distinctly different purpose. The purpose of this step is to (1) identify the parameters, or boundaries, of the system; and, (2) define the relevant inputs and outputs of the system being studied.

The identification of the boundaries of a particular system is important because it separates the system from its environment and forces consideration of possible interaction by the system under study with adjacent systems.

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[1]The major source used in the development of the outline is a working paper by R. C. Hopkins: A Systematic Approach to System Development, System Development Corporation, FN-4176, (Santa Monica, California: August, 1960), pp. 18-23.

Determination of the inputs is important because inputs are the "raw materials" needed to produce the outputs. The principal outputs are the "products" of the system.

The "black box" technique is used to aid in the determination of boundaries, inputs, and outputs. This technique treats the content or internal processing of the system as an unknown and only examines the inputs and outputs that enter and leave the system.

Step 3: Analysis of Requirements

Each functional objective is "expanded" by asking what specifically must be done by the system or what means must be provided for in the design of the new system to accomplish that particular objective. Because the system must operate within its environment and interact with adjacent systems, certain additional requirements are added to the list of functional objectives. Consideration is also given in this step to how each specific requirement can be reached.

Step 4: Division into Subsystems

The specific requirements are grouped into subsystems to facilitate further analysis of internal processing and, later, synthesis into a new system. The subsystems are grouped in such a manner as to minimize interconnections between the subsystems in order to reduce the possibility of error during information transfer between subsystems.

The division into subsystems will also facilitate the determination of techniques and processes which will be designed into the system in order to generate the required output.

Step 5: Synthesis

A preliminary conceptual design of the system is completed in this step. Various flows, processes and techniques are specified, in quantitative terms if possible, and then combined into a complete logical design for the system.

Step 6: Modeling and Simulating

The chief purpose of this step is to build a model and test it. The purpose of the model is to improve the overall design of the system rather than to test detailed component design. Simulation of the system can be accomplished through a variety of means. However, simulation via a computer is rapidly becoming the dominant method.

Step 7: Field Testing and Redesign

Field testing and redesign are often referred to as the "debugging" processes. The output of the system is monitored to see if the functional objectives defined in Step 1 are being achieved within the permitted tolerances. If the objectives are not being met, then components, subsystems, or possibly the entire system must be adjusted or redesigned.

Each of the seven steps listed above will be amplified in greater detail when these steps are compared and contrasted to the Specialists Model's ISD procedures used in the field trials. Each step will be analyzed in sequential order and compared to a similar step in the field trials. Strengths, weaknesses and omissions in the ISD procedures will be noted.

Data on the field trials has been collected from five sources. These sources are: (1) Written documents and papers produced by the project staff. All of the files and records of the project were made available for evaluation and analysis. (2) Comprehensive audio tape recordings of the interaction which took place between the specialists and the course instructors. (See Appendix A for a listing of these tapes.) (3) Extensive informal interviews with the ISD project staff. (4) Reports written by the course instructors. (5) Three mimeographed symposium papers prepared by the ISD project staff.[2,3,4]

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[2]John Barson, et al., A Systems Approach to Curricular and Instructional Planning, A Symposium conducted in Chicago at the annual meeting of the American Educational Research Association, February 10, 1965.

[3]John Barson, et al., The Use of a Specialist's Model in Analyzing Instructional Problems, A symposium discussion on the functions of the media specialist presented at the Convention of the Department of Audiovisual Instruction of the N.E.A., Milwaukee, Wisconsin, April 29, 1965.

[4]John Barson, et al., The Use of Specialist's Model

The Background of the Field Trials

During the year preceding the field trials, the ISD project staff developed the Specialists Model for ISD. Procedures for implementation of the model soon followed.[5] With the Model and tentative procedures ready, various departments throughout the University were contacted and asked to participate in the field trials. Of those which responded favorably, two diverse departments were chosen to participate. One introductory level course from the Department of Theatre Arts and one from the Department of Electrical Engineering were chosen to be developed using ISD procedures.

The original design of the field trials was to have two instructors from each course work with two separate teams of specialists. Each instructor was to work with a team in relative isolation from the other instructor and team. Each group was to be given the same inputs and the same course objectives. The idea was to see how similar or dissimilar an instructional system the two groups would develop, even though they were working isolated from each

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in Analyzing Instructional Problems, A symposium discussion on Instructional Systems Development presented at the Convention of the National Society for Programed Instruction, Philadelphia, Pennsylvania, May 7, 1965.

[5]For a description of the Model's procedures, see pages 94-108, Chapter III, above.

other. However, as the development time ran out and production funds ran low, the two groups gradually merged their efforts and developed a single instructional system for each course.

The teams of specialists were drawn from various sources throughout the University. The systems design coordinator served both teams and was a member of the ISD Project staff. Two evaluation specialists, one for each team, came from the University College Evaluation Services Bureau. Two instructional specialists with the skills required by the Model could not be found because none existed. As a substitute, two experienced educational media specialists served both as instructional specialists and media specialists. In addition to the educational media specialists, the Instructional Media Center contributed media production specialists, an instructional materials specialist, and various technicians. The basic ISD team consisted of:

- Course Instructor (subject matter expert)
- System Design Coordinator
- Evaluation Specialist
- Instructional Specialist
- Educational Media Specialist

with a support team of:

- Instructional Materials Specialist
- Media Production Specialists in:
    - Film
    - Still Photography
    - Graphics
    - Instructional Television
    - Programed Instruction
- Technicians

Even though all the specialists involved in the field trials were experienced, they should have been given extensive special training. They were being asked to perform in a totally new structure under entirely new procedures. Without training and orientation, they could be expected to function as they had in the past; using, however, different terminology as the only change. This turned out to be the case. The course instructor particularly needed extensive orientation; not one of the four instructors involved had even been subjected to "treatment" of any kind by instructional planning specialists.

Coordinating sessions were held between the design coordinator and the instructor, each session lasting approximately 45 minutes. During this time the design coordinator explained the general procedures and answered the instructor's questions. The instructors were assured that the subject matter was not being evaluated and the entire purpose of the procedures was to improve the instruction. All instructors seemed satisfied that their traditional rights as classroom teachers would not be violated.

Later sessions, particularly those sessions between the evaluation specialist and the course instructor, indicated that the coordinating sessions were not successful in informing the instructor about either the overall or the detailed procedures. Apparently the instructor's concern over what was going to happen to him and his rights as a teacher blocked the message concerning operational procedures. Even if the message on procedures had gotten through, one 45-minute session is not sufficient time to orient the instructor to his role in an ISD program _and_ instruct him in the details of the developmental procedures.

Generally then, the field trials got off to a poor start because the team members were not trained to work as a "team" and too little information was transmitted to those concerned about what an instructional system is and the detailed procedures for developing one.

Analysis

With this background, the actual instructional system development began. It started very unceremoniously with a meeting between the instructor and the evaluation specialist.

1. Determination of Functional Objectives

The Specialist Model for ISD is rather vague concerning the definition of the _functional_ objectives of a particular instructional system. It does require, however, a careful specification of _behavioral_ objectives. The two kinds of objectives are not the same. Behavioral objectives are more familiar to educators, especially those who are well acquainted with programed instruction. Behavioral objectives are unique to instruction in that they require listing, before a learner is submitted to instruction, what his behavior changes should be. These objectives are stated in measureable terms so that the actual change in behavior can be assessed after the instruction takes place. Functional objectives are considerably broader than behavioral objectives in that they ask the question, "What is the system supposed to do and why?" In determining functional objectives, broad questions are asked; e.g., "Does the student really need the block of knowledge being taught for future success?" "Does the course content have both internal and external validity?" "Does the course have secondary purposes, such as providing a training ground for teaching assistants, or giving the faculty members an opportunity to get acquainted with the students?"

In the Specialist Model, these broad questions concerning the overall function and purpose of the instructional system undergoing development are not questioned by the ISD team and are taken as givens. For example, the competency of the instructor in two vital areas, knowledge of the subject being taught in this particular course and his ability to articulate the objectives of the course, is not questioned. More basic questions concerning the legitimacy of the subject matter are also not asked. In accepting the functional objectives as "givens," the Specialist Model becomes an excellent example of Churchman's

Housekeeping Principle.[6] By limiting itself to a housekeeping function, the Model runs the risk of redesigning and modernizing obsolete courses. Several suggestions for the solution of this problem are made in the concluding section of this study.

2. Definition of the System: Its Inputs and Outputs

Since most of the functional objectives of the instructional systems (courses) are accepted as givens, the Specialist Model requires the collection of input data very early in the ISD process. This is in accordance with good system development practice. If a thorough examination of functional objectives were an integral part of the Specialist Model, specification of the instructional system's inputs and outputs would probably be taking place concurrently with development of the functional objectives. Input and output definition leads to a determination of the system's boundaries. Since (as discussed in Chapter II) the definition of a system is a conceptual device, the boundary of a system is, until defined, arbitrary and is usually chosen for convenience.

The boundaries of the system are determined using

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[6] For a description of Churchman's Housekeeping Principle, see page 66, Chapter II, above.

the black box approach (see Figure 2) and considering only those entities which enter and leave the instructional system. This occurs by definition of input and output. The idea of a boundary or parameter, particularly in a man-machine system, is meaningless apart from a consideration of inputs and outputs.

The design coordinator in the field trials attempted to collect input data, but the level of specificity was much too low. (See Appendix B for Input Data Sheets #1 and #2.) For example, the Input Data Sheets do not attempt to collect any pertinent information about the prime target of the instructional system--the learner. Almost none of the input data was required to be in quantitative terms.

The output data of the instructional systems were more complete than the input data largely because the evaluation specialist helped the instructor develop rather comprehensive behavior objectives in both the cognitive and the affective domains. The most serious problem in the specification of behavioral objectives seemed to be in making the jump from concepts and principles to be learned by the student to specifying them in a measureable form based on changes in the learner's behavior.

Because the inputs, and to a lesser extent the outputs, were not sharply identified, a second "given" was accepted by the ISD team--that the boundaries of the IS were the physical boundaries of the classroom. For example, one of the instructors in electrical engineering was not certain whether the course was accompanied by a laboratory section and, if it were, what subject matter was to be covered in the laboratory. In accepting the traditional classroom as the boundary of the system, the instructor became the central figure in the instructional system instead of the learner. The focus became one of "How can the IS help the instructor teach more efficiently and effectively?" rather than helping the student learn more efficiently and effectively.

3. Analysis of Requirements

The analysis of requirements is the most important step in the development of an instructional system. If the analysis is omitted or incompletely developed, a system without "system" design results. A thorough analysis of the system's requirements is a fundamental part of system design.

The purpose, then, of this step is to detail as specifically as possible all of the requirements implied by the objectives of the system undergoing development. There are two types and two sources of these requirements. One type of requirement is the conceptual requirement, which answers the question, "What does the system have to do conceptually in order to fulfill its functional objectives?"; the other type is the <u>physical requirement</u>, which answers the question, "What must be physically present in the system in order for it to fulfill its purposes?" The requirements are determined (1) by a detailed analysis of each functional objective and (2) by a careful study of the system's environments. Each functional objective is "expanded" to determine what physical and conceptual requirements must be provided in the system in order to accomplish its objectives. Certain other physical and conceptual requirements must be added to those determined by examining the functional objectives. These are discovered by studying such environments as the physical, legal, economic, sociological, psychological, and organizational environments. Usually, in a complex system, specialists representing various disciplines specify the requirements; for example, a sociologist would specify the sociological requirements of a system which operated within a significant social environment. Conceivably, in an IS all of the performance requirements (that is, the behavioral objectives) could be met by submitting a student to a curriculum consisting only of programed learning units. Hopefully, the educational sociologist would not permit this to happen.

With consideration given to all of the specific requirements of the system and to <u>how</u> these specific requirements might be achieved, attention is given to <u>cost</u> considerations: are all of the requirements brought out by the analysis worth their cost? It is at this point in the system's development that certain features of the system may have to be eliminated simply because they are too costly. Here again the judgment of the specialists involved in the system's design must be brought to bear on questions of utility.

With these points in mind, the next section will consider how the Specialists Model for ISD analyzed the IS requirements in the field trials.

It was stated above that two factors were accepted by the ISD team which limited the scope of the IS being developed. First, that the prime functional objective of the IS was to teach a given block of subject matter by making the instructor a more efficient and effective teacher. Second, that the parameters or boundaries of the IS undergoing development be limited to the physical boundaries of the traditional classroom.

With the scope of development limited by these two factors, the instructor and the evaluation specialist attempted to set the conceptual requirements of the IS by stating the terminal course objectives in behavioral terms. A great deal of difficulty was encountered in this attempt because neither the instructor nor the evaluation specialist had ever attempted to do this before, and without special training it was understandably difficult. One of the evaluation specialists did not know the three commonly accepted levels of instructional objectives; i.e., cognitive, affective and psychomotor; nor could he give examples of them when they were brought to his attention. This made it difficult to specify the course objectives, particularly in theatre arts, which had a number of affective objectives as a part of the course.

The ISD project staff anticipated the difficulty in working with objectives and provided the instructor and evaluation specialist with a form entitled "Aid to Identification of Objectives - Parts I, II, and III" (See Appendix C). This form was designed to help the instructor and evaluation specialist identify the course objectives, but because neither had any training in the use of the form, and because a complete example was not provided, the form tended to confuse the task more than clarify it. The behavioral objective matrix was finally completed in both field trials, but only with great difficulty. (The whole problem became particularly evident on tapes numbers six and eight.)

Because the IS was instructor-oriented, little consideration was given to assessing the student's entering behavior or to screening out or designing some remedial experiences for those who were below a predetermined threshold.

With the conceptual requirement set in the form of behavioral objectives, the physical requirements were then determined by writing actual test items which would assess the students' terminal achievement. The instructor and the evaluation specialist also designed test situations which would assess affective achievement.

With the functional objective pertaining to course content expanded into behavioral objectives (conceptual requirements) and evaluation instruments determined (physical requirements), the process of expanding functional objectives into detailed requirements was halted because no other broad objectives had been identified. Students' needs for advisement, discipline related guidance and counseling, for example, were not overtly considered to be an objective of the IS; therefore, provisions to meet these needs were not made.

After approximately six hours of interaction, the instructors shifted their sessions from the evaluation specialists to the instructional specialist who helped the instructor determine how the requirements might be achieved. This was done in two steps. First, by organizing the course content into a "logical" sequence and, second, by selecting the most applicable teaching examples. The logical sequence of the content was determined by the instructor's experience in teaching the subject matter. This entailed organizing the principles and concepts to be taught into a linear sequence beginning with the least difficult and progressing toward the more difficult.

In selecting the teaching examples, the instructor could draw upon his past teaching experience, and from the text and other readily available sources. This did not seem to be a workable system, since several cases came up where the need for an example was obvious both to the instructor and to the instructional specialist; but neither could find or think of a satisfactory one. The instructional specialist did not contribute a great deal to the selection of teaching examples since he was not familiar enough with the course content to offer many suggestions.

4. Division into Subsystems

In the division into subsystems, the detailed system requirements are grouped together to form components or subsystems. Grouping greatly facilitates further analysis and synthesis. The groupings may be based on various considerations; e.g., they may be grouped by common function, common inputs and outputs, geographical characteristics, the use of common processes or techniques, and so forth. By dividing the requirements and grouping them into subsystems, each subsystem can then be treated as a system and the whole development process repeated for each new system as applicable and as needed.

The detailed requirements for the IS courses, as determined by the teams during the field trials, centered around behavioral objectives and the test items which would measure the student's achievement of these objectives. It was at the point of grouping the detailed requirements into subsystems that the ISD team's unconscious decision to center the entire IS around the instructor became most evident. By limiting the scope in this way, grouping considerations based on the needs of the learner were not considered. All grouping considerations were based on the assumption that the instructor would be standing in front of a class in the traditional manner. This assumption eliminated from consideration such grouping possibilities as programed learning-type independent study, small group discussions, very large group lectures, discovery-type independent study, etc. Instead of making subsystems based on instructional strategies, such as those mentioned above, various instructional media became the basis for grouping the detailed requirements; i.e., some of the subsystems that were developed could be called instructor plus student responder, teacher plus single concept films, teacher plus overhead transparencies, teacher plus slides, etc.

By grouping all of the instructional requirements into one subsystem; i.e., a live instructor with a medium-size group of students, the ISD team conducted its analysis and synthesis only in terms of the instructor plus instructional media. (See Figure 1.) This is consistent

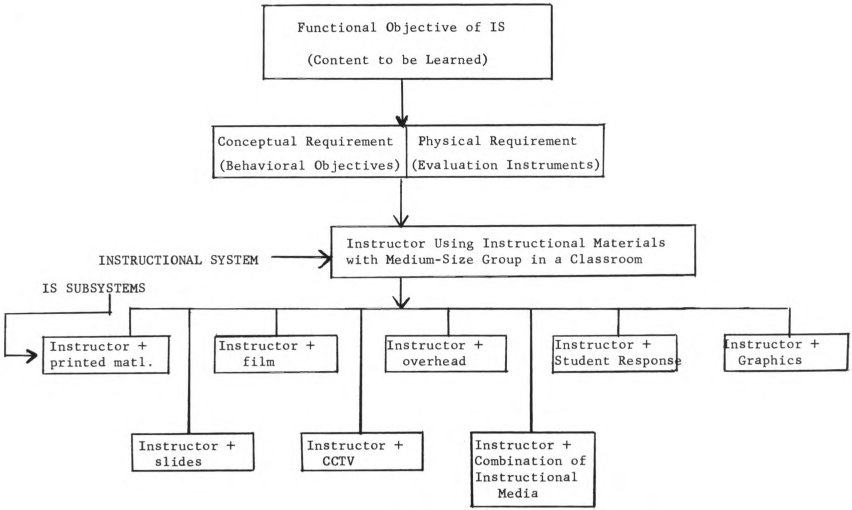
Functional Objective of IS
(Content to be Learned)
Conceptual Requirement
(Behavioral Objectives)
Physical Requirement
(Evaluation Instruments)
INSTRUCTIONAL SYSTEM
Instructor Using Instructional Materials
with Medium-Size Group in a Classroom
IS SUBSYSTEMS
Instructor + printed matl.
Instructor + slides
Instructor + film
Instructor + CCTV
Instructor + overhead
Instructor + Combination of Instructional Media
Instructor + Student Response
Instructor + Graphics

Fig. 1

with the decision to center the IS around the instructor teaching in a traditional classroom configuration.

It should be noted that the Specialist Model calls for the instructional specialist and the instructor to "Plan Overall Strategy." Planning the overall instructional strategy included consideration of the teacher-student ratio, communication patterns, student practice needs, etc. All decisions concerning the instructional strategy were to be based upon a "theory of instruction."[7]

The data indicate, as noted above, that considerations for "Planning Overall Strategy" (or, in more formal systems terminology, the division into subsystems) were not made. Two brief explanations which are pertinent to further analysis of the field trials are (1) that very little is known about strategies of instruction; i.e., when to specify the use of small group discussion and when to specify the use of discovery-type independent study as an instructional tactic, given well specified terminal behavioral objectives; and (2) the first three steps of the ISD process had consumed a great deal more time and energy than had been anticipated by the field trial planning staff. The ISD meetings had begun in June and it was August before Step 3, the analysis of behavioral require-

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[7]John Barson, symposium presented at D.A.V.I., Milwaukee, Appendix A-2.

ments, was completed. Pressure to "be ready" by September forced the ISD teams to adopt a much more conventional approach to course development. The more conventional approach was to "get out the syllabus, cut it into lecture hours, determine what main topics were to be covered, what back-up materials were needed to fill in, where more specific examples were needed, etc."[8] The result was an hour by hour breakdown of the courses into a listing of the lecture topics and the instructional materials needed to support the lecture. (For an example see Appendix D, from Barson's A.E.R.A. paper, Appendix B-6.)

If the field trials had continued to follow the original directions of the Specialist Model for ISD, then the findings of the ISD study would perhaps have been more significant. Modified course development procedures were followed in the process of completing the field trials. These modified procedures varied considerably from the procedures originally specified by the Specialist Model. The remaining sections will analyze these procedures in an effort to determine how closely they follow general systems development procedures.

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[8] John Barson, symposium conducted at A.E.R.A., Chicago, p. 10.

5. Synthesis

Following the grouping of the detailed requirements into subsystems, preliminary conceptual design of the system begins. A block diagram of the subsystem is drawn showing the communication networks between the subsystems and other logical relationships to be affected by the components of the system.

Another important part of the process of synthesis is the quantification of as many of the requirements as possible. Questions of how much, how many, what are the ranges and limits, what are the accuracies, what reliabilities are required or are reasonable to expect, what errors can be allowed, etc., are to be answered. This requires at least a conceptual understanding of the internal processing of each component or subsystem; i.e., the instructional specialist should have some basis for judging how much a student will have learned as a result of having participated in a particular small group discussion.

Even though after the division into subsystems, the original procedures of the Specialist Model were no longer being used in the development of the instructional systems in the field trials, considerable information which will be useful in the development of an instructional system theory can be gathered from the more conventional procedures used to complete the IS.

In the instructional systems which were undergoing development in the field trials, the detailed requirements, which were written either as behavioral objectives or as teaching examples, were grouped by the instructor and instructional specialist into one subsystem. This subsystem was an instructor teaching in a conventional classroom to a medium-size group. The goal of the IS became one of making the instructor as efficient and effective as possible. In order to do this, the content of the courses was carefully organized and it was decided to supplement the instructor's lectures with instructional materials.

The designers of the Specialist Model had intended that the step following the determination of the teaching examples by the instructor and the instructional specialist would be the selection of the form of representation, using Bruner's concept of the structure and form of knowledge.[9] Bruner theorizes that knowledge can be represented in three forms--enactive, ikonic, and symbolic; thus the teaching examples selected were to be studied, classified into one of the three forms and then presented to the student via a transmitter or media instrumentation system in the form in which it was classified. Unfortunately, this strategy for producing instructional materials was not attempted.

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[9]For a detailed discussion of Bruner's theory, see pages 94 - 96, Chapter III, above.

What did take place following the selection of teaching examples was that the instructor and the educational media specialist (EMS) sat down with the course outline, which had the content to be covered grouped into lecture periods, and went through this content, discussed it, and then decided that a transparency, for example, could be used at some particular point in the lecture.

In arriving at the decision, a great deal of time was spent by the instructor "teaching" the course to the EMS so that the EMS could help the instructor decide which of the many media instrumentation possibilities seemed most appropriate. A number of factors seemed to influence the decision as to which medium to use to represent a particular teaching example. Some of those noted were:

1. The breadth of previous experience on the part of the EMS
   a. with all types of media
   b. in helping an instructor choose between the media alternates.
2. The breadth of experience on the part of the instructor
   a. in teaching the content
   b. in the use of all types of media.
3. If either the instructor or the EMS had a "pet medium;" that is, a strong liking for a particular medium.

4. A recent experience with any medium by either person.
5. "Natural" indicators within the teaching example; e.g., motion seemed to be needed to illustrate the example--a film was immediately suggested.
6. Media which were improvements over currently used techniques; e.g., a classroom communicator was selected as an improvement over currently used "yes" and "no" cards. (Tape 34.) Overhead projectors were selected to improve upon chalkboard drawings. (Tape 33.)
7. The ability of either person to visualize the content graphically. (Tape 32.)

All of the decisions seemed to be made on the basis of the combined "best judgment" of the instructor and the EMS.

Following the decision to use a particular piece of instructional material in a given lecture, a search of the available instructional materials was conducted by the instructional materials specialist. The results of the search were not fruitful and it was decided by the instructor and the EMS that a number of items would have to be locally produced by the media production specialists.

The course instructors met with the media production specialist to work out the details of production.

The principal production specialists involved were a film producer and a graphic designer. With the exception of problems concerned with graphic symbols which were peculiar to the content being visualized, the production planning for the transparencies proceeded quite smoothly. The actual production of the transparencies was held up because the Audiovisual Center's graphics department had a very crowded production schedule. The production of the single concept films was delayed primarily because, first, the film producers insisted upon the rather lengthy planning period to which they were accustomed (i.e., one of the producers stated that he liked to sit in on a course for a semester before beginning production in order to acquire a feeling for the content being presented); and second, production costs had to be worked out between the departments involved and the ISD project.

A pertinent observation can be made at this point in the analysis. One of the purposes of having various educational specialists; i.e., an evaluation specialist, instructional specialist, and educational media specialist work with the instructor before confronting the production specialist was to save the production specialist time by presenting him with the behavioral objectives, teaching examples and all the other information needed to produce the instructional materials. In a normal situation; that is, without the other specialists, the instructor and the producer would have to sit down and work through the whole process together in order to produce the desired piece of instructional material.

In actual practice, however, little time was saved because the production specialists (particularly the film producers) insisted upon repeating at least part of the work of previous specialists. This was not unique to the production specialist; it happened to all of the other specialists; e.g., the instructional specialist rewrote many of the objectives which had been determined by the evaluation specialist. (Tapes 14, 15, 17, and 21.) Several factors seemed to influence the amount of repetition between specialists:

1. No standard form for reporting information exists; thus when a specialist received information, he translated it into the form with which he was accustomed to working.
2. Lack of a standard graphic code.
3. Language and semantic differences.
4. Uncertainty concerning the exact parameters of a particular specialist's role.
5. Poor communication between the members of the ISD team.

6. Modeling and Simulation

If system development procedures had been used to complete the field trials, the IS design coordinator would have assembled the newly designed instructional system and produced a model of it. The purpose of the model is to check the overall design and prepare the IS for simulation and testing.

The Michigan State University Specialist Model, contrary to general system design procedures, does not provide for either modeling or simulation of the instructional system. Modeling, particularly flowcharting, is not difficult to do and seems to be an essential part of the design of a complex such as an instructional system. Simulation, which is also an essential step in the design of any system, is more difficult to accomplish in a system as complex as an instructional system; however, advances in computer technology have put computer simulation of instructional systems within the range of possibility. Unfortunately, neither modeling nor simulation were a part of the field trials.

7. Field testing and Redesign

The Specialist Model for ISD specified field testing and redesign for the instructional systems produced, but these steps were not completed. Several factors prevented the field testing and redesign of the redeveloped courses. First, time forced the courses to become operational before they could be tested with a small group of students; second, the delays in producing some of the instructional materials which were mentioned above prevented testing the system as a whole; third, funds seemed to be lacking for redesigning those sections of the course which proved to be unsatisfactory; fourth, testing and redesign procedures were not worked out and presented to the course instructors for use by them.

Summary

Before drawing conclusions and making recommendations in Chapter V, several broad summarizing statements can be made concerning the analysis of the specialist model and the two field trials which were undertaken to test its procedures.

1. The field trials got off to a poor start because, (a) the specialists involved were not properly trained to competently carry out their respective roles; (b) the operational procedures of the Model were much too vague to permit their being carried out properly; (c) the instructors involved were not sufficiently oriented to their role in ISD.

2. The field trials ceased to follow the Model's suggested procedures approximately half-way through the ISD procedures because (a) only three months of planning time was allowed; (b) too little is known about instructional planning using a systems approach.

3. The Specialist Model for ISD deviates from the general procedures of systems development (a) by not utilizing an <u>inter-disciplinary</u> team of specialists to develop a system as complex as an instructional system for higher education; (b) by not requiring modeling and simulation of the instructional system under development.

4. The specialists involved completed the course redevelopment using conventional course planning procedures for the reasons mentioned in number two.

5. Instructional systems were not developed as a result of the two field trials for reasons mentioned in numbers one through three.

The last chapter of this study will discuss the results of the analysis, draw conclusions and make recommendations for further study.

CHAPTER V

CONCLUSIONS AND SUGGESTIONS FOR FURTHER STUDY OF THE INSTRUCTIONAL SYSTEMS APPROACH TO CURRICULAR PLANNING

Educators have been trying to improve instruction for many years. During this time, a variety of plans, methods, and theories have been tested with varying degrees of success. Educators are now being asked to accept still another approach to the improvement of instruction. This particular approach is based on the concept "system" and in its broadest context is called the "systems approach to problem solving" or simply the "systems approach." It derives its strongest theoretical supports from Bertalanffy's General Systems Theory and its operational methodology from a variety of systems disciplines centered in industrial and military management.

The purpose of this study has been to analyze critically the systems approach to instructional planning. The extent of its application to education and the present state of instructional systems theory were assessed through an extensive review of pertinent literature. The operational feasibility of the instructional systems approach to curricular planning was determined by a critical analysis of a model designed to develop instructional systems. The model, called the Specialist Model, was developed and field tested by Michigan State University's Instructional System Development Project.

The two field trials, which tested the Specialist Model's procedures, served a very useful function in this evaluation of the systems approach to instructional planning. They pointed out areas needing further development both by what they accomplished and by what they were unable to accomplish.

The conclusions which can be drawn and recommendations which can be made as a result of the analysis described above will make up the content of this chapter. The order of presentation will be a discussion, conclusions and recommendations covering the following major topics:

1. The applicability of General Systems Theory to educational planning.

2. The contribution of the systems disciplines to instructional system theory, with special attention to the difference between educational systems and industrial-military training systems.

3. The role of instructional systems in higher education, with emphasis upon the role of the instructor.

4. The Specialist Model and the field trials.

A summary section which draws together the minor conclusions and recommendations and discusses the major conclusions and recommendations will conclude the chapter.

General Systems Theory

The basic underlying assumption made by those who advocate the use of a systems approach to instructional planning is that the teaching-learning activity of education can be treated as a system. They also assume that instructional systems will function according to the principles and constructs which govern all systems. These "universal" principles and constructs were first formulated by Ludwig Von Bertalanffy, a German biologist, in the early 1950's and since have been expanded by the Society for the Advancement of General Systems Theory.

While Bertalanffy intended his General Systems Theory (GST) to encompass all systems, the principles and constructs which were elaborated first were those that described the behavior of systems in the natural sciences. Education, however, must be considered a social system and as such should be studied from a social science point of view. GST is not, at present, well developed in the social science area.

Some of the problem areas within GST which need to be studied by social scientists, particularly sociologists, before systems theory can be operationally helpful to educational system designers are:

1. In the definition of social systems. GST states that there is a hierarchy of systems from supra-systems down to sub-sub-systems; each of which can be treated and studied as a system. In the study of social systems, which are so closely interrelated, it is difficult to separate the systems on any basis other than physical boundaries; e.g., using the walls of a classroom as the boundaries of an instructional system.

2. An expansion of the internal processing characteristics of social systems. At the present time, GST is too general to aid in the understanding of specific social system operation. Principles and constructs covering the behavior of social systems have not been elaborated in systems terminology.

3. In the specification of inputs and outputs. It is more difficult in most cases to identify and measure, quantitatively, the inputs and outputs of a social system than to do so in a natural system. Directly related to the input/output problem is the question of environments which produce the input for the system under consideration. Principles to guide the identification of the relevant environments do not yet exist.

4. <u>The identification and operation of feedback mechanism in social systems</u>. It is very difficult to identify and categorize the types of information that serve as feedback in a social system. It is equally difficult in many cases to monitor the channel used to communicate the information; e.g., a puzzled or blank expression on a student's face can sometimes cause a lecturer to further elaborate upon a particular teaching point.

Because an intermediate level social systems theory does not exist as an organized whole (see Figure 1), instructional systems theorists find GST to be of limited value in the actual design of instructional systems, it is a metatheory and needs more specific theories to make it operational.

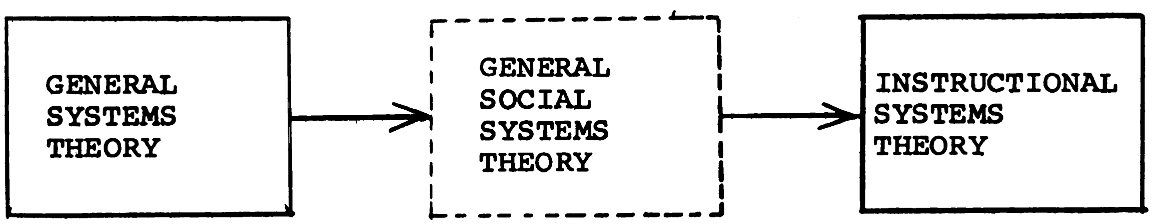

Fig. 1.

Before an instructional systems theory can be elaborated, a general social systems theory must be developed. Sociological theorists have already developed certain aspects of such a theory, but it has not been put in systems terminology. A careful review of instructional systems literature seems to indicate that educators are not turning to the social scientists for guidance in the development of an IS theory. It is therefore recommended that IS theorists concentrate more on the social science literature which deals with a systems approach to social action.

The Systems Disciplines and IS Theory

The systems approach to educational planning is confronted with an interesting paradox. It is presently equipped with strong methodological procedures for instructional system design, which it draws from the various systems disciplines such as systems engineering and operations research, and finds itself lacking in IS theory because of the gap between General Systems Theory and IS theory.

The strong methodology which is derived from the systems disciplines is very useful in instructional system development because in addition to its rigorous developmental procedures it identifies the key decision points. That is, systems methodology will systematically lead the

IS designer through the development of an IS and help him identify each key decision point.

Once the decision points have been determined, an IS theory is required in order to make sound decisions which cumulatively will result in an educationally sound IS. It is a conclusion of this study that such an IS theory does not exist. This conclusion will become more evident as recommendations for further study are made later in the chapter.

Some of the systems methodologies which are being adopted from the systems disciplines are flowcharting, analysis techniques, modeling and simulation techniques, techniques for the specification of functional requirements, and an overall design approach. It appears that most of these methodologies can be applied to educational system design with relatively little modification. This conclusion does not preclude the need to develop special system design techniques which are unique to educational systems.

A word of caution should be given in connection with the use of the various system methodologies. In order to take full advantage of these techniques, educational system designers are likely to engage the services of experts in the technique to serve as IS design consultants. A serious error can be made by asking the consultants to go beyond the technique, which identifies decision-making points, and to actually make the decisions. If this happens, the consultant will usually make the decision based upon his theoretical background, which is usually training-oriented. Training-oriented decisions in an educational system can become a problem because, as noted in the next section, there is a sharp philosophical difference between education and training.

Educational Systems vs Training Systems

The educational system designer should be aware that IS and training systems are designed from a different philosophical base. Training systems are task- or job-oriented with a prime concern to shorten the training period without a loss of training efficiency. Education, on the other hand, is divergent in its thinking. That is, while an IS is concerned with efficiency in learning and in shortening the time it takes to learn a particular unit of subject matter, it is also interested in expanding the total number of units taught within the time alloted. Relatively few educators are interested in producing a college graduate in two years by making the teaching-learning process twice as efficient as the present process, but many are interested in introducing, in the four years allotted, as many students as are capable to the rapidly expanding body of knowledge.

Higher Education and the Systems Approach

One of the purposes of this study was to evaluate the systems approach to curricular planning in higher education. As a means of making this evaluation, one of the first attempts to design an instructional system was carefully analyzed. This attempt was made by Michigan State University's Instructional System Development Project during field trials which tested the procedures of the project's model for IS development.

Before discussing the results of the analysis of the project's model, called the Specialist Model, several comments can be made about the use of an ISD model in higher education. These comments concern broad, but fundamental, questions which need to be answered before any course within a college or university is chosen for development using ISD procedures. The areas to be discussed include the selection of the course content, the role of the instructor, the availability of facilities and personnel, priorities for course development and the question of utility, and the interface between systems.

The Interface between Systems. Before ISD should begin, university administrators at a high level--preferably those in the Office of Vice President for Academic Affairs--should be concerned about the interface between educational systems both inside and outside the university. One of the more obvious educational systems that a university must be concerned with is the interface between institutions of higher learning within a particular region (see Figure 2). Another way of stating the question of interface between institutions of higher learning is to suggest that a given institution consider its total offering in relation to the offerings of the other institutions in the region. For example, a small, inefficient department at one institution should perhaps be transferred to another equally small and inefficient department at another institution if to do so would form a more effective instructional unit.

As the universe of knowledge grows and changes and the employment opportunities for college graduates change, so should the configuration of colleges within a university change to meet the new situation. Perhaps every ten years would be the time to systematically examine the college structure and every five years to make a serious study of the departmental divisions within colleges. Courses within departments should be re-examined every three years. If this were systematically done, using a systems approach, many of the overlaps and voids would be resolved. In each case, reorganization should be directed by the next higher agency; i.e., colleges should examine the departmental configurations, for as Elton Morrison points out in his ex-

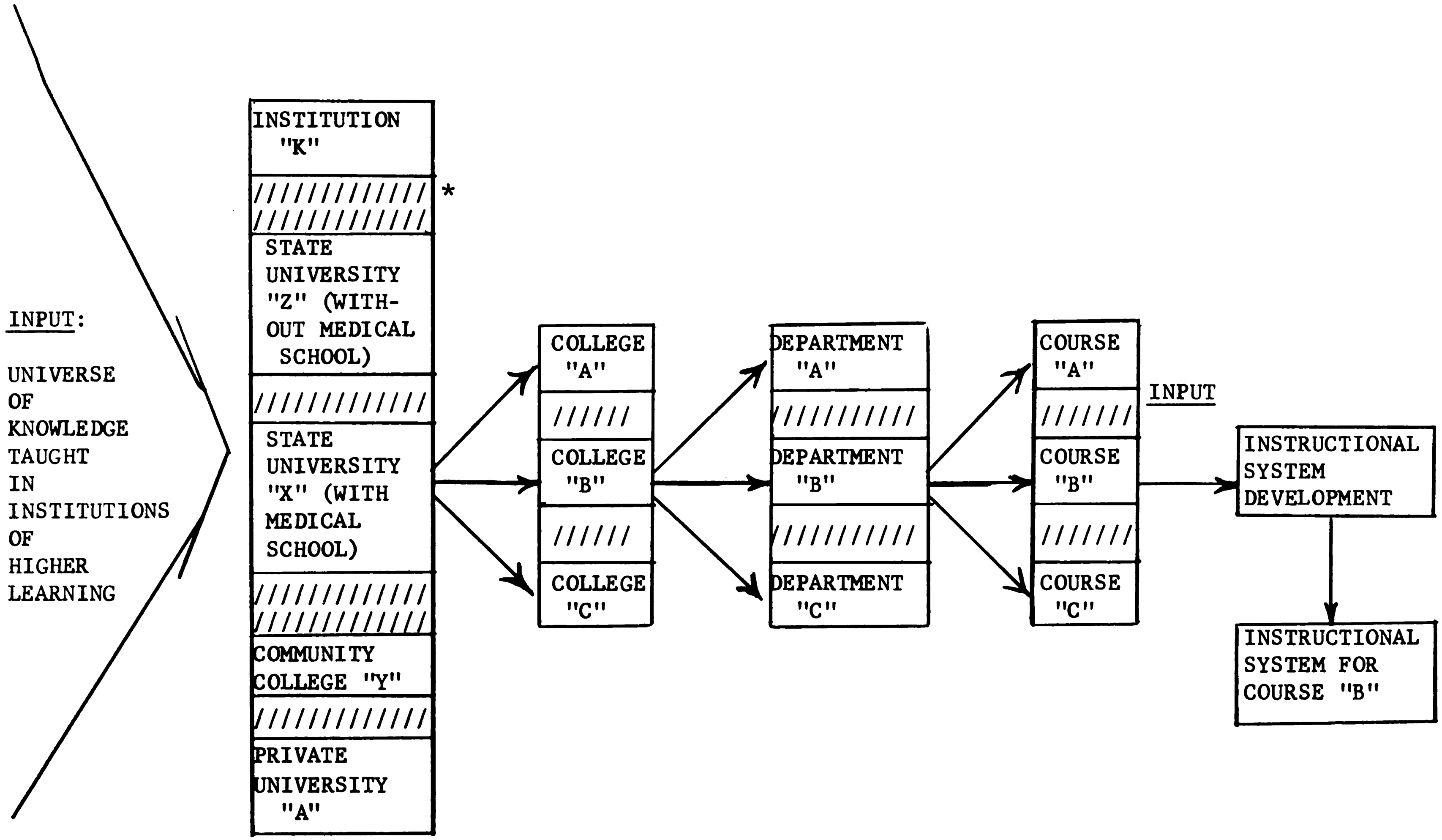

Fig. 2

* Area of Interface

cellent book[1], change takes place in many instances only when an outside agency steps in and forces it. For example, it seems reasonably clear that industrial arts education, which has been out of touch with American industry for thirty years, will not change until it is forced to by an outside agency.

Once the interface between systems question is answered, the instructional systems designer can proceed to develop an IS for a course with the assurance that the course is a valid one.

Determination of Course Content. Directly related to the problem of system interface and course validity is the validation of the course content. Before an IS designer can proceed he should be reasonably sure that the content of the course is accurate and up to date and that it serves a useful purpose in the course of studies taken by the student. Universities passed long ago the point where all knowledge can be taught to all students--some system must be used to determine content. Two questions which can be asked concerning a system of determining course content are (1) is the universe of knowledge to be taught by institutions of higher learning arbitrarily divided into colleges,

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[1]Elton E. Morrison, Men, Machines, and Modern Times, (Cambridge, Mass.: The M.I.T. Press, 1966), entire work.

then into departments and then into courses as shown in Figure 2; or (2) is the content of the courses dictated by the tasks to be performed and the attitudes to be exhibited by the student when he enters the world of work as shown in Figure 3. Perhaps the approach to the determination of course content varies with the academic area. The scientific areas at least lend themselves to a task and attitude analysis as in Figure 3. This analysis of the needs of the consumer is presently being done informally by university instructors--which suggests the following hypothesis: if a department's graduates are in great demand by employers, then the department's instructors are actively interacting with the employers. The role of the instructor is unquestionably an important one, but as pointed out in the next section, the role of the instructor is changing.

The Role of the Instructor in an IS. One of the principal reasons for using a systems approach to problem solving of any type is the existance of alternatives. Every system development procedure requires a careful analysis to delineate all of its requirements, in order to select the most promising solution from the alternates available.

Educational planners, until about a decade ago, did not have a range of complex alternatives from which to choose and thus did not require complex planning procedures. Before the instructional innovation revolution,

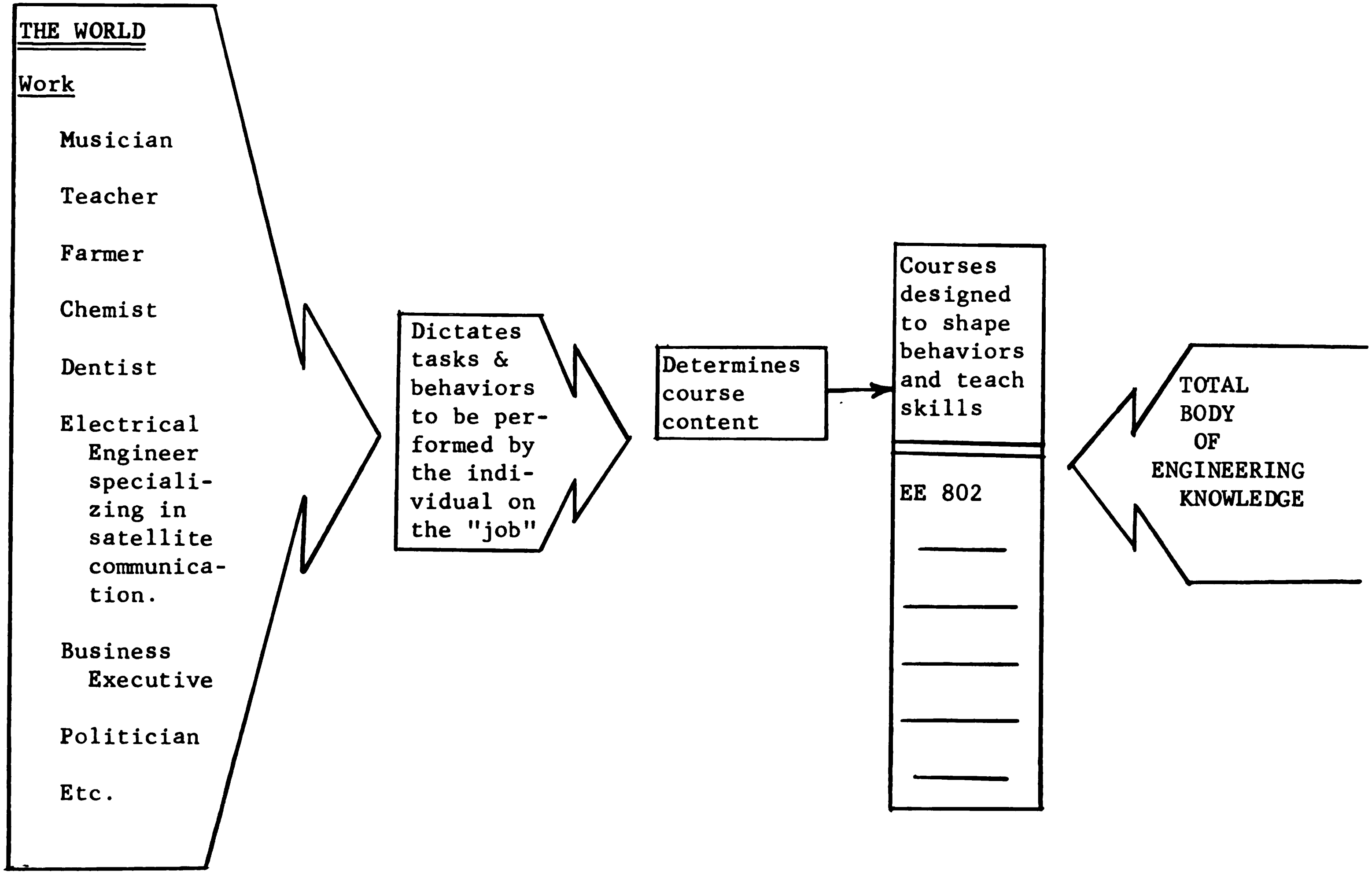
THE WORLD
Work
Musician
Teacher
Farmer
Chemist
Dentist
Electrical Engineer speciali- zing in satellite communica- tion.
Business Executive
Politician
Etc.
Dictates tasks & behaviors to be per- formed by the indi- vidual on the "job"
Determines course content
Courses designed to shape behaviors and teach skills
EE 802
TOTAL BODY OF ENGINEERING KNOWLEDGE

Fig. 3

the instructor was the central figure in the classroom and was free to choose instructional materials as aids whenever he felt they were appropriate.

Today's educational strategist is confronted with an expanding array of instructional alternatives made possible by the application of technology to instruction and the development of a variety of instructional strategies. Technologies such as CCTV, information storage and retrieval systems and computers make possible the use of mediated teachers in instructional strategies that range from very large group instruction to completely individualized, independent study. The alternatives are rapidly expanding as each new technology and strategy is developed; two of the newest are home-based computers and the use of educational "games."

But what is to become of the instructor lecturing to a class of 25 students? It seems quite clear that he will have to change, but what his new role will be is as yet an open question. How he will react to his loss of classroom autonomy is not known.

It seems likely that the key decision-making function--that is, what instructional strategy will be used--will not remain with the live classroom teacher. The live classroom instructor will become a strategy of instruction to be used or not used depending upon the requirements of the instructional situation. For public school teachers, this decision-making function has already left the classroom, or perhaps it was never there. For example, teachers do not decide, individually, to adopt the new curricula such as PSSC physics; nor do they decide to use or not to use instructional television in their classroom. Replacing the teacher as the instructional decision-maker will be a team of instructional strategists. The membership of the team is not clearly defined, but some of the most likely personnel are an evaluation specialist, a content specialist, an administrator, an instructional strategist, an instructional technologist, an educational psychologist, and a master teacher.

One of the principal reasons that the live classroom instructor will not be able to make the decisions is because it is unreasonable to ask him to pass judgment on instructional units which are on the same level he is. The decision must be made at the next higher level if it is to be made without emotion and prejudice. Figure 4 diagramatically shows the relationship. However, if a classroom teacher were to serve in the role of a master teacher on the development team then there exists considerable opportunity for growth on the part of the teacher.

The M.S.U. study did not give any insights into the reaction of a college instructor to such a team approach to instructional planning because, as pointed out in Chapter IV, instructional strategies which did not include

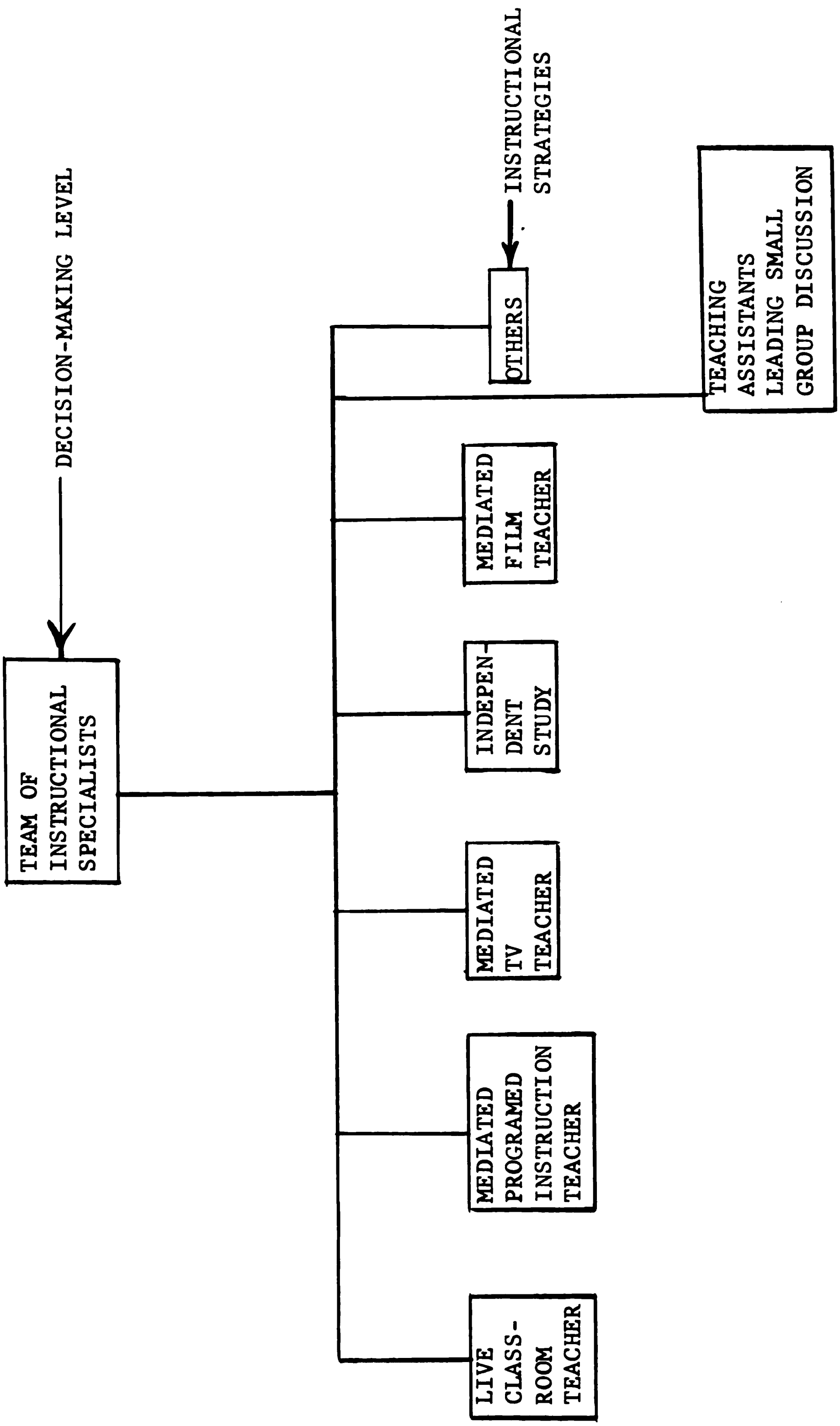
DECISION-MAKING LEVEL
TEAM OF INSTRUCTIONAL SPECIALISTS
INSTRUCTIONAL STRATEGIES
LIVE CLASS-ROOM TEACHER
MEDIATED PROGRAMED INSTRUCTION TEACHER
MEDIATED TV TEACHER
INDEPEN-DENT STUDY
MEDIATED FILM TEACHER
OTHERS
TEACHING ASSISTANTS LEADING SMALL GROUP DISCUSSION

Fig. 4

the instructor as the central figure were not explored.

Whether or not the course instructor will accept his changed role without crying out against infringement upon academic freedom remains an open question. One of the biggest factors regarding acceptance would seem to be the way in which the instructor is introduced to the changes.

A fruitful area for further study, then, would be an exploration into the role of an instructor in an IS, with careful consideration given to techniques for introducing change.

<u>Facilities and Personnel</u>. If the instructional system development teams are to take advantage of the strategies which are available, they must have the facilities and personnel at hand to put them into action; e.g., if computer-assisted learning is to be considered as an alternative, then computer science facilities and personnel must be available for use in an instructional system.

An established network of primary instructional technology seems to be a prerequisite to the establishment of instructional systems on a college campus. Primary instructional technology includes campus-wide distribution of CCTV programs, instructional materials production facilities and a variety of learning spaces ranging from electronically equipped study carrels to large group lecture halls. The concept of primary technology also includes the availability of a wide range of technical support personnel such as TV technicians and graphic artists.

<u>Priorities: Courses and Costs</u>. Two inter-related decision areas which need to be examined by a high-level agency in a college or university before ISD can begin are establishment of priorities on courses to be developed and a study of utility.

In the development of a policy which would deal with questions of what courses should be developed and in what order the development should take place, a number of factors should be considered. While workable, a first-come-first-served policy is not satisfactory because the departments which need help the most are not likely to volunteer and thus compete with other more aggressive and progressive departments. Selecting courses solely on the basis of total number of students served by the course in order to justify the development costs does not seem satisfactory: how is one to decide whether a freshman level men's physical education course which serves one thousand students per year is more important than a master's level course in social work which serves only fifty students? Or perhaps new courses should be given priority over established courses.

It seems that a carefully thought-out policy needs to be developed in order to make the efforts of an ISD program be of maximum benefit to a university's instructional program.

A problem which will be more difficult to resolve than course priorities in ISD is the question of utility. Utility in an instructional system is the weighing of development, production and operation costs against the desirability of the output. Although presently-used accounting procedures do not permit an instructional system designer to determine the cost of an IS, it is not improbable that more sophisticated and detailed accounting procedures will soon be employed to determine the relative costs of the various instructional processes. Very little, however, is known about desirability because of the complex variabilities of educational objectives and "intangibles" which are ever present as side effects.

At the risk of encouraging a continuation of what Callahan calls the "cult of efficiency"[2], it is recommended that a study be undertaken to research the utility question, for without some guidelines in this area the systems approach to educational planning will be severely handicapped. Even without a total systems approach in mind, educators need to be concerned about utility because, for

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[2]Raymond E. Callahan, Education and the Cult of Efficiency, (Chicago: University of Chicago Press, 1962), entire work.

example, $200,000 electronic classrooms are presently being developed. Someone will soon have to answer the question, "Is it worth it?"

If the educational system designer is faced with a series of problems which need to be studied before he begins IS development, then he is also faced with many serious questions after he undertakes the development of an IS, as the following section points out.

Instructional System Development.

As discussed above, the great potential value of the systems approach to instructional planning is its help in identifying the key decision points in the instructional planning process. While the system development methodologies identify the decision points, instructional system theory must help the IS designer choose between the alternatives available at each of these points.

It is in this area of IS theory that the greatest amount of work remains to be done. The two field trials of M.S.U.'s Specialist Model for ISD which served as the vehicle for determining the present state of IS theory and for assessing the feasibility of a systems approach to instructional planning showed the lack of IS theory.

Before detailing the need in specific areas for theoretical and practical development, some general comments concerning ISD can be offered for consideration.

Time as a Factor. ISD is a very time consuming process and if time can be equated roughly with money, then ISD is also very costly. A typical two-semester course could take up to three years to totally develop into a complete IS. A month-by-month breakdown might look like this:

6 months	- Preplanning; training personnel in ISD procedures; possibly having ISD staff sitting in on the course as presently organized.
3 months	- Gather input data; define parameters.
6 months	- Analysis of requirements--objectives and behaviors sought.
6 months	- Production and synthesis.
3 months	- Modeling and simulation of IS.
9 months	- Field test.
3 months	- Redesign.
36 months	total elapsed time.

It would be very difficult to estimate the number of man hours necessary to complete the IS, but it would be high. And since most of the man-hours consumed would be by professional personnel, the cost would again be commensurate with time.

<u>Instructor Training</u>. As discussed above, the role of the course instructor in ISD is uncertain. However, regardless of whether the course instructor (or instructors) is the central figure, as was the case in the Specialist Model, or it is a master instructor plus content specialists as suggested above, the individual should undergo extensive training before he attempts to become a contributing member of an ISD team. This training would pay off in two ways. First the instructor would be a great deal less apprehensive about ISD if he understood it and therefore could make considerable contributions during the actual ISD. Second, after the IS is in operation, the instructor could effect minor adjustments in the system based upon his immediate feedback without returning to each of the ISD specialists for counsel on how to effect the desired changes.

<u>Training the ISD Team</u>. The systems approach to instructional planning is significantly different from presently used planning procedure, so that all personnel involved need special training in (1) what the systems approach is and what it is attempting to accomplish; (2) what the role of the individual is to be on the ISD team; (3) group dynamics; (4) the procedures for ISD; and (5) what the communication channels are in the developmental system. Without training, the staff will, as in the field trials, adopt the systems terminology but function according to the pro-

cedures to which they are most accustomed.

The Inter-disciplinary Team. One of the weaknesses of the Specialist Model was that it lacked a true inter-disciplinary approach. The ISD team suggested by the Specialist Model was really an intra-disciplinary team in that all of the specialists were educators. The use of an inter-disciplinary team is one of the basic tenets of the systems approach and instructional planning is sufficiently complex to warrant the services of psychologists, sociologists, economists, systems engineers, etc.

The Need for Communication. Communications, or the free flow of information to interested persons, is crucial to the success of an IS. Instructional systems are new and will require changes in behavior on the part of many people, particularly the students and faculty. Much of the uncertainty that is a part of change can be alleviated by keeping the university community well informed through a variety of information dissemination techniques such as demonstrations, inservice training programs, news releases, etc.

With the pre-planning activities discussed in the sections above given the serious consideration they deserve, attention can then be focused on some of the instructional system design problems. These will be considered in the same order as they are encountered in actual system design.

<u>Defining the Course Goals</u>. One of the first steps in ISD, after the course has been selected and pre-planning activities completed, is the stating of the broad goals of the course. Broad, seemingly intangible goals should be stated and then, through careful analysis of the goals, be broken down into component parts and some provision made in the design of the IS to achieve each particular goal. Four areas should be considered as a source of these goals. They are the goals of the students, the instructors, the department, and the university.

Universities often state their goals in very broad terms. One such is the desire to prepare students for leadership, yet few university courses consciously set out to achieve this goal. Educators usually just hope that the student will develop leadership capabilities.

One of the strengths of the systems approach is its ability, through analysis techniques, to break down broad general goals and to convert them into specific achievable objectives. If educators are to take advantage of this strength, then they should begin ISD with broad goals. This did not happen in the M.S.U. field trials. Only specific course objectives were considered.

While the analysis techniques exist, they have not been applied systematically to broad educational goals. Another area needing development, then, is the conceptualization and testing of guidelines for applying systems analysis techniques to educational goals.

Defining the IS: Inputs and Output. As discussed in Chapter IV, an IS can only be defined, and thereby separated from its environment, in terms of the inputs and outputs of the system. Relatively little is known about which types of inputs are needed to design an IS or in which form they are most useful.

Based on experience gained from the field trials, the following conclusions and suggestions are made concerning input data.

1. Input data must be collected from numerous sources and at several levels. The instructor is a surprisingly poor source of input information. He does not have at his disposal the necessary information in some cases; e.g., an instructor does not know the amount of money the university is prepared to commit for the IS treatment of his course. He or the IS designer must collect this information from a higher level. In other cases the course instructor has not gone to the trouble to find the information--for example, in the field trials, the instructors knew very little about the background of his students, particularly what they were studying in other closely related courses.

2. To be useful to the team members, the input information must be specific. Just <u>how</u> specific is not known, but it would seem to depend upon the nature and relevance of the data.

3. The ISD team members need to be trained to use the input data once it is collected. An evaluation specialist, after six hours of interaction with the instructor, during which they worked on course objectives, did not know that a laboratory section accompanied the course. This fact was available on course materials collected earlier as input data.

One of the factors which can be used to guide the collection of input data is the requirements placed upon the system. The output specifications are worked into their final form during the analysis of requirements.

<u>Analysis of Requirements: Objectives and Behaviors</u>. Considering the difficulty encountered by the instructors and the evaluation specialists in the two field trials, it must be concluded that analysis of specific system requirements, i.e. specifying the objectives of the course in measurable behavioral terms, needs to be given further study. Some of the questions which should be considered during a study of the analysis of requirements are:

1. Should (a) the course instructor be trained

to write behavioral objectives, or (b) the evaluation specialist (ES) sit in on the course prior to ISD, or (c) the instructor teach the course in an abbreviated manner to the ES in order for the ES to write the objectives?

2. How specific should a terminal behavior be in order to design instructional materials which will produce or induce the desired behaviors?

3. Can a standard format for writing objectives be established in order to increase the amount of information communicated by each objective?

4. Would an articulate student be valuable in identifying objectives? Would he be particularly helpful in identifying objectives which were not directly related to the subject matter of the course?

5. Would it be helpful to establish a hierarchy of importance for the objectives of a particular course in order to establish a clear direction for the course?

6. How can the conflict between mastery of the course content and the task requirements be resolved? This question merits some amplification because it was a constant source of confusion during the field trials. If the content of the course consisted only of a block, or units of subject matter to be taught, then it would have

been relatively easy to break subject matter down into a series of test questions which would determine if the student had mastered the material. However, the requirement that the student's achievement be measured in behavioral terms, which implies that the student must demonstrate his ability to apply what he has learned, is more difficult to achieve. It is particularly difficult to determine under what conditions the student is to demonstrate his ability to apply his newly acquired knowledge. It is also particularly difficult to demonstrate and evaluate the acquisition of affective behaviors.

7. Is the order of presentation to the student determined by the "logic" of the content or by the "logic" of the behaviors which are to be demonstrated by the student? In order to provide for individual differences, should the content be organized into independent units and the student be permitted to determine his own order of presentation?

Many other questions could be posed concerning objectives and their translation into measured changes in student behavior, but those listed above should be sufficient to indicate a real need for further study in this area.

Strategies of Instruction. Before an instructional system designer can base his design decisions on scientific facts, developmental and experimental research needs to be conducted in the area of instructional strategies. Very little is known about the relative merits of various instructional strategies; that is, whether to specify that students work through a programed unit, attend a small group discussion, listen to a large group lecture, or participate in one or more of a number of other learning situations which can be useful in fulfilling the course objectives. A study should be undertaken which would delineate all of the known strategies and attempt to describe the merits of each. Much of the work has already been completed within the individual strategy; e.g., programed instruction as an instructional strategy has been reasonably well developed. But the integration of the various strategies and the relationship between instructional media and the strategies remain to be developed. Figure 5 shows one possible configuration of instructional strategies. While the diagram is far from complete, it does serve to illustrate some of the many alternatives which are available.

While most of the objectives detailed in an instructional system are related to subject matter, a small but important portion will be related to affective objectives, such as the development of leadership capabilities. These more intangible objectives need to be planned for, using special strategies. What strategies might be most

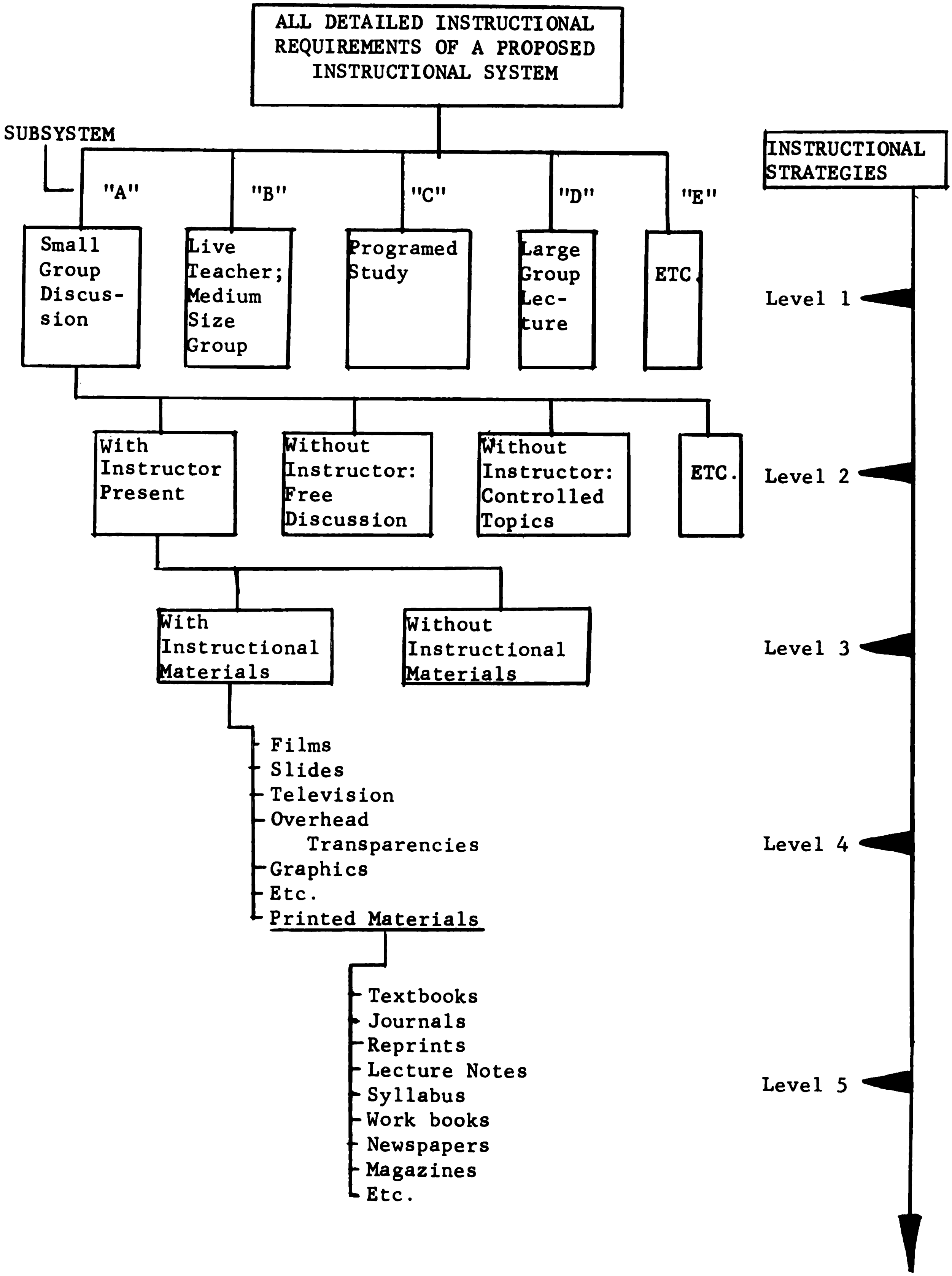
ALL DETAILED INSTRUCTIONAL REQUIREMENTS OF A PROPOSED INSTRUCTIONAL SYSTEM
SUBSYSTEM
"A"
"B"
"C"
"D"
"E"
INSTRUCTIONAL STRATEGIES
Small Group Discus-sion
Live Teacher; Medium Size Group
Programed Study
Large Group Lec-ture
ETC.
Level 1
With Instructor Present
Without Instructor: Free Discussion
Without Instructor: Controlled Topics
ETC.
Level 2
With Instructional Materials
Without Instructional Materials
Level 3
Films
Slides
Television
Overhead Transparencies
Graphics
Etc.
Printed Materials
Level 4
Textbooks
Journals
Reprints
Lecture Notes
Syllabus
Work books
Newspapers
Magazines
Etc.
Level 5

Fig. 5

fruitful is an area not yet explored by systems designers.

Selecting and Producing Instructional Materials. If the instructional strategy includes the use of instructional materials, then teaching examples must be chosen and instructional materials must be selected from existing supplies or new materials must be produced to meet the requirements.

When selecting the teaching examples, the instructor or subject matter expert must be well versed in the universe of teaching examples. If he is not, then some system needs to be created which will quickly introduce him to them. If none exist, then they must be created; however, it is surprisingly difficult and time consuming to create good teaching examples.

The search conducted by the instructional materials specialist at M.S.U. for existing materials which met the teaching requirements was not very successful. Better search techniques are needed. This requires some means of coding the materials before storage so that it can be retrieved when needed. The coding probably should be done in terms of teaching examples included within the particular piece of instructional material.

During the actual production of instructional materials, the instructor's ability to think graphically seemed to determine the overall success of production.

Media production specialists found it frustrating to work with an instructor who couldn't quite visualize what the finished product would look like.

Another problem in the production of materials is the use of graphic symbols. Perhaps a dictionary or chart of graphic symbols should be developed to aid in communication between the production specialist and the subject matter expert.

<u>System Synthesis: Modeling and Flowcharting</u>. Although modeling and flowcharting techniques were not used in the two field trials, these techniques are considered to be of vital importance in the process of IS development. To what extent existing system modeling and flowcharting techniques will have to be modified in order to be successfully applied to IS remains to be determined.

System simulation is also a synthesis technique which is an integral part of system design. Of all the system design techniques which are available for use in IS design, simulation is perhaps the most difficult to apply to an IS. In spite of the complexities involved, however, it is recommended that efforts be made to render the technique applicable.

<u>Feedback: Testing, Evaluation and Redesign</u>. The final phase of an IS design problem includes field testing, eval-

uation of the feedback and then redesign of the system based on the evaluation. Considerable room for development remains in this area. Conventional educational testing and evaluation techniques should be integrated into an instructional systems theory framework in order to take advantage of the work which has already been completed.

SUMMARY AND CONCLUSIONS

The instructional systems approach to curricular planning seems to have great potential as an instructional planning technique. Its two greatest contributions are the capability to identify key instructional decision points and a management/planning methodology which permits educators to take optimum advantage of what is known about the art of teaching. This potential, however, is largely unrealized because a comprehensive instructional system theory which is capable of producing a "true" instructional system has yet to be developed. Because of the need for an instructional system theory, the following recommendations which can guide its development are summarized below.

Theoretical Concerns

1. Instructional system theory should be developed within the framework of a social system theory. It should not develop within an industrial-military training system

theory because of the philosophical differences between training and education.

2. Training oriented system design experts should not be permitted to make instructional decisions.

3. Strategies of instruction, including those that are technologically oriented, must undergo extensive development before their potential can be realized.

4. The various strategies of instruction must be unified to form a workable theory of instruction which can operate within the parameters of an instructional system theory.

As a result of the analysis of Michigan State University's instructional system field trials, a number of operational problems which merit further study were noted. These are summarized into two groups; those which should be resolved before instructional system development begins and those which are of concern during ISD.

Concerns Prior to ISD

1. The validity of the course. The course which is being considered for ISD should be both internally and externally valid.

2. The role of the instructor. It should be determined prior to ISD which of the several possible roles the course instructor will assume. He should be involved in all phases of ISD to insure maximum personal growth.

3. The availability of primary technology. The availability of an established network of primary instructional technology seems to be a prerequisite to the development of an IS.

4. A priority policy. A central administrative unit of the university should establish a policy regulating priorities for course development through ISD.

5. The question of utility. An extensive study should be conducted on the cost of input versus the desirability of output in ISD.

6. Training the ISD team. A thorough training program should be developed to train the instructor and the interdisciplinary team in system design procedures.

7. Public relations. An active public relations program should be established to inform the university faculty, students, and other interested individuals of ISD activities.

Problem Areas within ISD

1. The determination and statement of IS goals.

2. The collection and use of input data.

3. The analysis of the objectives and behaviors which constitute the instructional system's requirements.

4. The selection, implementation, and evaluation of instructional strategies.

5. The storage and retrieval of instructional materials according to the behavioral objectives which they are designed to accomplish.

6. The production of instructional materials which are designed to fulfill specific behavioral objectives.

7. Simulation of the newly synthesized instructional system.

8. The collection and evaluation of feedback systems which will permit the redesign of instructional systems.

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APPENDICES

APPENDIX A

PHASE III

	Date	Time	Length	Tape
Coordinator				
Jack Gordon - Harry Hedges, E.E.	5/29/64	1:00 pm	1 hr.	2
Jack Gordon - John Kreer, E.E.	6/17	9:00 am	1 hr.	9
Jack Gordon - E.C. Reynolds, T.A.	5/28	9:30 am	1 hr.	1
Jack Gordon - A. Collins, T.A.	6/3	1:30 pm	1 hr.	3
Evaluation Specialist				
Richard Cox - Harry Hedges, EE	6/16	2:00 pm	2 hrs.	6
" " - " "	6/17	2:00 pm	2 hrs.	8
" " - " "	6/18	2:00 pm	2 hrs.	12
Richard Cox - A. Collins, TA	7/2	2:30 pm	2 hrs.	20
" " - " "	7/3	2:30 pm	2 hrs.	19
" " - " "	7/7	2:30 pm	2 hrs.	22
" " - " "	7/15	1:00 pm	2 hrs.	29
Dr. Lee Olson - John Kreer, EE	7/14	9:00 am	2 hrs.	26
" " " - " "	7/15	9:00 am	2 hrs.	27
" " " - " "	7/16	9:00 am	2 hrs.	30a
Dr. Lee Olson - E.C. Reynolds,TA	6/16	9:00 am	2 hrs.	4
" " " - " "	6/17	9:00 am	2 hrs.	7
" " " - " "	6/18	9:00 am	2 hrs.	10,11
Instructional Specialists				
H. Hartsell - Harry Hedges, EE	6/23		2 hrs.	14
" " - " "	6/30	9-12	3 hrs.	No recording
" " - " "	7/2	9-12	3 hrs.	17
" " - " "	7/8	9-12	3 hrs.	21
" " - " "	7/9	9-12	3 hrs.	24
" " - " "	7/16	9:00 am	2 hrs.	28
" " - " "	7/21	9-12	3 hrs.	No recording

. . . continued

APPENDIX A (continued)

	Date	Time	Length	Tape
H. Hartsell - Richard Cox, Ev.Spec.	6/19/64		2 hrs.	13
" " - " "	7/20		2 hrs.	31
H. Hartsell - A. Collins, TA	8/26	9:00 am	2 hrs.	39
" " - " " & Barson	8/28		1 hr.	40
" " - " " " "	9/3	2:00 pm	2-1/2 hrs.	41
John Barson - Lee Olson, Ev.Spec.	6/19		2 hrs.	5
John Barson - John Kreer, EE	7/20	3:00 pm	2 hrs.	30b
" " - " "	7/22	9:00 am	2 hrs.	32
" " - " "	7/23	9:00 am	2 hrs.	33
" " - " "	7/27	9:00 am	2 hrs.	34
" " - " "	8/25			No recording
John Barson - E.C. Reynolds, TA	6/26	10:00 am	2 hrs.	
" " - " "	6/30	10-11	1 hr.	15
" " - " "	7/2	9-10	1 hr.	16
" " - " "	7/3	9-10	1 hr.	18
" " - " "	7/8	9-11	2 hrs.	23
" " - " "	7/9	9-11	2 hrs.	25

Producers

Veenendahl - Mabrey	7/23	9:30-11	1-1/2 hrs.	35
Veenendahl -	7/28	9:30-11	1-1/2 hrs.	36
McCoy - Mabrey & Kreer, EE	8/4	9:00	2-1/2 hrs.	37

APPENDIX B-1

Instructional System Development Procedures #1

Initial Data Sheet

Project #____________
Instructor:__________
Title:______________
Department:__________
Telephone No.:_______
Date:________________

I. Assistance Desired: (Film Rental, Slide Production, Systemization of course instructional activity, etc.)

II. Rationale Leading to Need for Assistance: (Increased number of students, limited facilities, student and instructor discontent, etc.)

III. Prescribed Action:

(a) Confer with:________Date:________Confirmed:(Initials)
Concerning: (Specific Problem A)

(b) Confer with:________Date:________Confirmed:(Initials)
Concerning: (Specific Problem B)

APPENDIX B-1 (continued)

IV. Action Taken: Description: Date:______

APPENDIX B-1 (continued)

V. Follow up: (Satisfaction, etc.) Date:_________

APPENDIX B-2

Instructional System Development Procedures #2

Project #:_______

Date:_____________

Input Data Sheet

(The following sheet is used to compile information needed in making specific instructional decisions.)

I) Course Name, Number, and Catalog Description:

II) Expected Student Enrollment per Term:

III) Present Schedule Sequence and Flexibility to Change:

IV) Classroom Facilities:

V) Availability of Instructor(s) for Developmental Activities:

APPENDIX B-2 (continued)

Procedures #2 - Page 2

VI) <u>Finances Available (Indicate Range)</u>:

A. Course Operation <u>Amt</u>.

1. Staff ______________
2. Materials ______________
3. Equipment ______________

B. Course Development <u>Amt</u>.

1. Staff ______________
2. Materials ______________
3. Equipment ______________

VII) <u>Departmental Aids to Instruction</u>: (Graduate Assistants, Motion Picture Projectors, Language Lab, etc.)

VIII) <u>Specific Course Aids Available</u>: (Bibliographies, Study Guides, etc.)

APPENDIX B-2 (continued)

Procedures #2 - Page 3

IX) Syllabus: (Attach copy if available)

X) Departmental Policies Having Direct Bearing on Specific Course:

XI) Additional Information Pertinent to Situation:

APPENDIX C

AID TO IDENTIFICATION OF COURSE OBJECTIVES - Part I

I. Actions - The following are an attempt and therefore, guide, to the categorization of student behaviors dealing with information. They hopefully form a hierarchy from simple to complex.

   A. Recognition - To identify the correct alternative among a number of alternatives -- to discriminate.

      1. Reorganize - To identify both parts and whole - to be aware of relations between parts as well as their differences.

   B. Recall - To retrieve information from memory given both simple and complex hints.

      1. List - Recall both parts and the order among the parts.

   C. Translate - Transfer given information into new code - paraphrase.

      1. Condense - summarization - less words than original - cryptic - abstract.
      2. Expand - to become redundant or enlarge upon original.

   D. Infer - To draw solution from problem.

      1. Deduce - reasoning from the general to the particular.
      2. Induce - reasoning from the particular to the general.
      3. Analyze - breaking a whole into its component parts.
      4. Synthesize - building a whole from its component parts.
      5. Evaluate - weighing a new object or situation in light of a given criteria.
      6. Apply - using information in new situations.

   E. Create - To produce a work of thought or imagination.

APPENDIX C

AID TO IDENTIFICATION OF COURSE OBJECTIVES - Part II

II. Levels of Content - Below are possible categories which lead to efficient breakdown of subject matter.

A. Associations - tying of a certain symbol to an object or situation. e.g., foreign language.

B. Concepts - a set of objects or events differing in physical appearance, defined as a class. e.g., "chair", "round", "courage".

C. Principles - if-then statements usually concerning two or more concepts. e.g., "If the temperature is raised, the pressure goes up."

D. Strategies - The chaining of principles - problem-solving activities. e.g., using the scientific method.

APPENDIX C

AID TO IDENTIFICATION OF COURSE OBJECTIVES - Part III

Content-Behavior Matrix

III. The combination of Parts I and II form a matrix which might lead to more efficient determination of course objectives.

	CONTENT			
ACTIONS	Association	Concepts	Principles	Strategies
Recognize Reorganize				
Recall List				
Translate Condense Expand				
Infer Deduce Induce Analyze Synthesize Evaluate Apply				
Create				

APPENDIX D
CONTENT AND INSTRUCTIONAL PROCEDURES ANALYSIS FORM

Time Allotment	Content Outline	Pre-sent	Preferred	Available	Suggested	Production Needs
1st hr.	General Introduction--Course Req.	LC	LC			
2nd hr.	What Is Drama: Chronology of dramatic form Evolution from ritual 1. Primitive need to control environment and under-stand uni-verse Step to impersona-tion Conflict element Vicarious enlarge-ment of life through ob-servation	LC	LC - plus FS or S Show primitive rituals from various areas Watusi--Bear dance? Emp. mimetic function of participants in increasing degree of sophistication Show vicarious function of newspapers, books, drama Emphasize conflict Animation? Puppets? Newsreel clips -			

Etc.

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APPENDIX D (continued)

Time Allotment	Content Outline	Present	Preferred	Available	Suggested	Production Needs
8-9th hr.	Musical Comedy (Pal Joey, King & I) History of musical comedy Leading figures Modern developments	LC, DR, TR	LC, TR, and 16 mm	TR of old and new recordings- James Cagney George M. Cohan, Jeanette McDonald & Nelson Eddy, Pal Joey, Guys and Dolls, Pajama Game	Same-plus film clips of old musicals	
10th hr.	Absurdist Drama Definition Function of Author Debt to expressionism	LC	LC & 16 mm	Film of Absurdist drama?	Film of Absurdist production	2 x 2 slides on sketches of stages
11th hr.	Dramatic Criticism	LC				
12th hr.	Dramatic Criticism Implication of scientific thought					

. . . continued

APPENDIX D (continued)

Time Allotment	Content Outline	Pre-sent	Preferred	Available	Suggested	Production Needs
13th hr.	Form of Theatre - Architecture	LC & S	LC, S, OHT?, 1,2,3	Showing ground plans of theatres through various periods of drama--would have to be through conference w/ instructor.		

SYMBOL KEY:

CCTV - Closed Circuit TV
CH - Chart
DI - Group Discussion
DR - Disc Recording
FB - Felt Board
FS - Filmstrip
LC - Lecture
LD - Live Demonstration
MO - Model or mockup
MP - Motion picture

OHT - Overhead Transparency
OHT - 1,2,3, etc. Overhead Transparency with 1,2,3 or more overlays
OP - Opaque Projection
PI - Programed Instruction
S - 2 x 2 slides
TR - Tape Recording
8mm - 8 millimeter film
16mm - 16 millimeter film