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ABSTRACT

In a controlled experiment, the IIEP attempted to develop efficient teaching materials in the field of educational planning. Informal instructional materials were compiled from the tape recordings, transcriptions, and summary notes of seminars, lectures, and discussions conducted by the IIEP in its training and research program. This instructional unit explains and demonstrates the use of a systems approach and provides guidelines for the development of instructional systems. Related documents are EA 003 931-936, and EA 003 938-942. (RA)

The Fundamentals of Educational Planning : Lecture - Discussion Series

No. 45 SYSTEMS ANALYSIS AND EDUCATIONAL DESIGN

by T. A. Razik

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SYSTEMS ANALYSIS AND EDUCATIONAL DESIGN

by

T.A. Razik

This lecture is part of 'Fundamentals of Educational Planning Lecture-Discussion Series' a controlled experiment undertaken by the International Institute for Educational Planning in collaboration with a limited number of organizations and individuals aiming at the development of efficient teaching materials in the field of educational planning. By their very nature these materials, which draw upon tape recordings, transcriptions and summary notes of seminars, lectures and discussions conducted by IIEP as part of its training and research programme, are informal and not subject to the type of editing customary for published documents. They are therefore not to be considered as 'official publications'.

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CONTENTS

I INTRODUCTION AND DEFINITION OF A SYSTEMS APPROACH

The special meaning of the term systems and such related terms as systems concept, and systems approach and systems analysis, emerged during and after World War II as a result of research and development in problem solving, efficiency analysis and most important, the development of complex man-machine systems. A classic example of this is the development of combat aircraft during World War II. In building such aircraft, designers realized that they could not simply take an existing airplane and add communications and detection equipment, weapons, bomb and fuel storage space. Adding such equipment at random restricted the plane's carrying capacity, speed manoeuverability, range of flight, and other vital functions. Thus a new method of planning and development emerged, in which designers learned that they first had to identify the purpose and performance expectations of the system before developing the component parts of the whole system. It is the system as a whole - and not its separate parts - that must be planned, designed, developed, installed and managed. What is really important is not how the individual components function separately, but the way they are integrated into the system to achieve its goal.

From the above example, systems can be defined as deliberately designed and structured organisms, comprised of inter-related and interacting components which should function in an integral whole to attain a predetermined and specific purpose.

Since World War II the concept described above has become more sophisticated and has rapidly expanded into new areas. Systems surround us everywhere. In the home, the housewife, cooking equipment, lighting, water supply, storage and disposal facilities, food, dishes, all interact in a planned way to make up a meal-production system. (1) The stove, lighting, heating and plumbing are components of such a system. Their functions are determined by the purposes of the system. Such purpose is attained by execution of the component processes of the meal-production system in order to produce a predetermined outcome - edible food. A further analysis suggests that the purpose of a system

(1) This practical example, along with several others in this paper, is drawn from Benathy, Bela H. Instructional Systems, Fearon Publishers, Palo Alto California.

- in this case, meal production - determines the kind of processes to be followed within the system. These processes include planning the meal, acquiring, storing, preserving and preparing the food as well as the sanitation and environmental control. They are further structured into sub-processes. Procedures for achievement of the purpose of the system govern the selection and employment of specific components, based on the assessed effectiveness in carrying out these processes. For example, food acquisition requires the introduction of such processes financing, selecting sources of supply, purchasing, delivery etc. The components employed in selecting sources of supply may include wife-husband team, other members of the family, friends, newspapers etc. The process of delivery can be performed by members of the family, by a delivery man, by the milkman or by some other means.

This example illustrates the three main aspects of systems: purpose, content and process. The first aspect is that systems have purpose. Systems are built from parts or components, and the sum of these is the content of the system, for the accomplishment of a specific purpose. The operations and functions in which the content is engaged in order to accomplish the purpose of the system sum up the process of the system.

Systems thus have purpose, process and content The relationship of these three aspects is demonstrated in Figure 1.

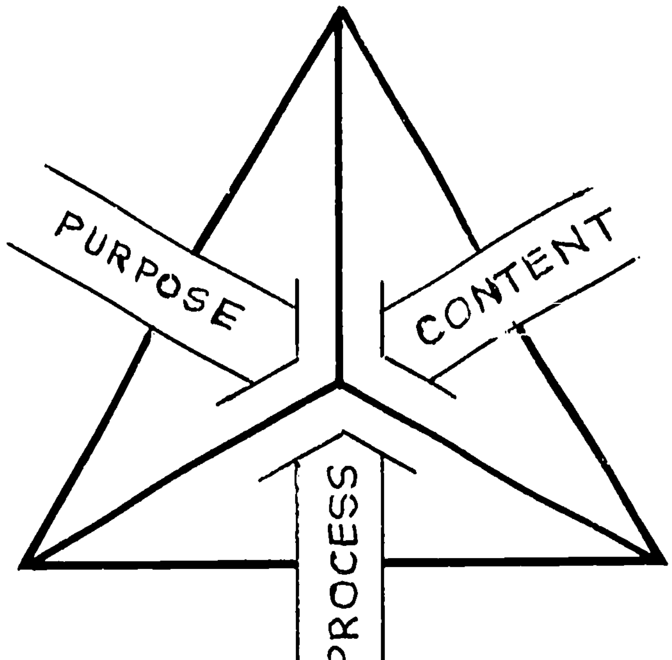

Figure 1. Variables of the system

Supra-systems

The supra-system, from which the meal production system, in the previous example, receives its purpose, resources, demands and limitation is the home. Systems operate in the larger context of their environment. This larger context of any particular is known as the supra-system. For example, the larger context of education is society. Society is the supra-system of education. Figure 2 depicts the relationship of education to society.

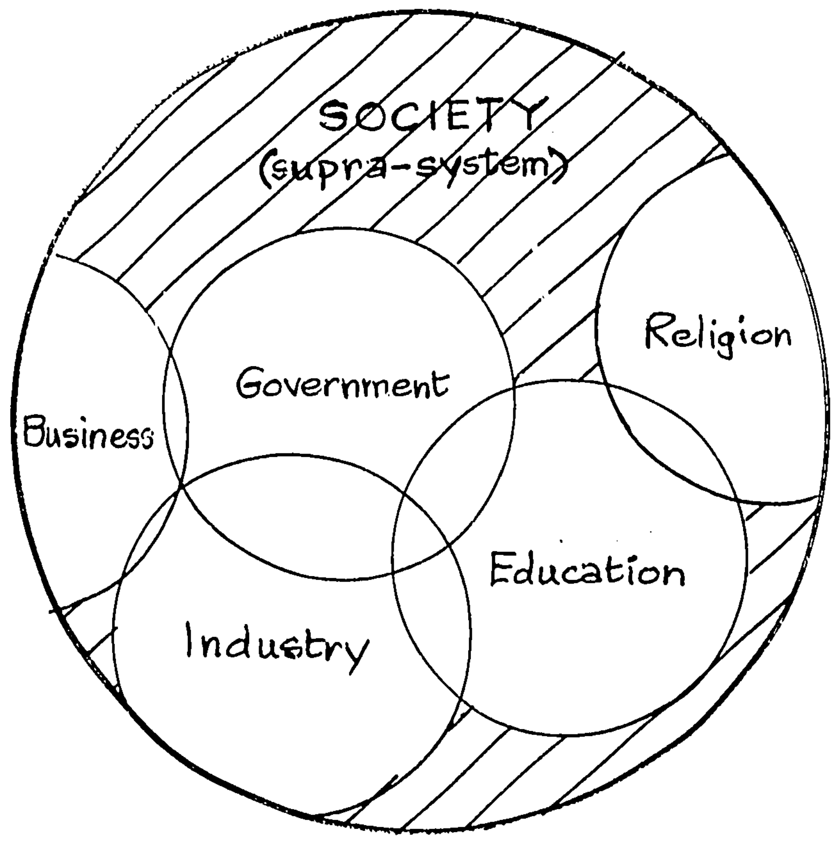

Figure 2. Supra-system

There are also other systems which are usually called sub-systems of society (supra-system). They are called peer systems of education. Business, industry, religion and government are examples of other peer systems. The supra-system has its own purpose, process and content. It surrounds the peer systems and interacts with them and from it the other systems receive their impact. From society, for example, education receives its purpose as well as its students, personnel, material and resources. It is into the supra-system that the system sends its output. In the case of education, these outputs include the person being educated and the knowledge thereby developing. If a system is to maintain itself the adequacy of its output must be assured. In order to achieve this, the system has to provide for continuous assessment of its output and for its feedback into the system. The feedback of the output assessment emerges as a basis for system adjustment. The structural relationship of input-output and feedback is shown in Figure 3, which depicts the first major adjustment demand to be satisfied towards maintaining compatibility of the system within its environment.

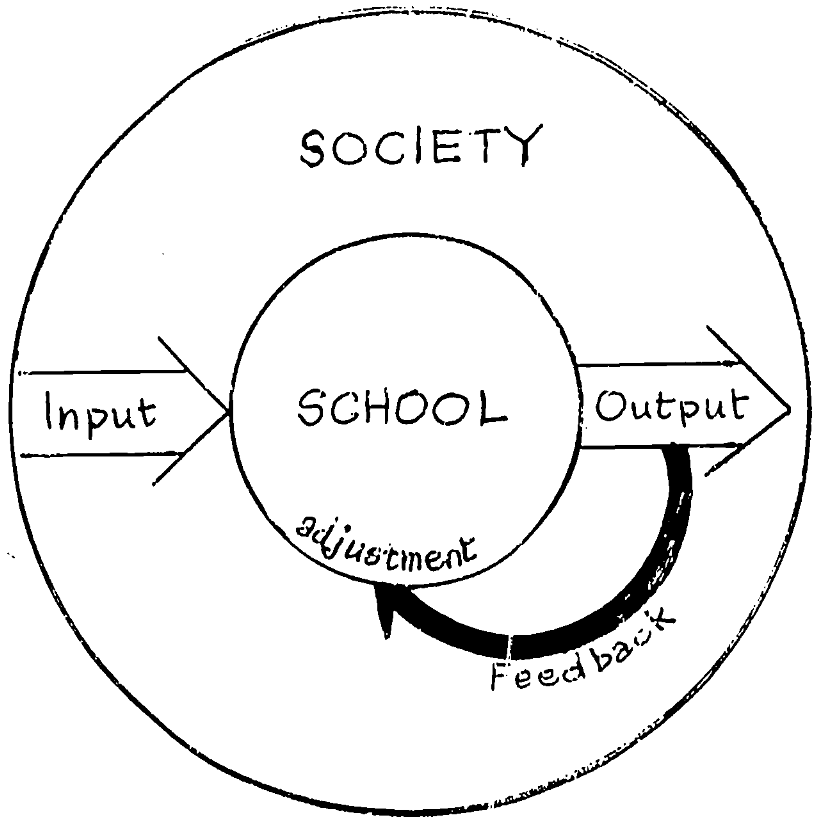

Figure 3 Input-output and feedback relationships

The system must adjust to the constraints imposed by its environment, the available resources of which are usually limited; the efficiency of the system will be judged by the utilization of these resources. The system must be sensitive to the changing needs and purposes of the environment for which it was created. The major purpose of the environment influences or determines the purpose of its component systems thus the system must be continuously aware of this major purpose and must be ready to adjust its own purpose if necessary.

Sub-systems

A sub-system is a part of a total system (gestult). Each sub-system is also designed to carry out a purpose, the attainment of which is necessary in order to achieve the overall purpose of the system. The processes of each sub-system are determined by its purpose. Selection of its content is also based on ability to perform a specific process.

Sub-systems must be integrated. In the meal production example, system planning is integrated with and influenced by food acquisition, which interacts with storage, preservation, preparation and other sub-systems. The effectiveness of the system depends on how well the sub-systems are integrated and how well they interfunction. Figure 4 illustrates this concept.

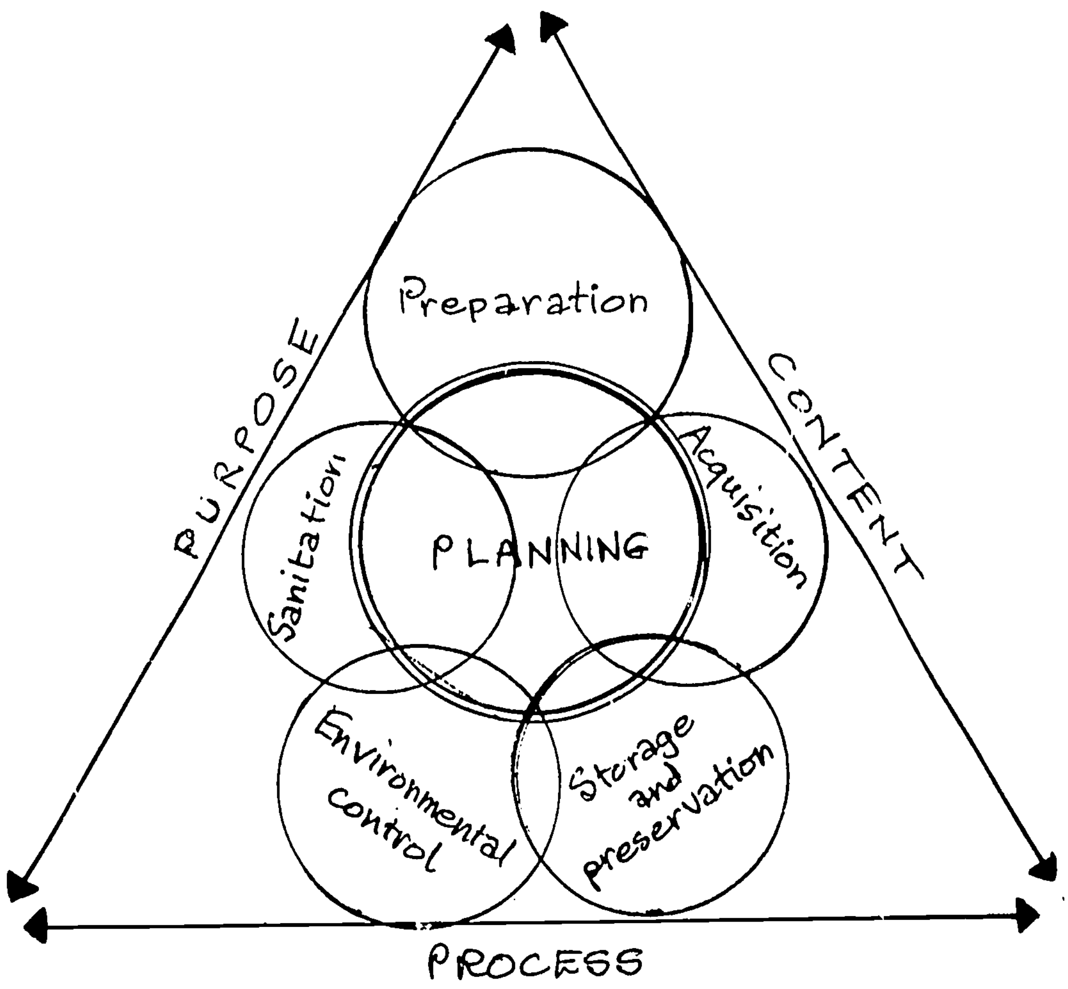

Figure 4.. System/sub-system relationship

Micro-system

Micro-system, applied to education, is derived from the sub-system and is considered the smallest unit of curriculum in which all characteristics of the sub-system are still reflected. It is developed around a clearly defined objective. The mastery of at least one learning task is required and alternatives can be considered for content, learning experiences, motivation and component selection. Furthermore, it can be installed and tested as a unit of the curriculum or lesson or part of a lesson. From the above discussion a comprehensive definition of the special meaning of the term systems should be as follows:

Systems are combinations of variables well designed and organised to attain specific purposes. The purpose of a system is realized by and controls the processes in which the components interact to produce a predetermined output. A system receives its purpose, input, resources and constraints from the relative supra-system. To justify itself, a system must produce an output indispensable to the supra-system.

Systems appraisal and development

Examination of the contemporary use of the systems approach indicates at least three major areas of application. The example of the weapons system presented earlier introduced systems development. The systems approach has been applied to at least two other areas - the analysis of the effectiveness and economy of existing systems, and the solution of complex problems. Generally the terms systems analysis and operations research refer to these applications. The basic systems concept underlines all three above methodologies of systems; many of their strategies are similar. There are, however, several different aspects thus warranting separate treatment and explanation. By design the subject of this discussion has been limited to systems development, which does not, however, imply that the educational application of systems analysis or operations research are of lesser significance. Systems analysis is being used with increasing frequency to evaluate efficiency and effectiveness of educational systems. Operations research offers unique strategies for the solution of complex educational problems.

The systems approach to the development of a system offers a decision-making structure and a set of decision-making strategies, thereby the designer has a self-correcting, logical process for the planning, development and implementation of man-made entities available to him. This provides a procedural framework within which the purpose

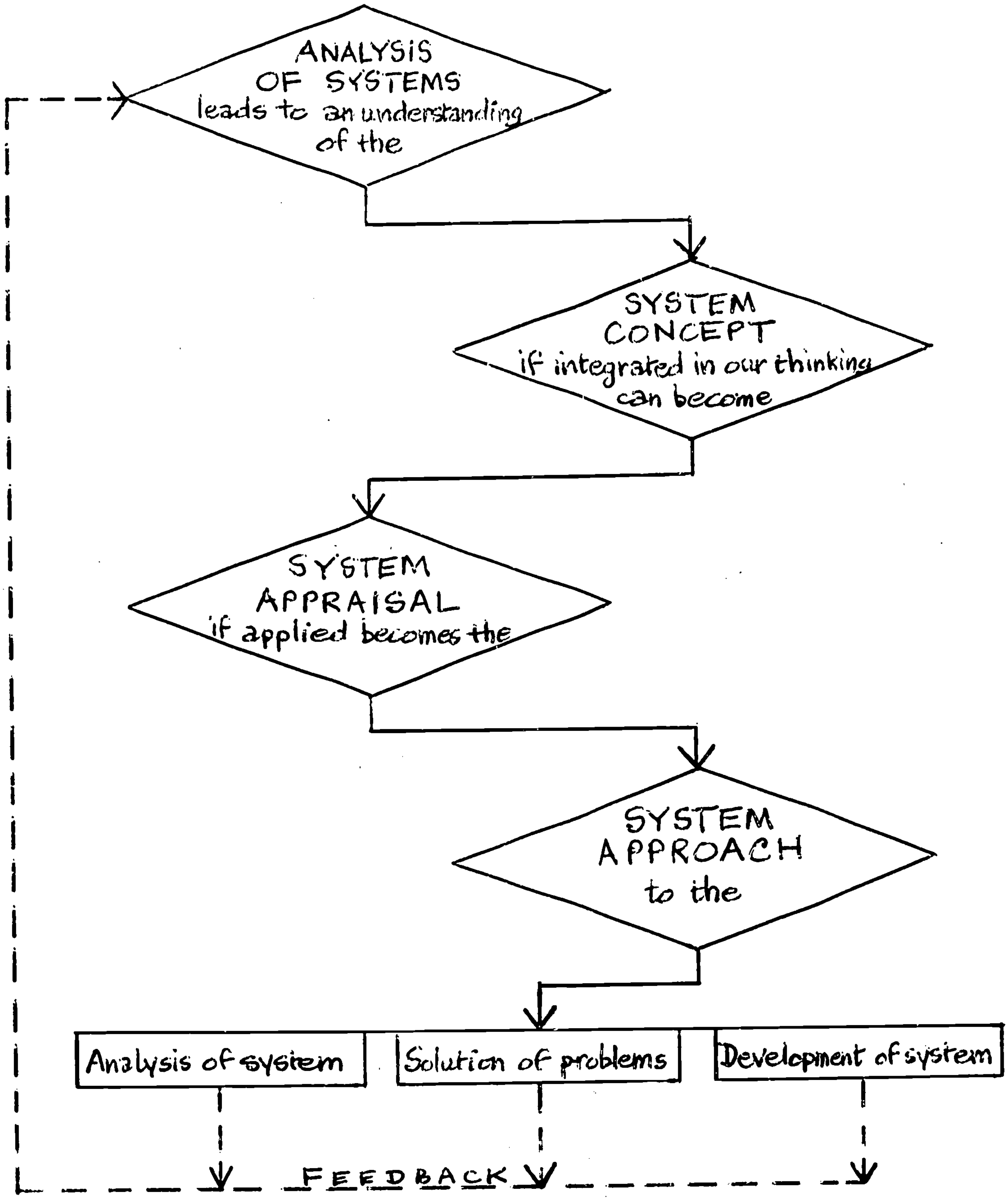

Figure 5. Development of a system

of the system is first specified and then analyzed to find the best way for its achievement. On the basis of this analysis, the components that are most functional for the effective performance of the system should be selected. Thereafter the design of systems planning will ensure that the necessary components will be available at the appropriate time, and will interact with each other as planned. Furthermore continuous evaluation of the system will also ensure the implementation of the purpose and provide a basis for planned change in improving economy and performance. Figure 5 illustrates the above points.

The application of the systems approach to the development and maintenance of systems makes possible the realization of the performance specifications prescribed for the output of the system. If the expected output is not met, the shortcomings can be assessed and the reasons for failure identified. Appropriate adjustments can then be made in both the content and the process to achieve the desired output and optimize the effectiveness of the system.

II SYSTEMS APPROACH AND ITS SIGNIFICANCE TO EDUCATION

In assessing the significance of systems approach to education, it should first be determined whether education is really a system. Education is a man-made structured entity with a specific purpose. Its purpose is usually integrated with and influenced by the purpose of its supra-system, that is society. Any educational activities receive their input, resources, constraints and evaluation of adequacy from society. Education is composed of numerous sub-systems such as curriculum, instruction, guidance, administration etc. Each of these sub-systems has its own objectives that each serve the overall educational purpose. Education is, furthermore, product oriented, its products being the educated person and knowledge provided through research results. Those responsible for education try to promote and practise economy and should attempt to maximise output, while continually improving the product performance with the most economical use of resources. It should be concluded that education is a system evolved in line with the theories of the above discussion and should, therefore, benefit from the application of the systems approach.

Many educators, therefore, realizing the systems nature of education and the unique potential that systems approach can bring to cope with complex problems and the design of educational programmes, have turned to this approach. The designer of instructional systems has only limited reliable research data available to him and must, on account of this, make pragmatic and intuitive design decisions. A considerable experimentation and testing in educational applications of the system approach is urgently required. In order to utilize fully the systems approach in education the most important characteristics relevant to systems approach should be reviewed. These characteristics are as follows:

Insistence upon a clear definition of the purpose of the system: clearly formulated performance expectations to enable construction of criteria that will subsequently indicate the degree to which these expectations have been fulfilled.

Examination of the input characteristics.

Consideration of alternatives and identification of what has to be done, how, by whom or what, when and where etc., to ensure attainment of the predetermined performance.

Implementation of the system and evaluation of its output to measure the degree of fulfilment of the expected performance.

Identification and implementation of any adjustments needed to ensure attainment of the purpose, and to optimize systems output and systems economy.

Translating these major system characteristics into the main domain of educational strategies requires:

Determination of specific learning objectives in behavioural terms, clearly stating what is expected of the learner, what he knows, and feels as an outcome of his learning experiences.

Construction of performance measures to evaluate the degree to which the learner has attained these objectives.

Examination of the input characteristics and abilities of the learner.

Identification of the types of learning as well as events that provide the necessary conditions enabling the learner to perform as expected.

Identification of forms of instructional events to facilitate the teaching-learning situation.

Consideration of alternatives for the selection of learning content, experiences, components and resources needed to achieve the stated behavioural terms.

Installation of the system and collection of information from the findings of performance as well as testing and evaluation.

Regulation of the system, the feedback from testing and evaluation will determine modifications of the system to ensure ever-improving learning achievement and optimum system economy.

A survey of contemporary educational trends will lead to the realization of the presence of marked inadequacies in the eight strategies stated above. Statements of educational objectives drawn up by educational policymakers are usually in such general terms that they permit too broad an interpretation of what actual learning tasks are and what content, learning experiences and components would best achieve them. Teachers are not usually accustomed to defining learning outcomes in operational and measurable terms: when questioned on outcome expectations teachers are mostly concerned about finishing the book, or having their students pass their examinations.

Without adquately specified objectives, it is difficult to assess input capabilities relevant to objectives and information on student characteristics is seldom complete. Learning content is usually equated with textbooks and is determined by committees selecting the textbooks. Without clearly identified learning objectives such textbook selections lack relevance. Vague objectives cannot serve as bases for designing output measures and as a result of this students are often uncertain about what is expected of them. They are sometimes tested on materials they have not learned, sometimes obliged to study subjects already mastered or, they are scheduled to master tasks upon which they are never given an opportunity for assessment. In contemporary instructional programmes there is an obvious lack of clearly designed and well-integrated curricula and of internal congruence of objectives, curriculum and testing. There are only a few provisions for improvement of instructional programmes and the learner's performance.

Bases for design of an educational system

Systems are developed around a purpose, which is the nucleus around which it grows. What is the purpose around which systems in education should be built? As Bloom (1956) states, education has three domains:

The cognitive domain which is mainly concerned with knowledge, information;

the affective domain, which includes feelings, attitudes, emotions etc. and

psycho-motor skills in which the learner should master a physical skill.

One of the purposes of education, therefore, is to impart specific knowledge, attitudes and skills. In other words, the purpose around which systems should be designed is instructional. On the other hand, one can propose that the purpose of education is to ensure the attainment of specific knowledge, attitudes and skills. Thus, learning is the purpose around which the educational system is to grow.

From this it is evident that there are crucial differences between instruction and learning. The following discussion demonstrates an educational system with learning as its nucleus. Although the aim here is not to explain the crucial differences between learning and instruction, some points should be mentioned to indicate these differences.

The typical classroom sets up an environment, one person (the teacher) faces 35 or 50 students. This environment is uniformly controlled through regulated instruction. If the learning process was to be seriously studied no-one would seriously support such methods: obviously 35 or 50 persons cannot learn with such limiting uniformity.

40 or 50 minutes is found to be the time usually scheduled for one class period. If learning were in focus, such rigid scheduling would not exist in as much as we know students learn at different speeds. There is, therefore, an urgent need for variation in the periods of time allowed for the mastery of particular learning tasks. In the methodology described above, the teacher's role provides the main source of information:

he is to impart knowledge and the students are his audience. In a learning oriented system, the roles would change; the learner would be on the stage and the teacher would manage the teaching/learning situation.

Hedegard (1967) supports the distinctions made above. He juxtaposed two kinds of educational systems. In the first, the learner's rôle is 'reacting' while the teacher's rôle is 'active'; the teacher selects the content and learning experiences and the learner reacts to them. The teacher-taught processes involve organization, while the student only reacts by making passive connections of impressions. The learner's unique motives are rarely accepted, often discouraged. In the second system, the learner assumes an active rôle in selecting content and learning experiences. His thought processes involve organization and he is required to do more than passively connect impressions. In the learning environment, experiences are sought that are personally satisfying to the learner. Rogers (1967) reports on an instruction-focussed approach according to which

the student was usually not trusted to pursue his own learning;

presentation was assumed to equal learning and any information covered in the classroom was assumed to have been learned by the student;

only what is considered to be established knowledge was covered;

the student learned passively, and

the student had to give an account of his progress at regularly scheduled examinations, the passing of which was the main goal.

In curriculum design, learning should be the focus; systems in education should be built primarily for the promotion of learning. Accordingly instruction is the process rather than the purpose of education. From a systems viewpoint, instruction denotes processes and functions introduced into the learner's environment, to facilitate the mastery of specific learning tasks. Therefore any interaction between the learner and his environment through which the learner is making progress towards the attainment of specific knowledge, attitudes and skills is viewed as instruction.

An instructional system can be assessed by the degree to which it provides an effective system for the learner. Such a system serves its purpose to the extent of achievement in the environment of the learner of all the possible interactions that will result in the attainment of the desired performance. Through the line of reasoning developed here, it is believed that instruction can become fully compatible with learning. By this means of rationale the subject Instructional Systems was selected here for this discussion.

The Design of an Instructional System

The development of an instructional system (system for learning) is a decision-making operation. Decisions have to be made on what should be learned, how, by whom, when and where, how learning should be evaluated and improved and what resources should be involved in preparing and providing for learning. The systems approach to instructional design and its development offers a logical structure and the efficient use of strategies for making these curriculum decisions.

Figure 6 introduces the structure and describes the systems strategies that can be utilized in the development of any instructional system The objectives of the system determine the relative design and action needed to attain them. The design is then implemented and the output tested by criteria developed on the basis of objectives specifications.

The test findings are interpreted to measure the extent of the accomplishment of these objectives and, if necessary, the system redesigned to ensure this.

In considering the structure as illustrated in Figure 6 the following points should be considered;

Identify behavioural objectives.

Determine and formulate a precise account of what the learner is expected to do, know and feel as a result of his learning experiences (formulate behavioural objectives).

Construct performance measures to be based on objectives and use them to test terminal proficiency (develop test).

Find out what has to be learned by the student so that he can behave in the way described by the objectives specified. In the course of this analysis, the input capabilities of the learner must also be assessed (analysis of learning tasks).

Consider alternatives and state action proposed to ensure that the learner will master the tasks (function analysis).

Determine who or what has the best potential to accomplish these functions (component analysis).

Decide when and where the functions are to be carried out (design of the system).

The designed system can now be tried out or tested, implemented and installed. The performance of the learner, who is the product of the system, should be evaluated in order to assess the degree to which he behaves in the way described (implement and test output).

Establishing the evaluation and then feed back into the system to forecast any necessary changes that might be needed to improve the system (modify or change and improve).

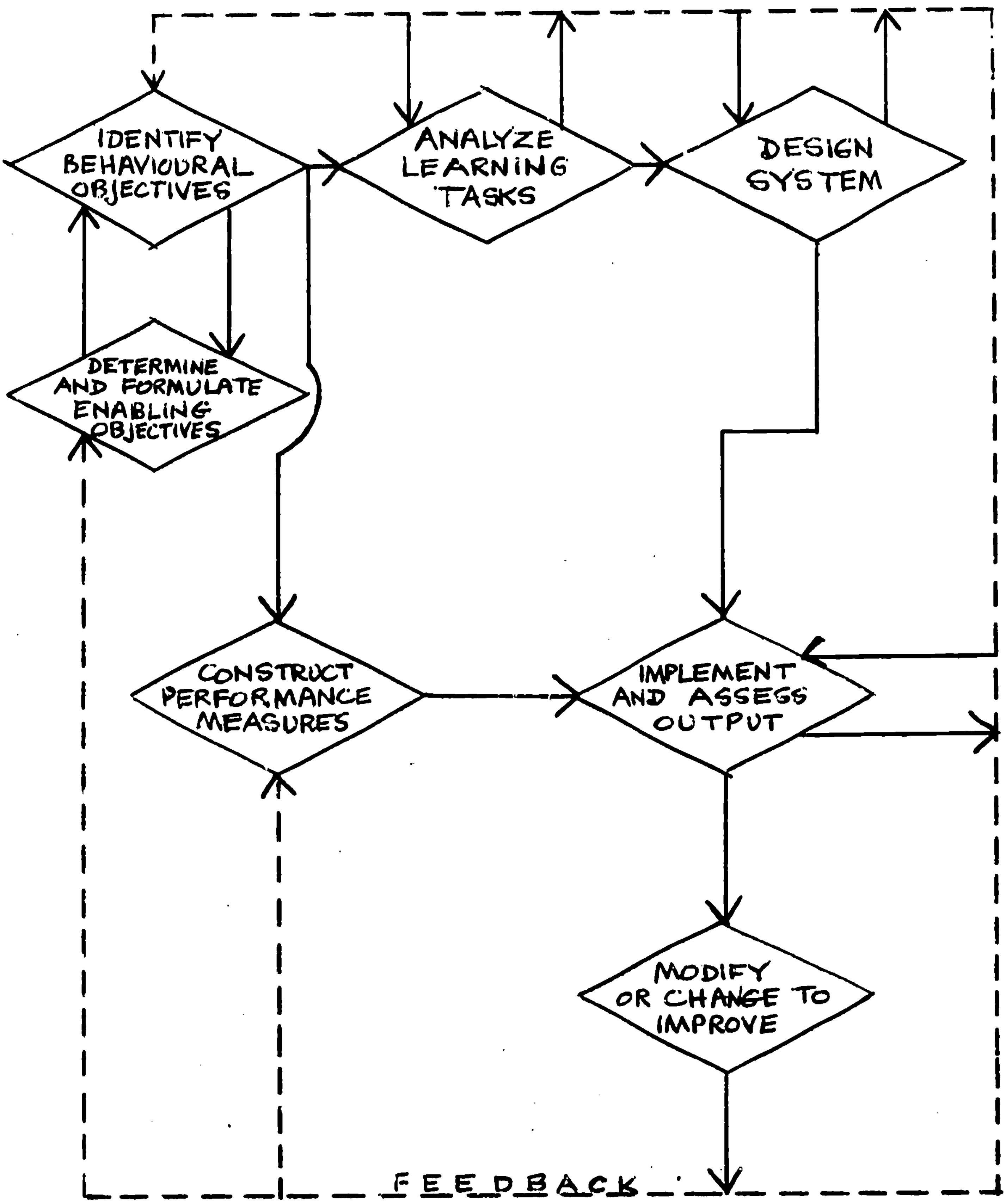

Figure 6. The design of an instructional system

With a broad framework as presented above, it is important to identify and discuss the component strategies of the development and design of an instructional system.

Determination and Formulation of Objectives

First, the overall purpose of the system must be established by determining the goal for attainment by the learner. Performance objectives can then be derived and carefully described.

An educational system can best be identified by its purpose, which establishes the nucleus around which the system should grow. In general terms this purpose is the reason for the system's existence, and should provide key information on the whole system, as well as describing its environment and the broad constraints under which it operates. The broad objectives are significant as specific constraints will be considered only during the design phase of the development of the system.

To illustrate the purpose, consider for a hypothetical course entitled 'The Application of Systems Approach' the emphasis would be on the application of the systems approach towards development of a system for learning. As an output, the student is expected to construct a system in a subject area of his own choice. The course would aim to:

Develop an understanding of the systems concept from which a systems view of the purpose would be evolved;

assist learners to select a purpose around which to build their systems;

demonstrate to the learner the potential and the strategy of the systems approach in systems design;

guide the learners in the application of the systems approach to their selected project;

provide opportunities for the learner to demonstrate their competence in the use of the systems approach.

The following statement describes the environment of the above proposed course and its constraints:

> "This course - The Application of Systems Approach - is offered broadly, to the working environment of learners such as teachers, curriculum specialists, educational planners, and administrative personnel, who most likely will take this course as part of their professional development programme.
> The above proposed course is taught by an instructor

in fifteen three-hour sessions. Only limited library facilities are available."

A statement of the purpose, however, is not a statement of objectives, but it serves the point of departure in formulating such objectives.

Specification of objectives

The systems approach confronts the planner with specific requirements as to how the objectives should be stated. Evolving these requirements, Mager, Tyler, Smith and Gagné provide some valuable guidelines in this regard. Objectives are deduced from the purpose of the system therefore a statement of objectives should specify:

What the learner is expected to be able to do, by
- using verbs that denote observable action;
- indicating the stimulus that is to evoke the behaviour of the learner;
- specifying resources (objects) to be used by the learner and those with whom he is closely associated.

How effective the behaviour of the learner will be displayed by identifying
- accuracy or correctness of his response,
- response length, speed, rate etc.

Under what circumstances the learner is expected to perform by specifying
- physical or situational circumstances,
- psychological conditions.

If the objectives are formulated in this manner, their attainment will be measurable and they can also serve as a basis for the development of the system. The following example demonstrates the formulation of the objectives derived from one of the purposes of the above proposed course, namely, The Application of the Systems Approach.

Objectives for Demonstrating Competence in the use of the Systems Approach to the Development of a sub-System and/or Micro-System

Applying the strategy of the systems approach, learners of the above proposed course will be able to develop, install and evaluate a micro-system of their choice. It is expected that the user of this micro-system will attain predetermined objectives or, if not, the designer of the system will be able to adjust his system so that the objectives will eventually be attained.

How do these objectives describe what is expected?
Do the verbs used denote observable action? Do the learners describe the micro-system they developed, noting both the process and the product?
These verbs indicate the stimulus that should evoke the expected behaviour?
How do these objectives state the performance expectations?
The use of this micro-system is anticipated to attain predetermined objectives or, if not, the designer can adjust his system in order to ensure attainment.
Submission of the micro-system the learner develops noting both the process of development, installation, evaluation, modification and/or change and the products of the developmental efforts.
How do the objectives state the circumstances under which the learner is expected to perform? There are two factors:
The designer is expected to install his system; this implies operation in an instructional environment.
A written statement which must explain the criterion behaviour demonstrated by the learner.

The above analysis of the sample objectives indicates that the criterion suggested for the determination and formulation of objectives was applied. But are these objectives, in the form stated, specific enough? How refined or specific should these objectives be? By continual refinement the designer should arrive at a level of precision that specifies each individual task. The above objectives can be further characterized on the task level as follows:
A statement of purpose of the selected system defining the anticipated learning environment and constraints.
Description of the processes and products of the planning and development of the micro-system. Descriptions should include all the following items: (i) A statement of objectives which should specify what the learner is expected to be able to know, do and feel as an outcome of his learning experiences. It should also specify how well the learner is expected to perform and under what circumstances The description should include the expected behaviour, use verbs denoting observable action and indicate the stimuli that produce such action. The expected behaviour should be specified in terms of the smallest independent unit performance. (ii) A description of the assessment measures for learner performance at the output point. These measures are also used for the quality control of the system. (iii) An inventory of learning. This is the result of an analysis of learning tasks. Based on a description of performance tasks, the analysis identifies what the individual has to learn and what performance is expected of him. (iv) A statement

of expected input competence, which is an assessment of capabilities of the learner in relation to the inventory of learning tasks. (v) A description of the test by which the input competences will be measured. (vi) A statement of actual learning tasks which is evolved by computing the difference between the inventory of learning and the learner's assumed knowledge at the input point. (vii) The characteristics of learning tasks. Identification of the type of learning the task represents and estimation of learning difficulty. (viii) A presentation of the learning structure which is the product of the arrangement of learning task categories. This arrangement is guided by an inquiry into a logical sequence - the attainment of Class A is a prerequisite of the learning of task B etc. (ix) An identification of functions, that provides for the acquisition of specified learning tasks and thus for the achievement of stated objectives; this is the outcome of functions analysis. The following variables should be considered here:

selection and organization of content;
selection and organization of learning experiences;
management of learning;
provision of effective learning;
evaluation of the system and continuous progress of the learner.

Describe plans for carrying out the above selected functions and consideration of alternatives and rationale for selection of particular alternatives. (x) A description of the survey of components. Consideration of all feasible components, human media and other material resources that have the potential to carry out these functions Rationale for distribution of the above functions among components. (xi) A schedule of what functions will take place, when and where they will be conducted, and by whom. (xii) A description of plans and procedures for the preparation of instructional materials for systems training and systems testing. (xiii) Report on how the system was installed. (xiv) A report on the results of evaluating the students, noting modification and/or change, which are planned to improve the system, as based on the findings of the output testing.

From the above points it is noted that objectives samples should be very specific in stating the expected outcome of learning. There are three factors necessitating such specific objectives. They are as follows:

A description of terminal performance forms the basis for the construction of the criterion test. This is the measuring instrument for assessment of achievement of the objective as the key means to the quality control system. Objectives should, therefore, be stated in measurable terms.

Objectives should also be stated in operational terms, which means that there should be sufficient detail as bases of departure for the actual development of the system under description.

Objectives should be formulated to communicate accurately what is to be achieved by the learner, the teacher and all personnel involved.

Reviewing the objectives further considerations can be made. The processes involve stating the purpose of the system, deriving objectives from the purpose and specifying objectives and appear to be of two kinds: analysis and synthesis. The purpose is subjected to an analysis to obtain operational and measurable descriptions of objectives. A further analysis should lead to refinement on the task level. The formation of these objectives also includes synthesis inasmuch as they have to be constructed according to predetermined criteria. In systems design these two processes are often interwoven. However initial strategies of systems development lay more emphasis on analysis than in subsequent strategies.

Analysis of learning tasks (1)

Once the specific performance expected of the learner has been identified, the next steps aimed at successful performance must be considered. The systems designer should analyse and formulate the learning tasks; this is a structural procedure composed of a set of strategies as shown in Figure 7. If, from a statement of objectives, the particular terminal performance expected of the learner is known, the human capabilities of learner-skill, knowledge and attitudes that the individual needs to carry out specified output performance must be determined.

It is important that the difference between performance and learning tasks is understood. Performance tasks, as described in the statement of objectives, indicate the behaviour of which the product of the system should be capable at the output point. Learning tasks and their analysis identify the extent of learning to be undertaken to enable demonstration of the performance described. Although the need to conduct an analysis

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(1) The process implied by the phrase - the analysis of learning tasks - differs from that denoted by - task analysis. This term usually involves a detailed listing of component behavioural elements of a job or task and their inter-relationships. For further reference, see Robert B. Miller, Task Description and Analysis. In Robert M. Gagné (ed.) Psychological principles in system development New York: Holt Rinehart and Winston 1962.

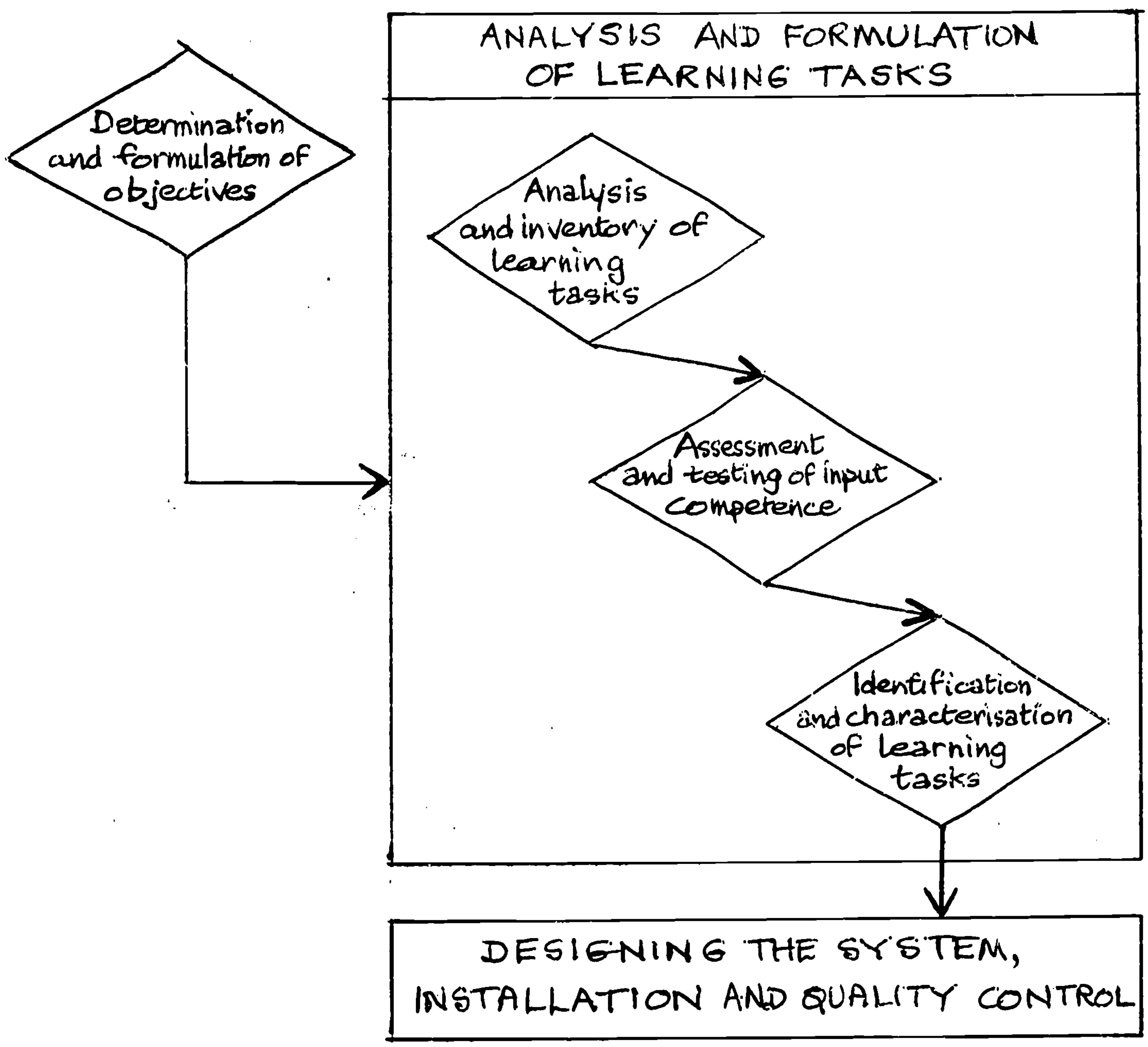

Figure 7. Analysis and formulation of learning tasks

of learning tasks is of great importance, it may be argued that an objective should inform the learner clearly what has to be learned. If the expected performance is described in behavioural terms, this also surely describes the learning tasks. It may well be that for certain behaviour, a description of output performance would identify the learning tasks. This could be the case when the process of acquisition of certain behaviour falls into such categories as response and chain learning.

More specifically, whenever the attainment of a performance task requires only imitative behaviour, its statement could aslo cover the learning task. Learning to open a box by observing someone else doing it or memorizing dates of a history lesson as a verbal chain would fall into this category. Even for these tasks, there is a need to learn to want to do them.

The performances most in need of facilitation in school are within the cognitive and relevant domains. Examples of the types of learning involved here are multiple descrimination, perception and use of concepts and principles, problem solving and decision-making. A description of performance expectation in these domains will rarely suffice as identification of learning tasks. Although implied, a learning is not explicit in a statement of performance; this must be deduced by an examination and analysis of the task itself. The analysis of the tasks usually describes the expected outcome behaviour which is only a basis for learning tasks and is not in itself a description of them. An inventory of learning tasks can be formulated from the conclusions of what the learner has to assimilate before he can behave as described in the performance tasks. This inventory, however, will probably contain more tasks than, in practice, have to be learned.

Input competence

In most cases the learner brings to the learning situation some skills, information, attitudes, etc. that are relevant to what he is supposed to learn. It would be a waste of time to teach competences already possessed by the learner. These usually tend to be competences such as initial or input capabilities orienting behaviour. System designers should assess the capabilities already acquired by the learner relative to the learning inventory. This assessment is pertinent even in the case of a learner who acquires some esoteric knowledge. For example, the learner of a foreign language will have at his disposal at the output point, features of his native language that are transferable into the target language. Native speakers of English who learn Spanish will find that certain syntactical constructions and some grammatical elements such as adverbs, prepositions and conjunctions work in similar fashion in both languages.

Input test

By using an input test we can determine what a student already knows about the subject in question. This will vary from one student to another. To consider this variation is important. The learner who has not acquired the capabilities will be frustrated and will not reach the desired performance. The student who is scheduled to learn what he already knows will be bored and probably lose interest. A test of input capabilities would help to avoid both pitfalls and would permit provision of a pre-input programme to overcome deficiencies in some learners and to arrange for the advanced placement of others.

Identification of Learning Tasks

It is generally found that the learner has already acquired capabilities relevant to a particular set of learning tasks. To identify the actual task of learning one must subtract whatever is already known to the learner (input competence) from a specific set of learning tasks (inventory of learning tasks). The characterization of learning tasks provides additional information about them to be used as input data for design of the system.

There are two methods by which the characterization can be accomplished. The first is to specify the type of learning represented by the acquisition of a particular learning task, Gagné (1) identifies a comprehensive set of learning types such as signal learning, response learning, motor and verbal chains, multiple discrimination, concept learning, principle learning and problem solving. These types differ significantly with regard to particular conditions needed to ensure the mastery of learning tasks for different types. For example, producing a new foreign language sound is identified as response learning; the learning of imitations as a sound. The conditions governing these types of learning are different from those governing the use of a new sentence structure, which is a principle learning. The use of grammatical structure, for example, cannot be learned by imitating or memorizing sentences in which the structure occurs.

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(1) Robert M. Gagné, The Conditions of Learning (New York: Holt, Rinehart & Winston, 1965).

The second method of characterization of learning tasks characterization is quantification. This involves the measurement of difficulty in the mastery of a specific learning task. The information derived is needed for two purposes: (a) it can be used to project the time needed to overcome a learning task, and (b) it acts as a guide in estimating the content needed for treatment of any particular learning task. Quantification data can be accrued from observing learning over a period of time and recording information relevant to the time needed for the mastery of the learning task. For example, in language learning observations can be made of pronunciation errors and the persistence of these errors. The more an error persists the more attention, content, and time needed for the particular task.

Examination of the strategies of learning tasks: analysis and formulation of learning tasks provide the systems designer with a clear statement of what has to be learned in the system in general and by specific students in particular. Figure 8 shows the strategies involved in this process.

The integrated use of analysis and synthesis appears to be a characteristic process of these strategies and becomes further activated as system planning moves into the actual design of the system.

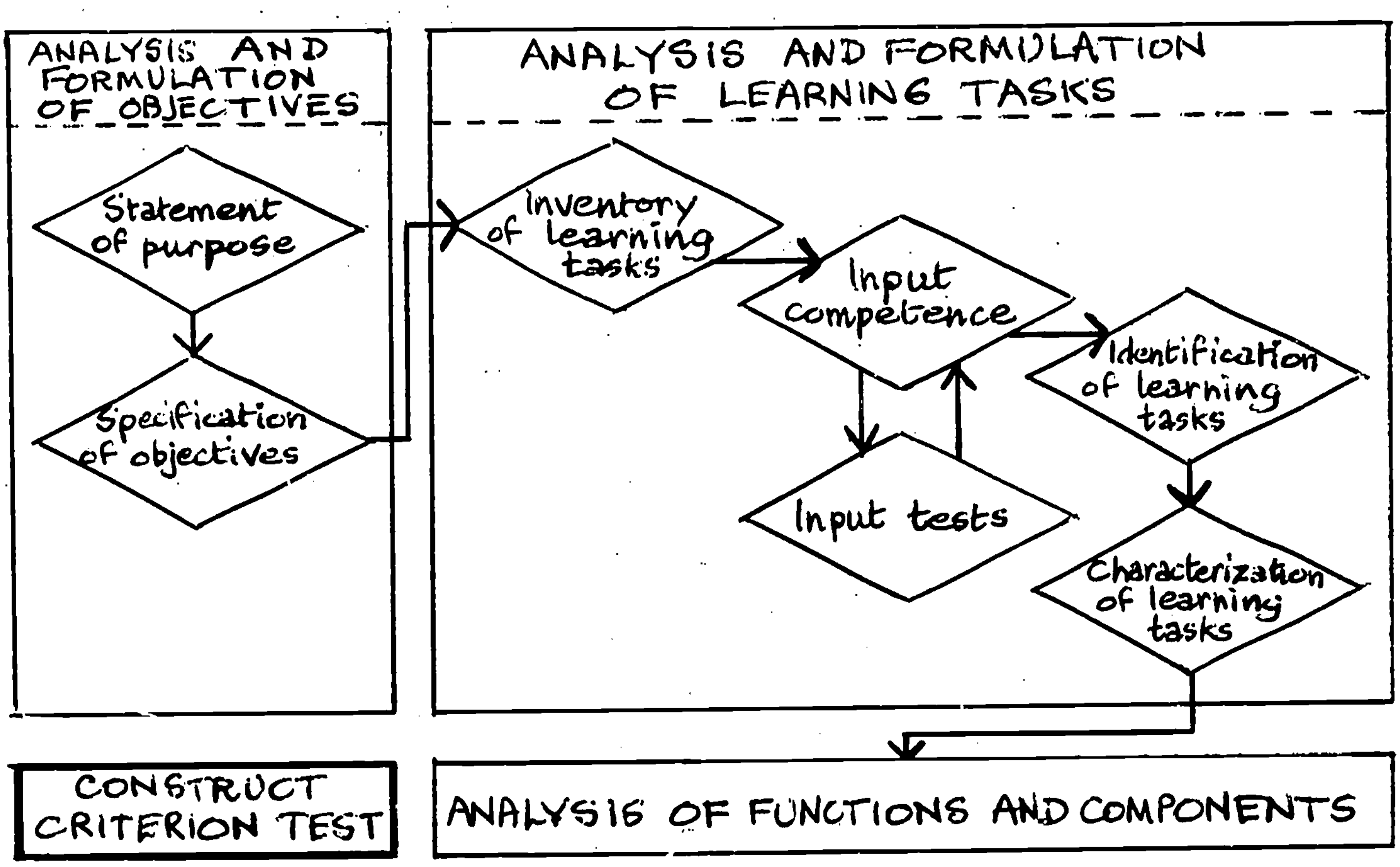

Figure 8. Strategies of learning tasks

III THE DESIGN OF THE SYSTEM

Once the tasks for attainment by the learner are identified and characterized, the planner should then design the system to provide for the mastery of these tasks. Systems development consists of four major strategies:
functions analysis (what has to be done and how?);
components analysis (who or what has the potential to do it?);
distribution of functions among components (who or what will do exactly what?);
scheduling (when and where it will be done?). Figure 9 illustrates the relationship of these strategies within the whole framework of the systems development structure.

Functions Analysis

The input data for functions analysis is the information gained from the identification and characterization of the learning tasks. The purpose of functions analysis is to identify every variable for inclusion in the system also to facilitate the attainment of the specified learning tasks. In designing the system there are four functions that need to be accomplished. They are as follows:
Selection and organization of the content;
selection and organization of the learning experiences;
managing the learners;
evaluation.

Selection and organization of the content

Most subjects provide unlimited scope for choice of content. Selection is, therefore, a decision-making operation demanding a sound rational basis. Characterization of the learning task is a primary basis for content selection as is information on the type of learning represented by a task. For example, in the field of foreign languages, appropriate considerations affecting and influencing the selection of content include frequency of occurrence, availability of the item, its flexibility of expression and its learnability which implies similarity, clarity, brevity

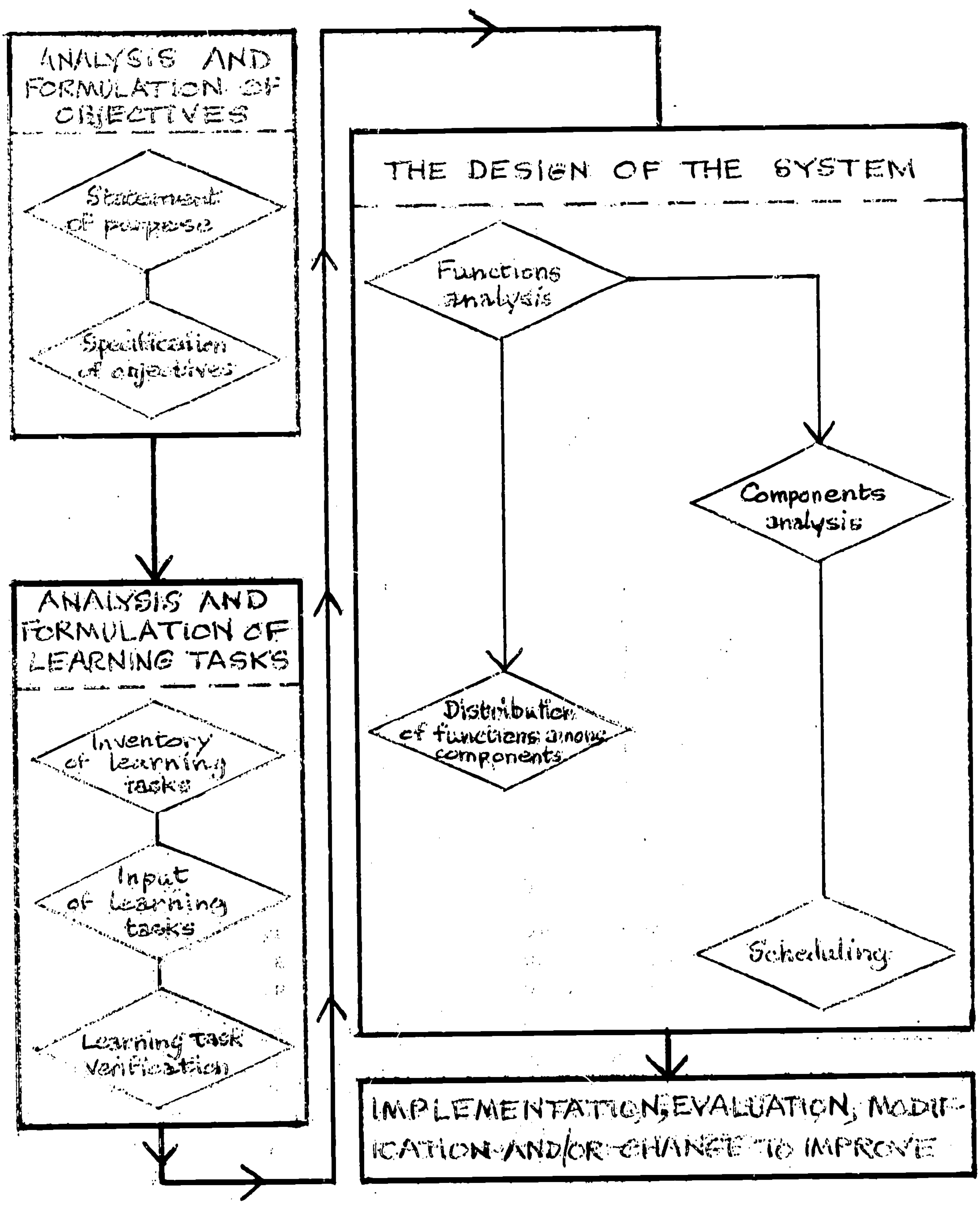

Figure 9. Relationship of design strategies

and regularity. The actual selection of a course content is more complex than the above foreign language example suggests. There will be confliction between the various factors for selection; therefore designers should consider the specific characteristics of the learning group and the individual differences of the learner.

The content selected has to be in line with the academic achievement and aptitude of each individual. The span and type of interest of the learner, his needs, his ability to comprehend the abstract or concrete and the specific level and style of his learning must also be considered. This rationale emphasizes the need for available alternatives in the content.

Organization must follow selection. The most important strategies here are sequencing, arrangement and presentation. Two factors determine the sequences: (i) the type of learning that a learning task represents and (ii) the notion of a logical sequence. The characterization of certain learning tasks should be established. Within the domain of a subject matter, learning tasks that represent response learning should be pursued before tasks of the chain or multiple-discrimination type. The learning of specific concepts should precede the learning of any principle comprised of these concepts. Problem solving cannot be attempted until the principles to be used in the solution of the problem are established or mastered.

Within the realm of a specific kind of learning, tasks should be further ordered in a logical sequence. The designer should determine what should be known by the learner to undertake the learning of this specific task. To supply this information, arrangement of the learning priorities can be constructed. These learning priorities will state, for example, that the learning of task A is prerequisite to the learning of task B and the learning of task B to task C etc.

The arrangement of a course content is a complex operation which requires appraisal of the compatability of content units with the types and amount of learning that a selected content requires.

Presentation is the final phase in the selection and organization of the content. During this operation the content selected as a result of the strategies described above, will be integrated into specific learning sequences, and specific learning units to be presented for the next phase of instructional systems development.

Selection and Organization of the Learning Experiences

The result of the content selection and organization determines what is supposed to be learned and in what sequence but it does not show how this learning should take place. There are many alternatives for presenting the selected and organized content to the learners and many different ways of practising, manipulating and making use of content.

Implementation of the phases of selection and organization of the content, should accommodate both the individual and the groups already mentioned. It is important that decision-making of learning experiences should take these differences into consideration. The processes of selection and organization of the learning experiences should be designed with many available alternatives to cope with the manifold varieties of learning habits. The different periods of time needed for mastery of a specific task is only one of the manifestations of individual differences. The ability to deal with the abstract or concrete, the interest span and the sensory needs, such as audio or visual perception are other manifestations. There are also differences in the degree of guidance and amount of practice required as well as the degree to which individuals are able to deal with complexities and manipulate objects. Furthermore, there are differences among individuals in the degree to which their imagination can be involved, their creativity motivated and in their ability to solve problems. One of the most complex tasks for the designers of a learning system is to identify and predict the expected differences of each type of learning experience in relation to the different types of learners. The designer needs to make assumptions about the most ideal combination of configurations and circumstances for optimum accomplishment of certain learning tasks.

In selecting and organizing the learning experiences, there are several variables such as information on what the learner already knows to assist him in mastery of the learning tasks specified by the system, aptitude variables and learning style of the individual learner or possible alternatives of available learning experiences, for eventual selection of those best matching the abilities of the learner. Criteria can then be formulated for matching appropriate learning experiences to appropriate learners.

While constructing his system, the designer is often tempted to speculate on the best means and resources to be employed to carry out specific learning experiences. This inclination to reach ahead is indeed tolerated by the systems approach; in fact, it is the recognition of the interdependence of the method and media decisions that makes the systems approach particularly meaningful. Although the systems approach offers a specific structure for instructional decision-making, this structure is not rigid. It has a built-in flexibility that enables the designer to think ahead and is not of one-directional nature, but one which allows not only feedback, but also 'feed-forward' strategies. These strategies must be continuously interrelated back and forth to assess correctly the interaction and mutual influence.

Managing the Learners

The third aspect of functions analysis, the management of learners, has been described by Smith as the process of identifying and effecting the functions that keep the learner participating productively in the learning activities. In developing a design for management of the learners adequate data about the learner is needed to introduce short-term and long-term incentives and to meet the individual requirements so that he can be kept optimally involved in learning. This management also includes the design of procedures and strategies to provide the teacher with an appropriate selection of suitable curriculum alternatives.

Evaluation

This function provides for the constant monitoring of the learner and of the system. It poses a continuous inquiry into the learner's achievements and into the effectiveness and efficiency of the system. More specifically, the designer of the system must find answers to the following questions. On the basis of the progress the learner is making, is he likely to attain his terminal objectives? If not, what adjustments ought to be made? Are the functions provided by the system the best to achieve the system's goals. What are some of the shortcomings? It could be by pursuing these inquiries and monitoring the learner and the system continuously.

Components Analysis

The curriculum resulting from function analysis needs to be qualified further by the findings of component analysis. This is considered to be one of the most radical departures from present curriculum practices suggested by the systems approach. The term component analysis refers to the decision to be made as to whom or what should be employed to carry out the specific functions. The application of the systems concept to education has introduced a new way of looking at the who's and what's of the learning environment. More specifically, the value of systems expressed by and inherited in the term instructional media has a different role. The teacher and the instructional media as diversified variables but as components of a system. They are used on the basis of their ability to accomplish specific educational functions. This idea is the central concept of components analysis. Given a specific function, derived from the components analysis, the problem is first to consider alternative means or components which have the potential required and then to select from among these alternatives the one that appears to be the best to perform the needed function. The system designer will choose the human resource, means, or tools that will best carry out the function and optimize the attainment of the predetermined performance. In conducting component analysis, system designersshould never take any component for granted merely because it has always been used. On the other hand, a component should not be rejected because it has been used for a long time.

One of the precepts of component analysis is that the components should fit the function and not the function fit the components. The idea of function fitting the components, or the non-systems way of thinking, is reflected in the widespread practice of assigning instructional functions to the teacher simply because he is in the classroom. It is to overcome the temptation inherent in this habit that the order of identifying functions first and components next is imperative.

A second precept of components analysis is that the designer should always consider alternatives. In considering and surveying components he needs to have the freedom to look for the one that offers the best possible potential to carry out the function and to select the one that is the most relevant to the learner. Following this, however, there are some other criteria such as practicability and economy. Considering these factors the designer should select the best component from the various alternatives after consideration of the limitations and constraints inherent in the system environment. As a result of this, the final decisions will not be made until the functions are actually distributed among the components.

In surveying the components, system thinking requires constant consideration of all possible human and material resources relevant to the potential for accomplishment of the specific functions. A component or a set of components should be selected on the basis of such criteria as:

(a) potential to accomplish a particular function, (b) ability to integrate with other components, (c) relevancy to the learner, (d) practicability and (e) economy. The human component will include the learner and the teacher, as well as personnel engaged in a wide variety of educational support and service functions, whereas the material component would cover both software and hardware such as textbooks, television, programmed instruction, films and other media. In considering the teacher as a component of instructional systems we should utilize the extensive research of recent years on the use of programmed instruction. The results of such research, as Hatch (1) stated, have shown that students can acquire information with as well as without the personal intercession of the teacher. Thus the rôle of the teacher as the source of information must be re-thought. Systematic component analysis will lead to the recognition that the teacher may best be described as the manager of learning. This primary function may include providing for the motivation of the learner, the planning and managing of the learning experiences and examination and utilization with the learner of the information he has acquired.

In selecting and organizing the content and learning experiences of a course the subject matter is usually determined by the relative textbooks or series of textbooks. This selection is generally the responsibility of the high level of the Ministry of Education. Thus the content of these textbooks is closely followed in the selection and organization of learning experiences, with the occasional involvement of the teacher and his class. The individual learner is seldom considered to have a valid contribution in the accomplishment of these functions.

During recent years there has been increasing recognition of the need to provide for individual differences by having curriculum alternatives. It has been suggested that variations in initial competence, aptitude, rate and style of learning should be met by variation in content and learning experiences. The factors used to determine what alternatives to choose, do not usually include the learner himself. It is the teacher who manages the instructional strategy; the counsellor plays a rôle in gathering data on the learner's achievements, background interest and needs. In most advanced instructional systems, a computer may monitor the students' learning and prescribe from available alternatives the specific path to follow. Thus in the contemporary educational spectrum although there is greater emphasis on learning, the learner does not yet actively participate in decision-making.

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(1) Hatch Winslow R., Approach to Teaching, Washington D.C., Government Printing Office, 1966.

One of the key criteria in this learning-oriented system is to have a number of alternatives available both in content and in learning experiences. These alternatives should be designed for the purpose of meeting individual differences. Another key criterion is that the learner should be considered a primary participant in making decisions about the selection and organization of content and learning experiences. These decisions should be made with him and not for him.

How can implementation of such learning and learner-oriented component selection be effected? In selecting the content, the designer should provide for alternative sets of content items which are aimed at the attainment of learning tasks. Alternatives should be related to potential individual differences and thus provide for variations in level of sophistication or abstraction, degree of complexity, grade level, length, extent of coverage and topics of interest. These alternatives should be prescribed for the learner but the learner should be consulted in selecting the one most appropriate for him. He, himself, should have an opportunity to test the alternatives in order to find out which one he responds to best or which stimulates him most. It is also possible that the learner can suggest a new alternative, one unique to him. He will probably need the co-operation of his teacher, counsellor, fellow-student, or others in his environment. He should co-ordinate his decision-making with that of others in order to make the best possible selection.

The organization of his time is also subject to decisions by the learner, likewise the point at which he will enter the learning system also depends on the measured input competence of the learner. The rôle of the learner as a component in the accomplishment of the selection and organization of the learning experiences will probably significantly increase. Variations in the design of learning experiences naturally will be even greater than variations in the design of the content. All this will lead to a system in which the learner will assume increasingly more responsibility for his learning.

Distribution of Functions among Components

Distribution is the process of assigning functions to specific components throughout which the designer must consider what component offers the best potential for accomplishment of a particular function. He must also consider the constraints and limitations of the system; this analysis must be conducted for each component. Sometimes he will find that the most effective component is also the most expensive one in terms of both money and time thus leading him to make some tradeoff and select instead a component that is still within the range of projected effectiveness and the costs limits of the system. The only aspect that cannot be compromised or traded off is the attainment of the objectives. Proper distribution, therefore, will ensure the selection of components to produce the predetermined output and still be within the limitations and capabilities of the system. In brief the goal is to achieve the best possible output within the least possible time and at the lowest possible cost.

Distribution as discussed above is the stress point in the systems development process. It is at this point that the key decisions are made and alternative functions and components are considered, weighed and then selected or rejected. In view of the critical nature of this process some clarifications are in order:

It must be emphasized that in making design decisions, <u>function</u> always leads and <u>components</u> always follow. Although this sounds logical, making decisions within this logic is not always easy and to be really effective will necessitate suppression of some of the present practices. One of the features of prevailing practices in education is that it is component oriented. Usually components that are already available - such as the teacher in the classroom and other resources - are considered first and functions assigned to them. To break away from this way of thinking and to consider functions first is one of the crucial challenges in establishing a systematic way of making design decisions in education.

Most of the design decisions are made at the time the functions are distributed to the components. Consequently, the process and product of this strategy - distribution - will be most frequently reviewed during the operation of the system. Whenever feedback from output testing data, operational efficiency or economy indicates a less than desirable product state, distribution must be re-examined, the resultant decision re-analyzed and the relevant necessary readjustments made. If systems objectives are not attained, the most likely area for changes is, in fact, distribution. If the system does not operate smoothly or if its economy is questioned, distribution decisions are the first variables to be re-considered. It is for these reasons the designers of systems have to keep detailed records of the decisions and include a list of alternatives, their characteristics together with an explanation for these decisions.

Scheduling

Another systems strategy is scheduling - which involves decision-making. It is the part of the learning system concerned with time and place. Once the distribution has been determined and the functions to be accomplished by relevant components established, the designer must decide when and where each function should take place. Scheduling places the information gained from distribution into a time and place frame, thereby ensuring the relevant human components and material resources will be available at the appropriate time, and that the location for the economic and effective execution of these functions will be available.

IV IMPLEMENTATION AND QUALITY CONTROL

The processes of design and development produce a system which is ready to be put into operation. Before the system is installed, however, two additional strategies should be introduced.

System Training. As Gagné stated, system training is a pre-installation exercise of the system. It helps to refine the operational inter-relationship and integration of the components or sub-systems. During the trial of this provisiona pattern it can also be ascertained whether the human variables of the system really possess the needed capabilities. If deficiencies are discovered, training or adjustment process should be introduced to attain the required competence. At this point the two pre-installation strategies - training and evaluation - may complement each other and show up inadequacies or weak points in components or functions that should be adjusted.

Systems Evaluation. The application of the systems concept also requires testing the system before it is installed. System testing serves the purpose of ascertaining whether the system can perform the processes for which it was designed. There are several ways to conduct systems evaluation or testing. As a minimum requirement the designer must think through the subsequent steps of the design process, continuously asking himself if the product of the particular step being tested is the best one to achieve the predetermined objectives of the system. This process can be carried out most effectively by a systems analyst. In fact, it is advantageous that the systems testing be conducted by someone other than the designer. The use of simulation for demonstration and evaluation of the functions of the system is one approach. For more sophistication, the use of computers is advocated. This, however, is limited to the testing components or strategies that are conducive for qualification.

The most satisfactory method of testing an instructional system is by trying it on the learners in the environment or at least in a simulated environment. As system testing and evaluation is a continual process it is difficult to determine when the evaluation is actually completed. The most important point is to provide sufficient pre-installation testing and make any necessary modifications.

System installation. Systems training and systems evaluation and testing are two initial strategies for the implementation phase of systems operation. The product of these strategies is the decision either to install the system or eliminate it. If installation is decided upon, then the system is put into operation in its planned environment and begins to process the input for production of predetermined output. During operation, the system is continuously evaluated in order to measure its adequacy and the cumulative and terminal performance of the learner.

Quality Control through Evaluation. The purpose of quality control of any system is to ensure that its objectives are being met. If not, adjustment should be introduced in order to modify or change the system so that the pre-stated objectives can be eventually attained. This phase of systems development is comprised of several strategies with specific purposes of their own; these are: (a) systems monitoring, which is used to evaluate continuously the effectiveness of the system, and (b) performance testing, which is a means of measuring the progressive achievement and terminal proficiency of the learner. The continued accomplishment of these two strategies provides information for effecting appropriate adjustment to improve the terminal performance of the learner and optimize the effectiveness and economy of the system.

Systems monitoring requires continuous evaluation and analysis; the adequacy of the system can be judged from the results of these operations. As the system operates the designer must introduce such queries as:

are the objectives clearly stated and formulated along measurable and operational lines?

does the criterion test truly reflect the objectives?

are the objectives properly interpreted in exploring the learning tasks?

has input competence been properly assessed and tested?

do the learning tasks identify every variable to enable the learner to perform in line with the objectives of the system?

were any tasks identified that do not contribute to the attainment of the objectives?

were all the functions necessary to accomplish the learning tasks or were some over-productive or inapplicable?

were the best possible and most economical components selected and do they function effectively?

Performance evaluation and testing. The evaluation of the learner's performance is accomplished through continuous checking of the learner progress and by testing his performance capabilities at the terminal point.

Evaluations, which are used throughout the programme are designed for the purpose of:

Measuring the input competencies of the learner in relation to the pre-established learning tasks;

measuring the degree to which the learner has the competencies prerequisite to mastery of learning in relation to the pre-established learning tasks;

diagnosing learning style and learning rate to accommodate the individual learner;

assessing the progress of the learner in order to introduce any changes necessary to enable him to perform according to expectation;

indicating specific deficiencies in the system itself.

The test to measure output performance should assess the degree to which the student is able to exhibit the behaviour specified by the objectives.

System adjustments: improvement by change or modification. Existing educational programmes do provide for the measurement of the learner progress and terminal proficiency. Test results are usually communicated to the learners to inform them of their progress and achievement. These results, however, are only occasionally used by the designer for the modifications and/or changes of the instructional programme. One of the most effective aspects of the systems approach is the continuous feedback of performance data into the system for the purpose of making adequate adjustments.

The self adjustment characteristics of systems development prescribe change as a perpetual process in the development operation and maintenance of systems. It is safe to say that the only valid means of maintaining a system is by purposely modifying and changing it. Those responsible for education and educational planning probably find difficulty in orientating themselves to this particular characteristic of systems development.

V CONCLUSION

The purpose of this paper is to explain and demonstrate the use of systems approach as well as to provide guidelines for development of instructional systems. The development design described presented a structure and a set of strategies for making curriculum decisions.

The basis of a system for learning is its purpose from which systems objectives can be derived. From this the designer has to determine the variables to be learned to ensure the attainment of these pre-stated objectives. Input competence for the learner can be assessed to see if he has already acquired capabilities relevant to his learning task. The differential analysis of learning tasks as opposed to input competence provides a set of actual learning experiences.

Once the learning tasks have been identified and characterized the design of the system can commence. It is essential to consider the functions of the system to ensure the mastery of learning tasks.

Functions have to be distributed among components; decisions made on this basis lead to the design of the system. After evaluation and training for the system, installation should follow. Finally, the feedback gained from output testing and system monitoring is used to introduce adjustment and improvements in the system.

Figure 10 summarizes the development of an instructional system design.

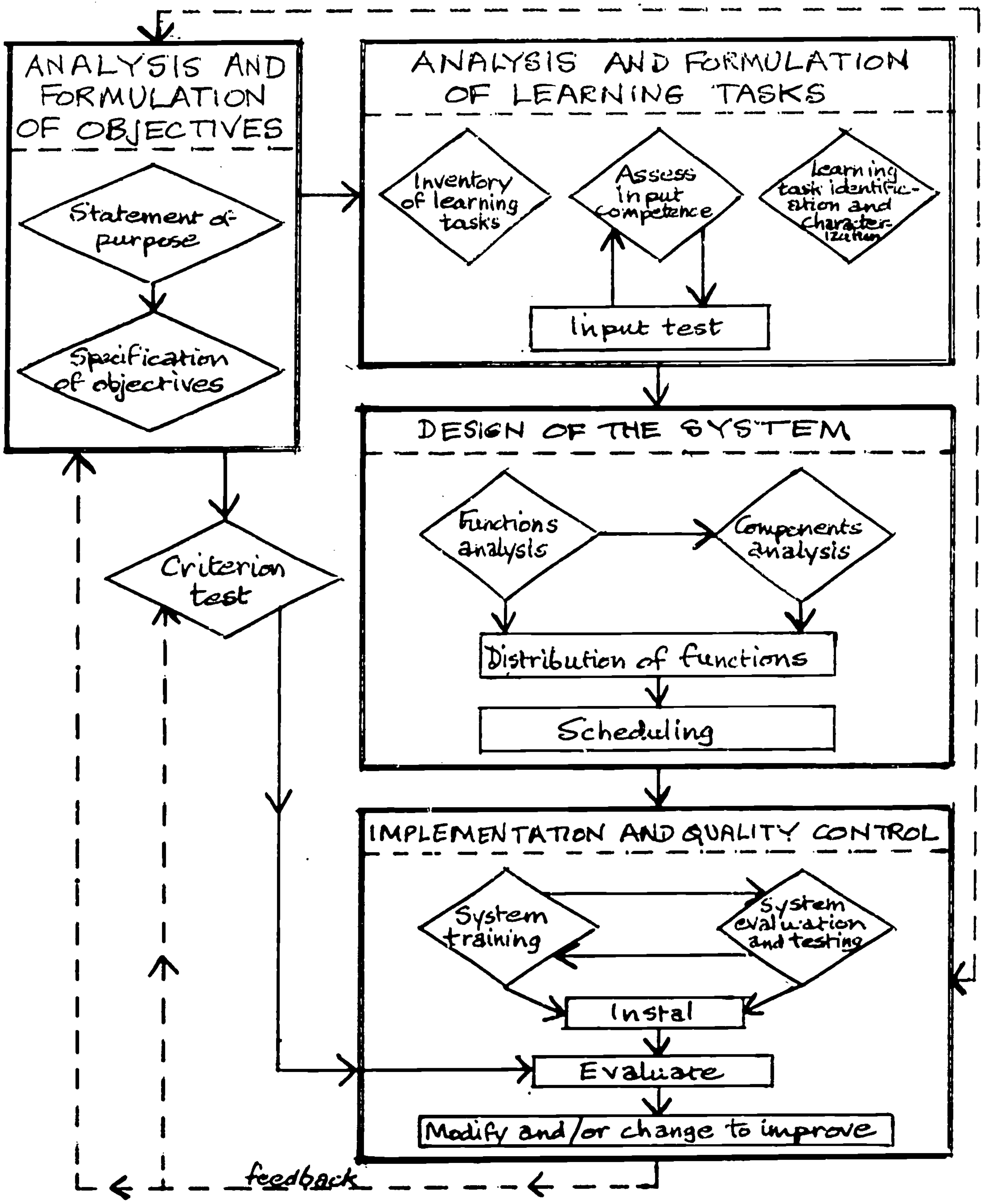

Figure 10. Development of an instructional system design

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