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ABSTRACT

The objective of this report is to present a design model which will serve as a pattern for the development of a vocational education professional development program to be implemented in a state agency of vocational education. The model delineates the procedural requirements for determination of priorities, assessment of personnel needs, selection of projects, assignment of resources, and management of the program. The data requirements for the establishment of a management information system are enumerated and the procedure for the establishment of a planning-programming-budgeting system described. The role of inquiry in education is elaborated upon in order to provide a theoretical rationale for systems procedures. Major emphasis is devoted to vocational and technical education teachers, since they account for the majority of the developmental efforts. (Author)

DEVELOPMENT TRAINING RESEARCH

A PLANNING SYSTEM FOR THE IMPLEMENTATION OF SECTION 553, EDUCATION PROFESSIONS DEVELOPMENT ACT, IN STATE AGENCIES FOR VOCATIONAL EDUCATION

DONALD W. DREWES
NATIONAL CENTER FOR OCCUPATIONAL EDUCATION

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A PLANNING SYSTEM FOR THE IMPLEMENTATION OF SECTION 553, EDUCATION PROFESSIONS DEVELOPMENT ACT, IN STATE AGENCIES FOR VOCATIONAL EDUCATION

Donald W. Drewes

National Center for Occupational Education

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The paper presented herein was written pursuant to a grant with the Office of Education, U. S. Department of Health, Education, and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Office of Education position or policy. This work was performed under a subcontract with the North Carolina Board of Education through a grant from the Vocational Education Branch, Bureau of Educational Personnel Development.

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PREFACE

System design is constrained by "state-of-the-art" technology. All procedures either utilize existent research results or require data collected according to established methodologies.

The objective of this report is to present a design model which will serve as the pattern for the development of a vocational education professional development program to be implemented in a state agency of vocational education. The model delineates the procedural requirements for determination of priorities, assessment of personnel needs, selection of projects, assignment of resources, and management of the program. The data requirements for the establishment of a management information system are enumerated and the procedure for the establishment of a planning-programming-budgeting system described. The role of inquiry in education is elaborated upon in order to provide a theoretical rationale for systems procedures. Major emphasis is devoted to vocational and technical education teachers, since they account for the majority of the developmental efforts.

This report was originally produced under a subcontract with The Institute of Human Ecology, Raleigh, North Carolina, and it is now presented by the Center in the hope that those responsible for leadership development in occupational education will find the following rationale and suggested activities helpful in coordinating their approaches to professional personnel development with the rapidly expanding needs in the field. The work was also supported by a subcontract with the North Carolina State Board of Education through the Division of Occupational Education, North Carolina State Department of Public Instruction. The original project was supported by a grant from the Bureau of Educational Personnel Development, U. S. Office of Education.

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John K. Coster
Director

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PART ONE - SYSTEMS OVERVIEW

The purpose of this report is to present the design schematics of a management system to promote the implementation of Section 553 (a), Part F, of the Education Professions Development Act, which provides:

> The Commissioner is authorized to make grants to state boards, as defined in the Vocational Educational Act of 1963, to pay the cost of carrying out cooperative arrangements for the training or retraining of experienced vocational educational personnel such as teachers, teacher educators, administrators, supervisory and coordinators, and other personnel, in order to strengthen education programs supported by this part and the administration of schools offering vocational education. Such cooperative arrangements may be between schools offering vocational education and private industry, commercial enterprises, or with other educational institutions (including those for the handicapped and delinquent).

The fundamental premise of this paper is that development of vocational education personnel as specified in Section 553 (a) can best be realized via a systems approach. Although dating from antiquity, use of the systems approach as a disciplined mode of problem-solving has gained momentum in the post-World War II era and has been applied to a variety of scientific and operational problems and, more recently, to educational decision-making (Silvern, 1971). In spite of the fact that systems definitions are as numerous as practitioners of the systems approach, the following formal definition is offered:

> A system is an interrelated (organized) set of activities governing the utilization of resources so as to achieve a specified mission.

In order to facilitate the elaboration of the systems concept in the context of educational and professional development, the following ancillary terms are defined:

Act - An action event.

Action - Expenditure of energy.

Activity - A prescription (rule) for action.

Behavior - Performance over time.

Components - The subordinate parts of a system.

Energy - A capacity for action.

Environment - Everything outside of the system that both influences and is influenced by the system.

Goal - A desired consequence of system-initiated action and environmental reaction.

Input - Energy and/or information imported by the system.

Mandate - The sanction for system existence.

Mission - The ultimate purpose of the system.

Negotiable environment - That part of the environment subject to direct influence by the system.

Non-negotiable environment - That part of the environment not subject to direct influence by the system.

Objective - A desired system performance.

Output - Energy and/or information exported by the system.

Performance - Execution or accomplishment of an act.

Program - A plan for resource allocation.

Resources - The medium for system action.

Supersystem - That larger system of which the system of concern is a component.

System management - The process whereby system resources are allocated so as to achieve the system objectives, goals and mission.

It follows from the definition of system that system purpose is achieved by the expenditure of energy via resources in a manner prescribed by the activities. In this sense, the activities can be said to manage the resources and, hence, represent the essence of the system.

For the purposes of this paper, system activities can be typed into three major classes hereafter referred to as management functions. These functions are defined as:

Planning - The planning function consists of those activities associated with preparation for the future commitment of resources. This preparation includes formulation of system mission, goals, and objectives; consideration of alternative allocations of resources; and a resolution of alternatives that enables the system to pursue its purposes effectively and efficiently.

Activation - The function of activation involves the [illegible] of resources, determination and organization of activities required to achieve system purpose, and assignment of resources to activities. Thus, activation "energizes" the activities by a resource assignment and, as such, manifests the intent expressed in system plans.

Control - The control function involves monitoring and coordinating the performance of the system to ensure that action-events conform to the activity requirements as expressed in the plans.

It is axiomatic that system purpose as embodied in the mission can not be achieved by unilateral system action. Goals as time-phase mission segments require corresponding environmental reaction to produce a desired outcome--a state of affairs that obtains as a result of system behavior, various uncontrolled environmental influences, and supersystem action. Outcome consequences for the system are dependent upon the significance of the outcomes for mission attainment. Because of the wide variety of potential outcomes, the system must be prepared to select according to some strategy a resource utilization scheme that interacts with the environmental status so as to enhance system survival.

Thus, in a dynamic environment, the system must be able to adapt its activity structure to accommodate changing demands, requirements, and constraints if it is to remain viable in a future environment. System change is considered to be accomplished by planning, a process defined as:

> . . . (that) of deciding the actions to be implemented to realize the future goal in a future environment given today's position in today's environment. (Cruze, 1970)

As indicated in the definition, planning requires formulation of system goals, knowledge of the present environment, and a prediction of a future environmental state. The outgrowth of the planning process is a plan--a set of coordinated activities that imply a commitment to a future course of action. For the purposes of the paper, plans are classified as: (1) strategies, (2) policies, (3) procedures, (4) programs, (5) budgets, and (6) projects.

Strategies are the primary activities that guide system utilization of resources so as to achieve desired objectives. Objectives are deemed desirable to the extent that interaction with a specified environmental state will produce a desired outcome state. However, an outcome state is desirable to the system only to the extent that the outcome contributes to mission attainment. Thus, the mission broadly stated in terms of ultimate results must be translated through a series of reductive stages until meaningful objectives are obtained. The reductive process of objective identification is morphologic in that once the initial integration of system purpose has been achieved, progressively finer differentiations eventually isolate the objectives at a suitable level.

That is to say, mission as an ultimate state of affairs is implementable through a temporal sequence of primary activities--the system strategic plans. Each primary activity can in turn be decomposed into its secondary cognate activities, which in turn can be segmented into more homogeneous activities until the basic operational activities necessary to mission achievement have been identified. For a further discussion of the hierarchical process of strategic planning, see Vivekananthan (1971).

Attainment of system mission necessitates that system objectives be contingent upon future environmental states. As success or failure depends upon the consequences of the outcome of system-environmental interaction, the system can ill afford to rely on the occurrence of fortuitous environmental states. Rather, future states of the environment must be anticipated and appropriate system objectives selected. The process of projecting the present environment into the future so as to predict the forces that would influence the system is termed <u>forecasting</u> and is an integral part of strategic planning. The time period covered by the forecast is termed the <u>planning span</u> and is governed by the amount of time required for resources to fulfill their commitment to a specific plan. Since strategic plans involve long-term resource commitments to achieve a desired future position, they are referred to as long-range plans and underlie all decisions regarding present and future acquisition and utilization of system resources.

<u>Policies</u> are general formative rules that constrain the choice of alternative activities. <u>Procedures</u> differ from policies in that procedures are more specific substantive rules that delineate method as a temporal sequence of activities whereby specific objectives are attained.

A <u>program category</u> is a class of interdependent activities that correspond to a goal area identified by the morphologic process wherein mission is further explicated by a segmentation into subordinate outcome classes. The determination of the correspondence between often vaguely defined goals and system activities required to implement the goal is at best difficult and follows no clear-cut formula. Uncertainty about environmental contribution requires that alternative programs be considered and evaluated under a variety of projected future environmental states. Program activities are related to strategic plans in that they represent a decomposition of primary activities into more fundamental requisite, subordinate activities that further clarify the action procedure prescribed by the primary activities. Since programs form the means for mission attainment, programs planning should emphasize a long-range time frame commensurate with that of strategic planning.

A <u>budget</u> is a financial expression of an intent to commit resources over a specified future time period. This intent is conveniently expressed in monetary terms that state the barter equivalency of resources in standard units. Program budgets require that the financial plan be expressed in program rather than functional cost categories and that the planning span be dictated by program requirements instead of by the short-range orientation imposed by annual budgets.

Objectives, programs, and budgets are all part of an integral long-range planning process referred to as *planning-programming-budgeting*, a process first developed by the Federal government and applied successfully to agencies such as the Department of Defense (Novick, 1965). Central to the formation of a planning-programming-budgeting system (PPBS) is an analytic capability to generate alternative means of achieving system objectives, to evaluate alternatives in consideration of benefits received for costs expended, and to choose a best or at least acceptable resource allocation from a range of alternative possibilities.

Analytic capability resides in a *model*, an abstraction of the "real" world expressed as a set of relations that enables the consequences of an interaction between a given state of system performance and a set of environmental conditions to be predicted. The result of the application of a model is an *outcome array*--a matrix where rows represent the alternative resource mixes available to the system; the columns, the possible environmental states frequently referred to as "states of nature"; and the cell entities, the consequences of a particular outcome. If the outcome consequences are described in terms of benefits to the system, the model is termed a *benefit model*; if the consequences are described as costs, the model is said to be a *cost model*. Cost and benefit models are frequently combined into a more general model which assigns a cost-effectiveness index to each outcome in the array (Quade, 1965).

All system models require informational inputs to predict outcome consequences. Since outcomes are the state of affairs resulting from the interaction of system performance and environmental conditions, information may be categorized as: (1) external information about the non-negotiable environment, such as the general economic, social, political, philosophical, and technological context; (2) internal information about program alternatives, such as availability and location of resources, relevant priorities, policies and procedures, action sequences required to achieve specific performance objectives, and time and budget constraints; and (3) transactional information about program linkages with and mutual effect on the supersystem, complementary systems, and competing systems.

The process wherein decision-makers are provided with information relevant to the choice of viable alternatives is referred to as a *management information system*. Energy expended for the collection of information is termed *research* and is judged to be useful to the extent that the resultant information contributes to the strategic and tactical efficacy of future decisions. Research activities are thus constrained by the informational needs of the decision-makers as determined by the input characteristic of the decision models.

Projects are defined as the set of organized activities necessary to achieve a specified objective and, as such, are the basic components of any planning system. The project objective is a terminal product of the reductive process that successively fractionates mission into constituent performance implications. Project as a plan for resource commitment includes a combination of policies, procedures, and budget that indicates the sequence of actions to be taken, the resource commitment required to support the actions, the anticipated performance, and the expected time-frame. As project objectives may vary considerably in implementation time, the span of project planning ranges from short- to long-range. Project structure is achieved by combining cognate projects into subprograms and subprograms into programs according to the inverse of the reductive process.

The dimensionality of programming-planning-budgeting can be depicted by a cube where one dimension represents the programs; another, the class of resources to be allocated; and the remaining dimension, the time period over which the programs are to be implemented. In this framework, a single cell represents a class of resources allocated to a given program for a given time period, say, personnel allocated to program X for the first year.

An integral planning document of a PPBS is the multi-year program and financial plan, which is a tabular presentation of benefits and costs for recommended programs, subprograms, and projects projected over a planning span in annual intervals. In order to predict costs and benefits, future environmental states must be forecasted by extrapolating relevant historical data series. The anticipated environmental state eliminates uncertainty and, when coupled with internal information, provides the inputs to the cost-benefit models required to generate year-by-year predictions.

The program and financial plan (PFP) represents the best program structure currently available as an outlet for system action. As such, it reflects an implicit choice of program mix and level of emphasis. These choices are made explicit by a program memorandum which provides for each program a description and justification of the definitions, logic, philosophy, methods, and criteria underlying the program recommendations.

The activation function of system management involves the specification and assignment of resources to designated activity classes. Resources are regarded as converters that transform given matter, energy, and information inputs into predetermined matter, energy, and information outputs in accordance with an instructional plan. Accordingly, resources are the material media for system action and, when appropriately utilized, perform the work necessary for achievement of system purpose. Since resources are in essence integral input-output systems, they form the subordinate components of a dynamic system. Resources are assumed to be well-defined in that each has certain external boundary conditions that establish its physical uniqueness. Since only the input-output transformation characteristics of resources are of consideration to the system, they may be treated as "black boxes" whose inner structures are unknown and unknowable.

Resource transformations can be developed by specification; by analogy, similarity, and modification; or by observation and experimentation (Hare, 1967). Resources whose transformation are known by specification are generally standardized classes of components whose behavior has been verified by past experience. Transformations may be suggested by similarity or analogy with well-known theoretical models or suitable modifications. In those cases where relatively little is known about resource behavior, transformations must be developed from empirical generalizations of observational and experimental data.

Resources vary in the order to which they exhibit memory and feed-back characteristics. A zero-order resource has no memory or feed-back capabilities; hence, its performance is strictly determined by the input stimuli. First-order resources have a detector that compares the output with a desired standard (goal). Deviance between the desired and actual output is fed back to the system as input and the system effect action so as to reduce the error magnitude. The effect is to dampen output amplitude, thereby causing the system to exhibit simple goal-homing behavior.

Both zero- and first-order resources exhibit no memory in that they do not store the results of past behavior and are, thus, incapable of prediction and conditional choice. Second-order resources, in contrast, contain an additional memory and control device that enables them to store a wider range of plans for a variety of input contingencies. However, since the system cannot generally change plans immediately because some lead time is required, second-order systems must have the capability to predict future input states so that the optimum alternative plan can be put into effect before the actual input occurs. Consequently, second-order resources are capable of tactical decision-making based on input information and fixed decision strategy; i.e., they can make procedural decisions. Second-order resources differ in complexity according to the variety of stored plans, sophistication of the prediction model, and comprehensiveness of the decision strategy. Operations are generally performed on symbolic abstractions of material configurations which are attributed informational value according to some decision model. Information must be stored in memory in a format that permits rapid access and retrieval, translation, and manipulation of symbols which, when combined with current input, provide the basis for prediction, decision, and control.

Second-order resources--while able to take a diversity of action depending upon current input, stored information, and variety of stored alternative plans--are limited by an operating program that stipulates the plans, decision rules, and predictive models to be used in the input-output transformations. Resources which, in addition, are capable of conditional modification of the stored operational program are categorized as third-order resources. Such resources alter their transformations in accordance with changing environmental inputs and, therefore, are said to learn by experience. The stored programs which provide the operational stability are of a higher supervisory order in that the program component activities prescribe how other lower-order activities should be created or changed. Learning involves modification of memory storage, which may take place by reorganization and/or replacement of existing informational pattern as well as by an alternative of the values placed on the informational patterns. By a process of data input, storage, evaluation, learning, decision, and consequent action, third-order resources are capable of the self-adaptation, invention, novelty, value, and priority allocation required to formulate policy.

Finally, the highest-order resources are those which, as a result of learning, formulate system objectives, goals, and mission. Thus, fourth-order resources are the most autonomous in that they must be aware of the coalescence of external informational patterns that are important to the long-range viability of the total system. As the most complex resources, they are more individualized and determined by their particular experience. They possess a richness of memory and pattern interconnections which represents the historic structural residue of past experiences, a residue that determines present functional activities. In this capacity, they formulate the strategic decisions that give purpose to system and provide the form-creating variability required to adapt to the vagaries of the environment.

Resources can be structured in these overlays depending on the kind of input-outputs emphasized. If resource input-outputs are defined as material entities, then resources as transformations can be regarded as components of a product subsystem through which materials flow in the process of being converted to a finished product. If energy is the primary input-output consideration, then resources as "workers" are the component parts of a work subsystem which produces the action required to transform products into a finished state. And finally, if input-outputs are treated as informational, resources as decision-makers are the components of a management subsystem which controls the product and work subsystems. As a consequence, resources are organized differentially depending on whether they are considered as transformers, workers, or decision-makers.

Resources as previously defined are intentionally restricted to the class of biological organisms and machines. Money, while often cited as a resource, represents a medium for resource acquisition rather than for direct action. Similarly, space and time are significant only to the extent that action is space-time dependent.

For the remainder of this paper, resources as an abstract systems concept will refer primarily to human resources. Humans as resources are considered to be self-adapting person-systems with all the manifestations of systems in interaction with their environment (Drewes, 1971).

The work subsystem represents a plan for the expenditure of energy necessary to flow products through the system in a manner prescribed by the product subsystem. Since component activities of the plan are often separated in time and place, division of labor is mandatory. Requisite activities for goal achievement are grouped into morphological classes termed tasks which are related by specific precedence rules of time and place, i.e., tasks must be performed at a given place in a specified sequence. Tasks are grouped into superordinate classes. The specification of the transformational properties of an idealized task group performer is defined to constitute a position. As such, a position denotes a class of resources (person-systems) that by definition have the potential for action prescribed by the tasks. Person, as differentiated from person-system, refers to a person-system identified only to the extent of the positional specifications. Person, then, is related to task only through the notion of position.

Task as a morphologic class of heterogeneous activities becomes a true superordinate entity instead of a mere collection of activities the more that the activities interact rather than passively coexist as equivalents. Tasks exist in a hierarchical structure where each task as an entity at a given level is composed of subordinate tasks at a lower level, but which also serves as a subordinate task of a superordinate task at a higher level. The higher the task level, the more enduring the task structure and the greater the variety of action patterns called for. Thus, higher order tasks are more individualistic, more permanent in nature, fewer in number, and reflect more the influence of past system experience.

Performance of a task at a given level depends on performance of the subordinate tasks at a lower level, which in turn depends upon performance at a sub-sub-level, and so on. Thus, since tasks are ideally performed by persons assigned to positions, task hierarchy induces a corresponding positional hierarchy. This position structure is commonly known as the formal organization and is graphically depicted by means of an organizational chart.

Task levels have their equivalence in the control orders of resources; that is, performance of higher-order tasks requires ideal resources (persons) with higher-order control and memory functions. More specifically, higher-level tasks, because of their complexity, require resources that carry a richer symbolic repertoire; have a heightened awareness of the present situation; learn from experience; can develop and modify plans, decision rules, and models; and are capable of developing, changing, and implementing operational goals.

The hierarchical position structure has long been the cornerstone of traditional management theory. Strategic decisions combined with planning and policies are assumed to originate at the apex of a pyramidal structure and to percolate downward to be implemented at lower competency echelons. The positional relationships are essentially vertical with superiors exercising de jure authority in accord with their position in the chain of command. Homogeneous activities are compartmentalized into autonomous units which are assigned responsibility for organic functions. Command decisions are exercised by line supervisors with advice and counsel provided by staff groups. Authority is delegated down the command chain and is constrained by departmental boundaries of the functional units aligned in the chain. Goals are the appropriate responsibility of some position at a designated level. The de jure authority of positions emanates from an ultimate authority source and is delegated downward through position descriptions, titles, policies, and related procedures. Authority is limited by the number of subordinates, as responsibility of a position is a function of the number of subordinates controlled and cannot be delegated.

Adherence to a linear hierarchical position produces a bureaucratic organization composed of semiautonomous units with parochial and often conflicting interests. Resource arrangements once established tend to be perpetuated and expanded independently of the original purpose. Heavy dependency on formal policies and procedures vertically administered has the effect of stifling innovation and often produces a static organizational structure unresponsive to environmental change.

Morphogenic systems, in contrast to bureaucratic systems, seek to maintain a dynamic equilibrium by mobilizing internal forces to counteract the stress imposed by the environment. Subordinate units respond to reduce overall stress and in so doing often irreversibly move the organizational structure to a new level of equilibrium. Thus, change is irreversible as the adaptive process modifies structure to achieve purpose. Organizational adaptability is evidenced as organizations research and develop new products, modify existing ones to forestall obsolescence, react to crisis situations, expand markets, and create and synthesize knowledge necessary for the development and implementation of technological solutions to social problems; in short, as organizations perform the myriad of activities associated with survival and growth.

Adaptability requires organizational openness, a willingness to modify internal structure so as to minimize the shock of environmental encounters. Effecting structural modification, however, necessitates a mechanism for change that contravenes against structural ossification. One such mechanism is the project approach to system management. Projects as an organized set of activities that control the purposive utilization of resources for a finite time duration provide the means for organizational flexibility. As projects exist for a finite time duration (usually not exceeding 3-5 years), organizations based on a stream of products must of necessity be temporary and, thus, amenable to change (Bennis and Slater, 1968).

The appropriateness of project management as opposed to functional management is dependent upon the degree of internal system interrelatedness and the degree of system vulnerability to environmental influence. Project management is most desirable when: objectives are multilateral, thereby requiring cooperative utilization of resources; there is social or competitive pressure to advance the existing state of product technology; environmental uncertainty and situational unfamiliarity create a high risk of failure; developmental or feasibility studies are required; product tasks cut across functional departmental boundaries; and the undertaking is ad hoc and represents a substantial resource investment.

In the project approach, managers are assigned to special projects where they function as unique project agents. Each manager is responsible for his project. In carrying out this responsibility he must deal with persons at various functional levels within the organization as well as with external organizations. The flow lines of communication, influence, and work are lateral and diagonal as well as vertical, thereby enmeshing the project manager in a web of authority and responsibility relations rather than the traditional scalar line of command. In many instances, these ad hoc relationships created to expedite project performance develop sufficient strength and permanence to give de facto legitimacy to the modus operandi of the project manager.

Project management is superimposed on the functional organization to create a hybrid organization. Project management largely determines what support is needed and when it is needed. Functional managers have the prerogative of deciding how the technological and routine administrative support will be provided. Conflicts of interest are generally resolved by negotiation, with only the exceptional case going to a higher level for adjudication. Much of the project manager's authority stems from his personal and technical competencies, persuasiveness, and ability to build political alliances, rather than from resort to the legal authority of his position. Thus, political factors play a large role in determining the effective authority of a project manager.

It is often useful in system analysis and design to be able to represent schematically the interrelatedness of the projects via an organizational chart. Since structure is but process frozen in time, organizational charts are but static approximations of organizational dynamics. Person-systems as resources do not conform exactly to positional specifications. Task activities are expanded or contracted according to reciprocal bargaining, and communication and authority linkages seldom follow exactly the orderly patterns implied by the chart. Nevertheless, organizational charting provides a useful function in organizational analysis since it focuses attention on the highly complex working relationships required to achieve the multilateral objectives of dynamic systems.

A recently developed technique termed linear responsibility charting seems particularly well suited as a device for clarifying the authority relation when multiple positions share in the responsibility for the performance of a task. The linear responsibility chart (LRC) is basically a matrix with positions listed as columns and tasks as rows. As shown in Figure 1, the positions are blocked out by lines and sequentially arranged to correspond to the linear representation of a traditional pyramidal organizational chart. The positions included should represent only those of interest in the analysis. Tasks are grouped under corresponding projects and projects under parent programs.

The element in the intersection of a row and column represents the task-position relation. Relations are of three basic types: (1) primary, (2) control, (3) informative (Cleland and King, 1968). The primary relation is that of work performed directly on the product according to the activity specifications of the task. Control relations are subdivided into direct supervision and general supervision. Direct supervisors monitor and evaluate the performance of the task according to policy and procedural guidelines, schedules, and other control devices, and by so doing shape the form of the transformation of the primary position. General supervision provides a second-order policy strategy framework for the direct supervision and the primary position which serves to encourage maximum closed loop direct supervision. Routine inter-task integration is a control relation concerned with the functional input-output compatability of primary transformations, i.e., work outputs of one position are acceptable as inputs to another. Occasional inter-task integration differs only in the special nature of its application. Informative relations are inter-task coordination, occasional inter-task coordination, and mandatory output notification. Inter-task coordination is an informational input to the primary resource--such as sequencing, quantities, qualities, and scheduling requirements--that does not change the form of the transformation of the primary position. Occasional inter-task coordination as a relation differs only in its intermittent occurrence. Mandatory output notification requires that the informational output of a primary position be transmitted to another position, but it implies no control function. The relations and their corresponding symbols are presented in the legend of Figure 1.

Determination of the relational types for all entries in the LRC matrix requires a detailed analysis of the organization. Each entry in the chart indicates an intercoupling between the static formal organization and the work subsystem that when considered as a whole depicts how positions and tasks are organizationally integrated. Each row considered separately indicates all positions that share the responsibility for task performance and the nature of that responsibility. Each column shows a breakdown of the tasks linked to that position associated with the column. Absence of a symbol means that the position and task are not significantly related.

Control as a major system management function is concerned with verifying whether or not actions conform to established activities. Since purposive systems proceed toward objectives according to plans, it is imperative to know the extent of deviation from system objectives and to maintain the deviation within acceptable limits by displacement-correcting responses. Deviation is controlled by a negative feed-back system which, as previously indicated, contains a sensor to measure system performance, a comparator to evaluate measured performance against a standard, and an activating device that is capable of producing or eliciting the changes required to maintain the desired condition. Control, like planning, is future-oriented in that it uses past information to direct present action so as to attain a future state. Therefore, deviation must be detected early in order to forestall the possibility of larger future displacements that could exceed system tolerance levels and lead to system pathologies or dissolution.

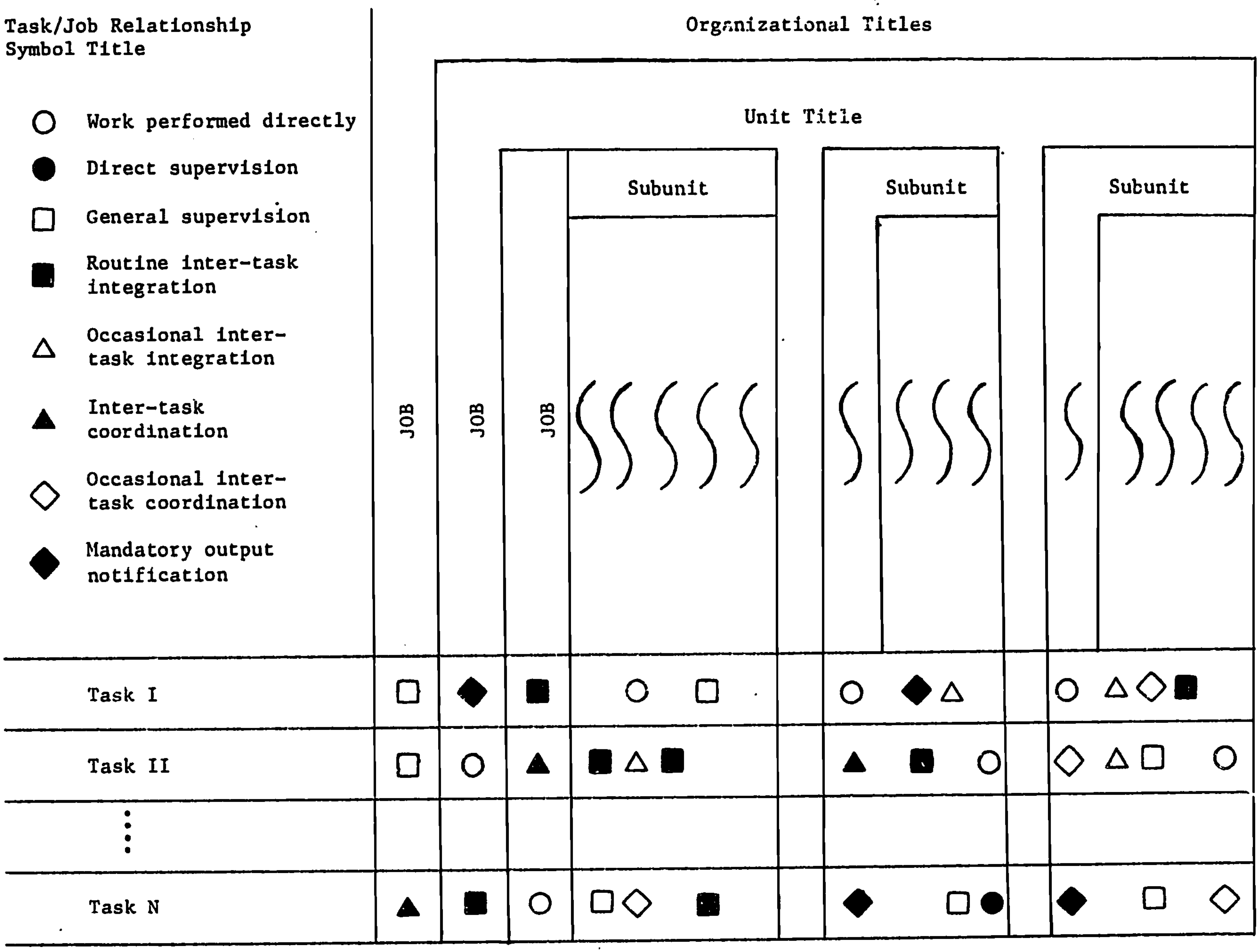


Figure 1. Systems LRC for a General Organization

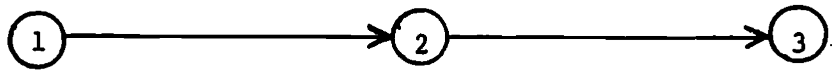
Basic organizational control resides at the project level. Project managers require information concerning cost, scheduling, and technological factors in order to evaluate progress against the project objective. Comparative information is needed in order to assess how a particular project compares with other ongoing complementary and competing projects. Evaluative information must be supplied to identify project areas whose deviance may pose a threat to objective attainment. Finally, anticipatory information such as deviance rates of change must be provided which will enable the project manager to forecast future affairs and, if necessary, take corrective action.

Informational networks should be provided which will facilitate the vertical, horizontal, and diagonal flow of communication. In a formal communication network, information flows are primarily vertical and follow the authority flow along established policies, procedures, methods, and organizational relations. In the informal communication network, information is transmitted by horizontal and diagonal channels that connect peers, associates, and colleagues rather than superiors and subordinates. Personal communication networks differ in that position incumbents communicate in a personal rather than an organizational capacity. In a project-based organization, informational systems should be designed to utilize all types of networks.

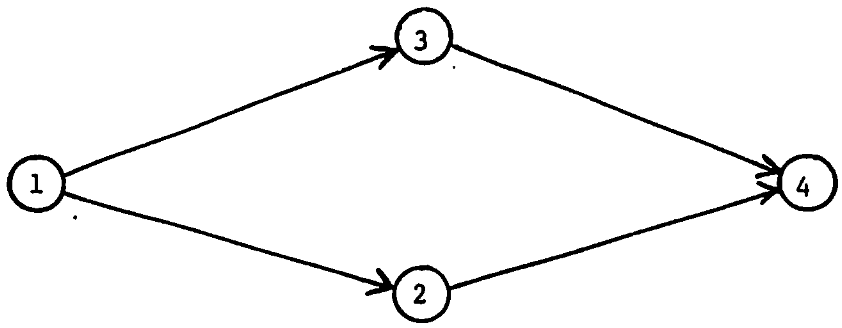
Schedule control as a basic element of project control integrates planning and control to conserve time as a valuable commodity. One important planning and scheduling technique is that of network planning. A network plan may be depicted graphically by a directed graph (diagraph) which consists of a set of circles together with directed lines (arrows) that join pairs of circles. The arrows correspond to activities and the circles to events whose occurrence signals the end and/or beginning of an activity. Circles and arrows are sequentially arranged in the order in which activities are to be performed.

Networks always begin with an origin event and end with one or more events called terminal events; that is, time flows from a predecessor event which initiates an activity to a successor event which terminates an activity. If two or more activities can be performed simultaneously, the activities are said to be concurrent. Two activities such that the successor event of one activity is also the predecessor event of the other activity are termed sequential activities. Sequential activities are time-dependent in that one activity cannot begin until the other has been completed. In many instances, concurrent activities are constrained in that the successor activity cannot begin until both predecessor activities have been completed. This constraint is represented by a dummy (artificial) activity depicted by a broken arrow. A variety of simple networks is shown in Figure 2.

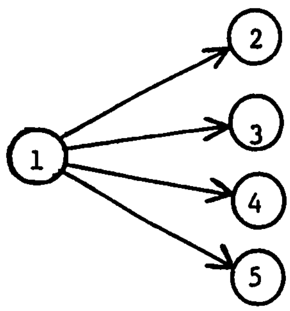
Project networks are, thus, convenient graphic devices for displaying project structure. However, network plans become an analytical tool for project scheduling and evaluation when time estimates are



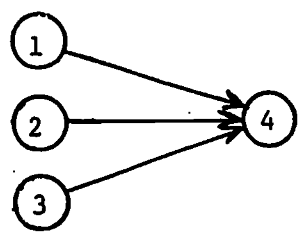
Series Construction



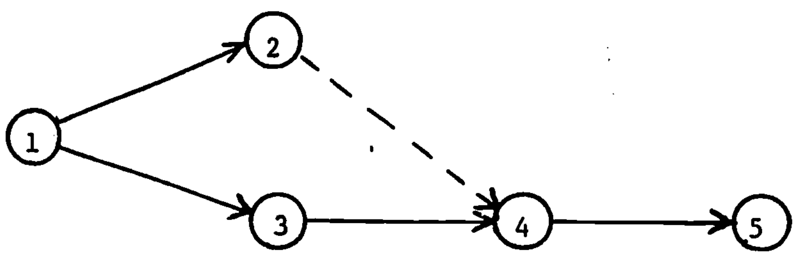
Parallel Construction



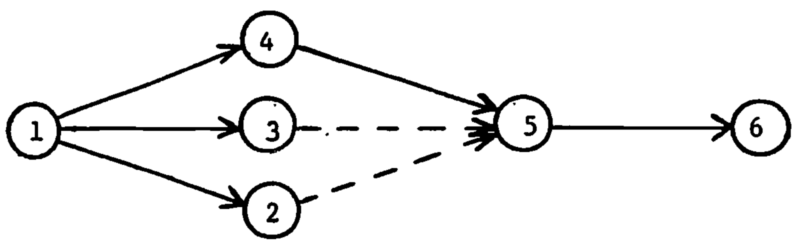
Burst Construction



Merge Construction



Single Dependency Relation Shown by Dummy Activity



Multiple Dependency Relations Shown by Dummy Activities

Figure 2. Simple Network Plans

attached to each activity. The time estimate of a network path is referred to as the length of the path and is obtained by adding the time estimates of each of the component activities comprising the path starting with the origin event and proceeding to each successor event in a sequential manner until the terminal event is reached. The longest network path is called the critical path because the length determines the minimum time required for completion of the entire project. Critical events are those events located on the critical path.

If projects are to be expedited, the accomplishment of at least one critical event must be expedited, for critical events pace the project. Slippage in any one of these critical events will delay project completion. Critical activities are expedited by transferring resources from non-critical to critical activities. A number of techniques for project planning and scheduling are available, of which PERT-Time and PERT-Cost are the best known and most widely used (Cook, 1966).

Cost control as an element of project control has the responsibility of organizing, directing, and controlling all cost procedures required for the project. Costs for separate project tasks are obtained from project participants and accumulated into a central file. Authorization for the expenditure of project funds is centrally maintained. Periodic project audits are conducted, and estimated costs to completion are updated. Records of costs sustained to date are maintained and periodically updated. Comparisons are made available between actual costs and programmed costs; areas of potential averages are flagged; and corrective action suggested.

Overall project management is facilitated by proper project documentation and review. The major project document is the master project manual which is the summary expression of the major policies and procedures guiding the project. The manual should be updated frequently so as to provide current information to the project manager. Periodic project review by an ad hoc independent group provides an appraisal that often contributes to improved project understanding and control. A project check list provides needed structure for project review and evaluation and serves to identify areas where further planning may avert future difficulties.

PART TWO - SUGGESTED APPLICATIONS

FOREWORD

The following sections contain the essence of a state-wide general system for professional personnel development in vocational and technical education. The system's functions are seen as planning, activating, and controlling the developmental process. The system per se is considered as a set of activities so sequenced as to achieve system function. Each section corresponds to a major system activity. Activities as components of the developmental system indicate what action must be taken in order to effect professional development. Since the system cannot operate directly to produce the desired developmental results, system actions affect the development indirectly by controlling the direct actions of the developmental resources.

The system is hierarchically structured according to a morphological reductive process in that each major activity is further divided into subactivities which are, in turn, further divided until a specified level of vagueness is attained. Contrary to expectations, a certain amount of vagueness in the activity specifications is useful--in fact, mandatory--for system design viability. Vagueness as contrasted with ambiguity provides a latitude of interpretation that is necessary if the proposed system is to be adaptive to a variety of contingencies unforeseen by the system designers. An apt analogy is that of the U. S. Constitution, a set of rules whose strength lies in their vagueness--a vagueness that expresses the elusive spirit of the law without resorting to a categorization of specific circumstances which would have doomed it to immediate obsolescence.

Whenever feasible, alternative means of carrying out general system activities are suggested. However, in all cases, system activities unavoidably reflect a point of view, a philosophy that stylizes the resultant design. Without a directing philosophy, the level of vagueness of the activities would allow nearly complete freedom of action alternatives and, hence, would do little to reduce the potential variability to manageable proportions--a condition which unfortunately characterizes much of systems literature.

Reduction of variety is not without its inherent price. In order to achieve a desired purpose, certain assumptions are stated. Once incorporated into the system design, they preclude other assumptions; thus, effectively reducing freedom of choice. Each successive system activity based on the given assumptions further reduces the action alternatives. Increased specificity of system activities increases the complexity of the system organization with resultant difficulties of user comprehension.

A PROTOTYPE EPD SYSTEM

The (E)ducational (P)rofessional (D)evelopment system outlined in this paper is offered as a prototype to demonstrate the utility of the systems approach to developmental planning. The model system is intentionally vague so as to be sufficiently flexible to be modified to meet the needs of individual users. At certain places in the development--for example, the mission and goal statements--content has been added more for completeness than logical necessity and may be altered without affecting the structural integrity of the model.

The following glossary of terms is offered in order to coordinate the abstract system notions previously introduced with their manifestations in the proposed EPD system:

Generalized vocational capabilities -

That commonality of values, attitudes, decision strategies, generalized skills, and information that characterizes the basic human requirements for a family of jobs.

Goals -

To develop the human resources needed at the (1) middle-grades level so as to foster a basic occupational awareness and to initiate development of general personal and interpersonal work skills; (2) secondary level so as to facilitate initial career decisions and to provide parallel opportunity for orientation toward professional or subprofessional career development; (3) postsecondary level so as to develop the general vocational capabilities required for initial entry into subprofessional careers; and (4) adult education level so as to develop the general vocational capabilities required for progression in subprofessional career sequences.

Mandate -

The public interest expressed in Part F of the Education Professions Development Act and other supportive state laws.

Mission -

To develop the human resources needed to provide every citizen the opportunity to develop general vocational capabilities required for entry and progression in a career sequence that is consistent with both individual potential and the requirements of society.

Negotiated environment -

Policies, procedures, rules, and regulations of local, state, and federal agencies and institutions.

Non-negotiated environment -

General economic, social, political, legal, and technological conditions.

Objectives -

To plan, actualize, and control projects for the development of human resources needed to activate the state programs of vocational and technical education at the middle-grades, secondary, post-secondary, and adult educational levels.

Product -

Human resources in the form of vocational teachers, administrators, supervisors, coordinators, and guidance personnel.

Resources -

Teacher education institutions; local education agencies; other federal, state, and local human service agencies; private and non-profit organizations.

Skill level -

A qualitative distinction indicating differences in intensity rather than kind of generalized vocational capabilities.

Supersystem -

Division of Program Planning and Development.

System -

EPD system administratively housed in Office of Vocational-Technical Education Personnel Development.

The organizational location of the EPD system in a hypothetical state division of vocational education is shown in Figure 3. The significant feature of the organizational chart is not necessarily the locus of the EPD system but the horizontal lines of authority, responsibility, and formal communication which cross functional boundaries. Office of Vocational-Technical Education Personnel Development personnel are responsible for the management of projects to provide an adequate supply of personnel to staff state vocational and technical education programs. In carrying out this responsibility, project managers must

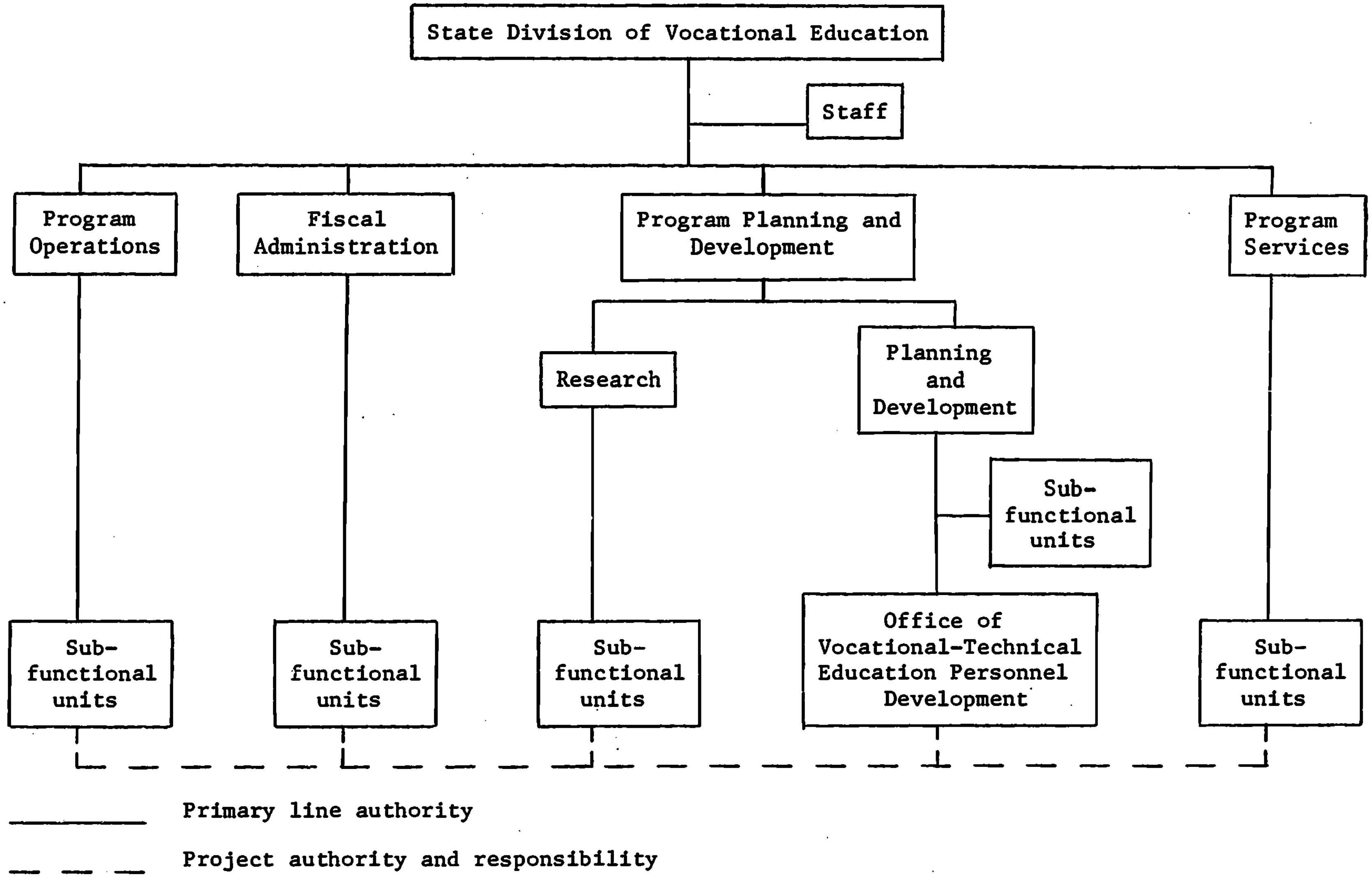


Figure 3. Functional Organization of a Generalized State Department of Education

obtain support from a variety of curricular, fiscal, special education, training, manpower, and evaluation specialists as well as from external agencies and organizations.

Figure 4 graphically depicts the major component task flow of a prototype EPD system (Coster, Dane, and Morgan, 1970). Task 1 concerns the establishment of priorities for program areas which reflect crucial current and projected technical and vocational manpower demands of the state. Task 2 pertains to the identification of present and anticipated future State educational programs required to meet these manpower demands. Task 3 involves determination of personnel needs on the basis of the discrepancy between estimated demands for and supply of trained personnel. Task 4 deals with the preparation of specifications for projects to develop critically needed personnel. Task 5 serves to identify the available developmental resources, and Task 6 assigns the resources to projects according to specified assignment rules. Task 7 indicates how projects are to be managed, and Task 8 relates to the evaluation of the product.

In terms of EPD system management functions, Tasks 1-4 are planning functions, Tasks 5 and 6 are activation functions, and Tasks 7 and 8 are control functions. Each task is analyzed into its constituent sequential activities in the following sections of this report. Whenever possible, various alternative means for activity implementation are presented and evaluated in terms of system requirements.

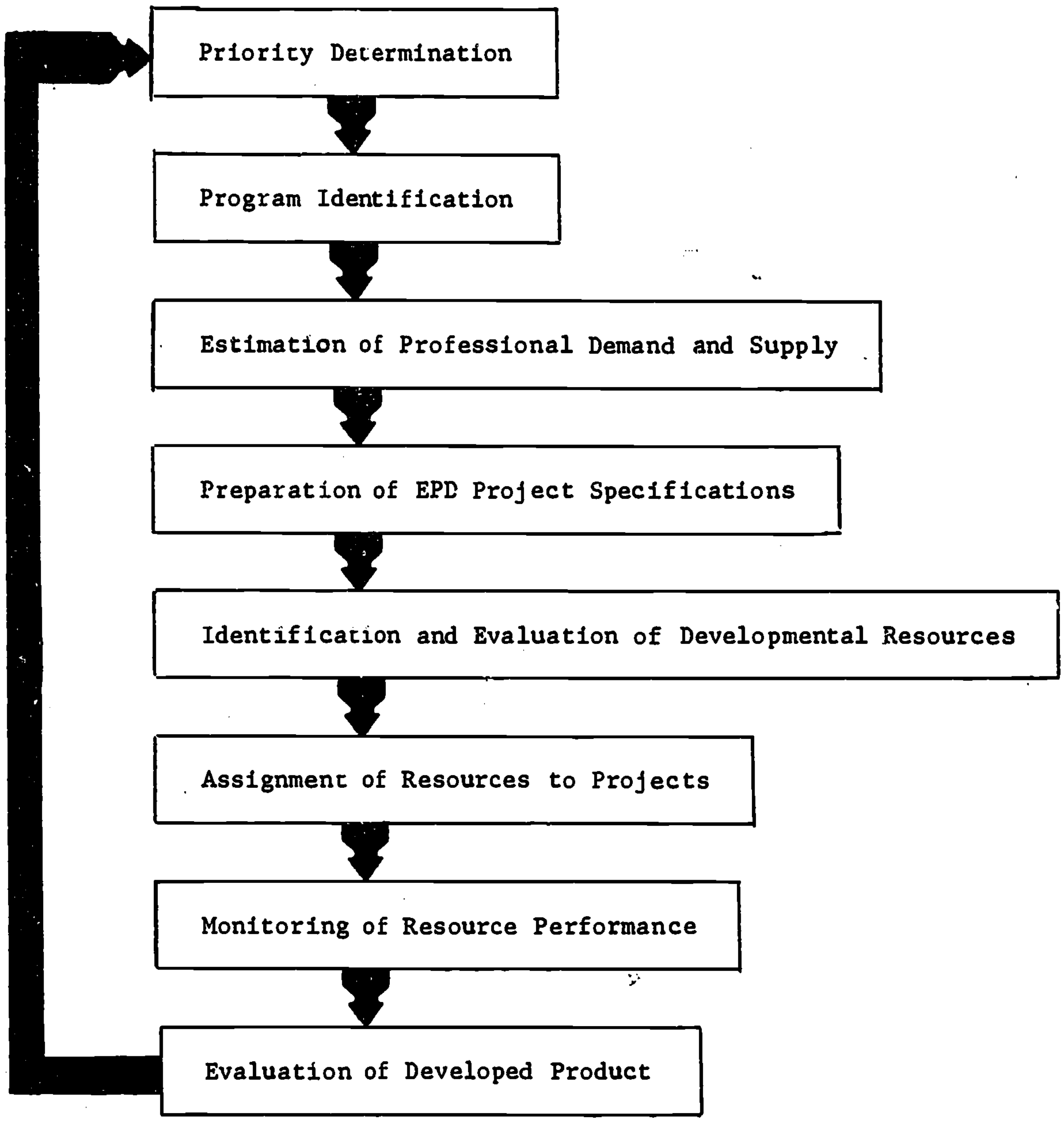


Figure 4. Flow-chart of the EPD system

PRIORITY DETERMINATION

Activity 1 - Develop State and Area Employment Projections

The procedural mechanism for determination of priorities is based on the assumption that program priorities should reflect the critical manpower needs of the state. Since present needs are an uncertain indicator of future requirements, manpower projections are required to predict changing future manpower demands.

The techniques for developing first approximations to area employment projections can be roughly classified according to use of: simple trend projections of the ratio of local to national industry employment; econometric regression models which predict local employment as a function of regional conditions such as population, demand, and per capita income; and industry-occupational matrix to develop occupational employment patterns. The techniques or mix of techniques selected depends on the number and technical competency of available personnel, required accuracy and degree of industrial and occupational detail, and the availability of computer assistance.

The following alternatives are suggested:

A-1 - Obtain projections from other state or local sources.

(+) Requires little expenditure of personnel time. Projections are tailor-made by area analysts familiar with local conditions and available data.

(-) May be unsuitable for developmental purposes in that the details of industrial, occupational, or area classifications are too gross.

A-2 - Develop area employment projections based on extrapolations of local to national industrial employment.

(+) Simple technique. Appropriate if area and national employment trends show a close relationship.

(-) Questionable for area industries that sell in local and regional markets.

A-3 - Develop area employment projections by econometric regression techniques.

(+) Increased precision of employment estimates due to larger numbers of independent variables.

(-) Requires technical sophistication for development.

A-4 - Use national industry-occupational matrix to develop employment projections. An industry-occupation matrix is an array of industries and occupations depicting the percentage distribution of employment in an industry across selected occupational classes. The Bureau of Labor Statistics (BLS), in an attempt to provide guidelines for state and area manpower projections, has developed a national matrix for 116 industries and 162 occupations on the basis of 1960 census data and has projected the matrix to 1975 based on an explicit model of economic growth (Bureau of Labor Statistics, 1969). State and area occupational projections using a national industry-occupational matrix can be made by a variety of methods; however, two methods seem especially worthy of discussion.

Let

L_{ij} (year) = Area employment in occupation j for the given year.

L_i (year) = Total area employment in industry i in the given year.

f_{ij} (year) = National fraction of occupation j in industry i for the given year as found in Tomorrow's Manpower Needs (BLS, 1969, Volume IV, Appendix G).

L_j (year) = Total area employment in occupation j.

Then, by projection Method A, the projected area employment in occupation j for 1975 is

$$L_j\ (75) = \frac{\sum_{i=1}^{n} f_{ij}\ (75)\ L_i\ (75)}{\sum_{i=1}^{n} f_{ij}\ (60)\ L_i\ (60)} \cdot L_j\ (60) \cdot$$

Method B differs to the extent that an industry-occupation matrix specially developed for the area 1960 base period is required. Then, if

L^*_{ij} (year) = Area fraction of occupation j in industry i for the given year

and

$$L^*_{ij}\ (75) = \frac{fij(75)}{fij(60)} \cdot L^*_{ij}\ (60),$$

then, L_j (75), the projected employment in occupation j in 1975 is

$$L_j (75) = \sum_{i=1}^{n} L_{ij}^{*} (75) \cdot L_i (75)$$

Both methods require area industry estimates for 1975. Such projections should be available from other state sources. If not available in suitable form, they can be readily obtained from census data. However, care should be exercised to ensure that area employment data used for projection be modified to include self-employed, unpaid family workers and government workers, and that adjustments be made for multiple job holders. Projections of area employment in occupation j for intervening years can be made by linear interpolation of f_{ij} (year) between f_{ij} (60) and f_{ij} (75).

Area occupational projections developed by either method should be regarded as tentative first approximations to be modified by local experience. Changes in the occupational structure of the national industry-occupational matrix and/or projected area industry employment allow considerable flexibility in preparation of a range of projections which reflect differing assumptions about future area economic conditions.

It should be emphasized that the projections developed are estimates of employment demands resulting from economic growth and expansion. To these estimates must be added the replacement needs resulting from expected deaths, retirements, and other withdrawals from the area labor force. In lieu of actual separation data, one simple means of estimating number of occupational separations is to apply the national occupational separation rates to the estimated area projections for each occupation (BLS, 1969, Volume I, Appendix A). Of course, this assumes that age separation rates, as well as mortality and retirement patterns for the area, are the same as for the nation. Another means is to apply the age-specific rates derived from national data to the age distribution of area occupations (BLS, 1969, Volume I, Table 14). The effects of transfers (geographic mobility) are generally difficult to estimate and, hence, should be omitted from the projections unless specific area data are available.

(+) Method A is simple to use and requires only area industry employment projections as inputs; whereas Method B is more complex, as a special area matrix must be developed from local data. Use of BLS projection data represents a savings in personnel time; requires less technical sophistication and computational effort; serves as a potential source of information when local data are unavailable, incomplete, or too gross to be useful; and provides a national economic and technological context for interpretation of state and area manpower needs.

(-) State and local needs may not parallel national staffing patterns.

Activity 2 - Determine a Taxonomy of Programs for Vocational Preparation

The plethora of information about vocational education must first be categorized into taxonomic program classes in order to serve as a basis for decision-making. Information about organization, administration, content, resources, and process of vocational instruction has meaning for the EPD system only to the extent that the information is expressed in well defined, standardized units that can be classified collectively into objective program classes.

A-1 - It is recommended that information terminology follow that developed in Standard Terminology for Instruction in Local and State School Systems (Putnam and Chismore, 1967). Vocational program areas as therein defined are: Agriculture, Distributive Education, Health Occupations Education, Home Economics, Office Occupations, Technical Education, and Trades and Industrial Occupations. Representative subject matter areas are identified, coded, and described for each of the major vocational program areas. Restriction of the domain of state vocational and technical programs to those subject-matter areas therein described provides the procedural uniformity necessary to support EPD system activity. However, these categories are arbitrary and in no way preclude the use of other subject-matter representation.

Activity 3 - Project Manpower Needs for Vocational-Technical Program Areas

This activity involves determination of occupations for which a particular vocational program would be potentially useful. A program is said to be a useful preparation for an occupation if the primary program intent is to increase the skill level of the generalized vocational capabilities associated with that occupation. In the absence of more definitive data relating generalized vocational capabilities to occupations and curricular program areas, determination of potential utility must be subjectively based.

A-1 - A tentative assignment of program areas to the occupations for which the program preparation appears most relevant is presented in Figure 5. Program areas are assigned to occupations whose requirements appear most congruent with the subject-matter descriptions of programs given in Putnam and Chismore (1967). The occupational titles are those used in the BLS tables (Volume IV, Appendix F). The assignment procedure appears workable for all program areas except for gainful employment in home economics-related occupations. In this instance, the BLS occupational classification appears too aggregate to provide acceptable estimates without further refining assumptions.

Agriculture	Distributive Education	Health Occupations Education	Home Economics	Office Occupations	Technical Education	Trades and Industrial Education
Farmers and Farm Workers	Personnel & labor relations workers Credit men Purchasing agents Managers, officials, & proprietors n.e.c. Sales workers	Technicians, medical and dental Other medical health workers	Dietitian and Nutrition	Accountants Librarians Postmaster and assistants Clerical & kindred workers	Surveyors Technicians, other Officers, pilots, engineers, ship	Draftsmen Air traffic controllers Radio operators Workers in arts & entertainment Designers Photographers Conductors, railroad Craftsmen, foremen & kindred workers Operatives and kindred workers Service workers Laborers, except farm and mine

Figure 5. Assignment of BLS Occupational Titles to Vocational Program Areas

Given a program area-occupation correspondence, projected requirements are individually estimated for each occupation using the techniques identified in Activity 1. The projected labor demand for each program area is then obtained by summing over all occupations associated with that program area. Unless total employment needs are used, estimates will reflect only the employment requirements resulting from economic growth. If total future manpower needs are to be estimated, replacement needs for each occupation should be estimated, added to the projected employment demand, and then summed over relevant occupations to generate estimates of total manpower needs for a given program area.

A-2 - An alternate technique for projecting vocational requirements has been developed by the National Center for Educational Statistics (1967). Their technique involves three steps: (1) projection of employment by industry, (2) preparation of an industry-program area matrix, and (3) estimation of program area requirements by multiplication of industry employment projections by program proportions and summing over the relevant industries.

(+) A-1 is simpler to operationalize than A-2, which requires the development of an area industry-program matrix depicting the proportion of employment in each industry for which a specific vocational program area would provide useful preparation. Conversely, A-2 may provide a more accurate appraisal of local demand for formal vocational education programs.

(-) Both procedures produce somewhat exaggerated estimates of program demand as the contributions of private intra-organizational training and developmental efforts are generally not accounted for due to absence of valid data.

Activity 4 - Establish Area Planning Regions

Diversity of economic and demographic characteristics is generally greater between than within geographic areas and thus argues for dividing the state into separate planning regions. The boundaries of the planning regions should generally conform to county lines and should be determined by such factors as the boundaries of: the Appalachian Development Region, local development districts within this region, recognized state planning regions, regions designated by the Office of Business Economics, and local area labor markets.

Activity 5 - Determine Planning Region Priority

Let the following variables be defined for each of N planning areas:

X_1 = Ratio of planning region population to state population.

X_2 = Estimated population growth rate over the planning span.

X_3 = Ratio of planning region median income to state median income.

X_4 = Ratio of regional unemployment in 14-25 age group.

X_5 = Ratio of public assistance recipients.

X_6 = Ratio of physically handicapped.

X_7 = Ratio of mentally handicapped.

X_8 = Ratio of school drop-outs.

X_9 = Ratio of households with annual income under $3,000.

X_{10} = Ratio of regional population with less than 9 years formal education.

Definition: The regional priority (P_j) for the j^{th} planning region is

$$P_j = \sum_{i=1}^{8} Wi\ Xi/(1-X_9)\ (1-X_{10}) ,$$

where Wi are arbitrary positive weighting constants which reflect the relative importance of each variable. The weights which reflect subjective expert judgment would be obtained by application of the Delphi technique (Helmer, 1966).

Activity 6 - Determine Priorities for Vocational Program Areas within a Specified Planning Region

Let

W_{ij} = Ratio of current employment related to the i^{th} program area to current total employment in the j^{th} planning region.

X_{ij} = Unemployment rate in the j^{th} region for the occupations served by the i^{th} program area.

Y_{ij} = Estimated average change of X_{ij} over the planning span.

Z_{ij} = Estimated average change of W_{ij} over the planning span.

Definition: The priority index (P_{ij}) for the i^{th} program area in the j^{th} planning region is

$$P_{ij} = W_{ij}\ (1-X_{ij})[1-aY_{ij} + bZ_{ij}],$$

where a and b are positive weighting constants, and $a + b \leq \Delta p$ where Δp is the length of the planning span. The restriction on the weights is necessary to ensure that $P_{ij} \geq 0$.

The priority for the i^{th} program area, P_i, is defined as

$$P_i = \sum_{p=1}^{N} P_j \ \cdot \ P_{ij} \ ,$$

where N is the number of planning areas, i.e., the priority for program i is the sum of the within-region priorities for the i^{th} program weighted by the planning region priority. In this manner, general economic and demographic factors associated with the planning regions are allowed to influence the overall program priorities, whereas within-region program priorities are a strict function of employment needs.

PROGRAM IDENTIFICATION

The most immediate purpose of vocational education is the attainment of knowledge. Knowledge as an organized set of beliefs (suppositions) about the nature of "reality" can be classified as: knowledge of the existence of objects and/or events; knowledge about the attributes, properties, or characteristics of objects and/or events; and knowledge of how to control objects and/or events. Knowledge is viewed as an organized experience created by man in an active encounter with his environment and never discovered as natural truths. Since a claim cannot be validated against a criterion of unknowable absolute truth, knowledge must be evaluated according to the degree to which it serves human need. Knowledge is assumed to serve two major purposes: first, to anticipate future events, and second, to control future events (Meehan, 1968).

Knowledge, then, is instrumental in reducing the uncertainties associated with an as yet unexperienced future. Whether the purpose is to reduce uncertainty by anticipating future environmental states or by intervening so as to modify the likelihood of the occurrence of specific future environmental states, reliable expectations (beliefs) about the future are required. These expectations about future environmental states of affairs are created as the product of theory which serves as the basis for knowledge.

The role of theory in education is cogently summarized by Marc Belth (1965), who argues:

> It is not until we postulate a contextual character of knowledge that education changes from passive verbal exposure to active exploration. We must see the relationship of a statement made to the theories from which it derives and to the models by means of which it is interpreted. Then it becomes clear that knowledge depends upon a grasp of (1) process, (2) theoretical, explanatory grounds (the basis for the contextual character of knowledge), and (3) analysis of terms and events. When this fact enters into consideration, knowledge ceases to be a matter of absorption and becomes, instead, the very subject of inquiry.
>
> If the function of education is development of knowledge, we must add a fourth condition to the three noted above: a concern for ways in which knowledge is created and altered. What enters into the knowledge-making process takes on the most fundamental importance in the study of education. Thus, we become obliged to examine the role of theory in the development of knowledge and in the employment of knowledge, or the act of thinking.

The following notions will be used in examining the role of theory in education:

Axiom -

A basic statement about a construct.

Axiomatic system -

The constructural variables and the set of associated axioms.

Concept -

A class (set) of percepts embodying a common feature.

Conceptual framework -

An interrelated set of concepts that serve to define the phenomena of inquiry.

Conceptual variable -

A rule for assigning a symbol to a percept which is a member of the concept.

Conceptualization -

The process of creating a conceptual framework.

Construct -

An entity of an abstract or idealized world.

Constructural variable -

A rule for assigning a symbol to a state of the construct.

Description -

A set of propositional assertions corresponding to an empirical situation.

Empirical situation -

An instance of a phenomenon defined as a set of percepts generated over a time frame which are members of the concepts comprising the conceptual framework.

Explanation -

Making an empirical situation isomorphic to a theory.

Isomorphism -

The condition of a model describing an empirical situation, if and only if for every relationship between the constructural variables of the axiomatic system there exists a parallel relationship between the corresponding conceptual variables of the conceptual framework.

Logical argument -

A claim that a statement follows from the conjunction of axiomatic statements.

Logical calculus -

Operational rules for determining the validity of a logical argument.

Model -

A loaded theory; one in which there exists a one-to-one correspondence between the constructural variables of the axiomatic system and the conceptual variable of the conceptual framework.

Percept -

An attribution of object/event entity to an organization of sensory flux.

Phenomena -

The object-event domain of inquiry.

Proposition -

A declarative concatenation of symbols according to grammatical rules which corresponds to a relationship between concepts.

Sensory flux -

The fundamental "stuff" of the external world.

Theorem -

A statement that follows from the axioms by logical argument.

Theory -

A set of logically valid theorems derived from an axiomatic system.

The attainment and development of knowledge are seen as an inquiry process wherein claims to know are pragmatically validated against the purposes served. In essence, man as an inquirer receives information, processes it, and takes appropriate action. To receive information is something of a misnomer in that it implies a passivity on the part of man, an acceptance of something that is offered from an outside source. On the contrary, man participates in the creation of the information he receives. Information does not reside in its stark completeness in the external world to be received as such; it is created by man.

The external world is a stream of undifferentiated but potentially orderable <u>sensory flux</u> that presses on man and is expressed by him as representations of an external objective reality. Through the process of perception, man objectifies his external world by creating a mediated world of perceived objects and events. Thus, percepts legitimize the existence of objects as spatial and events as temporal patterns in the perceptual world.

Meaning is attached to percepts only when they can be regarded as particulars of universal classes called <u>concepts</u>. Concepts as classes are the rules whereby experience is organized and as such provide the distinction between the particularity of a presently experienced percept and the timeless universality of its class. Unity of experience is achieved through the diametrical means of analysis and synthesis. Although a logical synthesis is sought--a knowing of the particular percept only as an instance of a universal concept--this synthesis is nowhere accomplished until experience is changed into a form which can be synthesized into an ordered structure. Before objects and events can be comprehended in a structural unity, they must first be analyzed in terms of features that have no direct existential counterpart in the flux of sensory experience. It is only through the identification and subsequent relating of features such as traits, attributes, or basic constructural elements that perceptual order is perceived. To identify the percepts requires a differentiation into the constituent elemental features and a classification according to concepts, while relating perceptual entities requires a combination of these features. In this sense, perceptual organization is dialectical in that the process always operates both analytically and synthetically in the transformation of percepts into their concept equivalents and the subsequent conceptual regroupings.

The focal point for systematic inquiry is determined by the <u>phenomena</u> under consideration and is a function of the <u>conceptual framework</u> brought to bear in the inquiry process. The conceptual framework provides the logical foundation or ground which makes possible the regrouping of perceptual experience (percepts) into an unequivocal determination--a unified view in which particular objects and events attain meaning in the context of a conceptual structure. The conceptual framework serves as a filter, a pair of spectacles, that shapes by inclusion and exclusion what the observer will "see." Facts, then, are not immutable states of "reality" to be discovered, but rather they depend on the discriminative power of the chosen conceptual framework.

Concepts as classes of objects and events are human inventions. The symbols used to represent concepts are drawn from a language in which object-classes are generally referred to in the noun form and event-classes in the verb form. Classification, modification, and invention of concepts are of major importance in the attainment of knowledge. Conceptualization of an area of inquiry is hindered by the conceptual inadequacies of ambiguity and vagueness. Ambiguous concepts, by definition, do not have well-defined classificatory properties; hence, assignment of perceptual referents cannot be justified. While ambiguity is to be avoided, vagueness in the early stages of concept formation and usage is frequently beneficial in that it provides needed latitude to explore new dimensions of perceptual classification that may have potential utility. Of course, ultimately, a concept must be more precisely defined if it is to serve a variety of purposes.

Conceptual variables are linked to form propositions which describe an empirical situation. For example, the propositional assertion, "water boiled at 212° F," requires a conceptual framework consisting of the intersection of three concepts symbolized by "water," "boiled," and "212° F." An empirical situation exists when a percept is created which is a referent (member) of all three classes, i.e., is in the intersection of the three concepts. If the percept is a member of all three classes, it is simultaneously assigned the symbols "water," "boiled," and "212° F" according to grammatical rules. The proposition is, thus, a symbolic, historical accounting of the existence of a percept that was a member of all three concept classes of the conceptual framework.

Percepts as organized experience are products of past encounters with the environment. Hence, description can attest only to those past situations that man has experienced in a temporal-spatial context. In the example, the past tense is appropriate since "water boils at 212° F" is not an assertion of what man has already experienced but rather a declaration of what he might expect to experience.

Descriptions as knowledge "of" and knowledge "about" an empirical situation say nothing about "how" nor "why" the events occurred. Furthermore, there is no explicit justification for expecting past relationships to project unchanged into the future and, hence, no basis for an inductive extension of experience.

In order to create knowledge of "how to do," relations between antecedent and consequent events must be established so that control at least in principle is possible by manipulation of the antecedent events. In other words, there must be some logical reason to expect that alteration of one or more relevant variables will produce a change in the remaining variables.

Anticipated relations between real-world events are fabricated in an idealized, hypothetical world--a world where, by definition, primitive entities referred to as constructs are governed by logical rules. The undefined mental constructs are given objective representation as constructural variables, hereafter referred to as variables. Basic statements about existence, attributes, behavioral characteristics, and interrelatedness of the variables are referred to as formal axioms and serve to explicate the role of the variables in the hypothetical world.

The variables (V_1, V_2, . . . , V_n) together with the set of associated axioms constitute a formal axiomatic system (DeLong, 1971). The variables of the formal system are combined to produce formal axiomatic sentences such as "$V_1 + V_2 = V_2 + V_1$" or "if V_1 and V_2, then V_1" according to formation rules which indicate the legal ways in which variables may be combined to produce formal sentences. Sentences are manipulated to produce new formal sentences by the application of transformation rules. Continued application of transformation rules to axioms and/or formal sentences generates a finite string of statements called a proof, the last statement of which is a theorem.

The form of the theorem is completely specified by stating the variables, the allowable operations on the variables, the formation rules, the transformation rules, and the logical assumptions. For brevity, these operations, formation and transformation rules, and logical assumptions are referred to together as a logical calculus. The validity of a theorem is established by logical argumentation rather than empirical verification. A theorem is said to be valid if it is implied by an application of the logical calculus to the variables. Only logical inconsistency can invalidate a theorem. A theorem is inconsistent and, hence, invalid if it is possible for the theorem to be the negation of some other statement; i.e., contradictory statements are implied by the formal system. Thus, if the axioms are assumed to be true statements, all valid theorems are true by implication. Since axioms as descriptions of an idealized world can never be empirically verified, truth has meaning only in the context of logical consistency.

Theory, then, consists of a set of general statements that are timeless in that the variables, being undefined, have no specific empirical referents. Although the theory refers to no definite empirical situation, it can be said to refer to all empirical situations for which the axioms generate useful explanations. The fact that the formal axiomatic system and its associated logical calculus are concerned with the form of the argument and not its content represents the greatest power of theory as it allows explanation to go beyond the contextual limitations of sensory experience.

Theory must be linked with empirical descriptions in order to provide reasonable expectations concerning the consequent effect of altering antecedent empirical events. The linkage is provided by loading a theory to create a model of an empirical situation. A theory is said to be loaded when variables of a theory are linked via coordinating definitions with the conceptual variables used to describe an empirical situation. For example, $V = C \cdot R$ is a theory relating the variables V, C, and R. If V = voltage, C = current, and R = resistance, then the variables are loaded by measuring the volts, amperes, and ohms, respectively, in an empirical situation consisting of a power source and a circuit. The coordinating definitions are provided by the rules of correspondence built into the structure of the measuring instruments.

An empirical situation is said to be explained if the empirical description is entailed by the theory, i.e., if the model is isomorphic to the empirical situation. It is important to note that since only change requires explanation, all descriptions of empirical situations must contain a record of change in order to be explainable. Thus, the process of explanation requires (1) a phenomenon of inquiry manifested in an empirical description that contains a record of change, (2) a formal axiomatic system to generate expected relations between a set of constructural variables, and (3) a loaded model that produces a prediction about the content of an empirical situation that is in accord with actual observations. This three-step process of explanation is graphically portrayed in Figure 6.

As an example, suppose that the phenomenon to be explained is the noticeable increase in temperature of a circuit when additional household appliances are connected in parallel. The description of an empirical situation contains a record of two changes: one in the increase in circuit temperature, the other the number of appliances connected in parallel. The empirical situation is described by the conceptual variables

V_1^* = number of appliances connected in parallel

V_2^* = temperature of the circuit

and the connecting relation

R_1^* = an increase in the value of V_1^* was accompanied by an increase in the value of V_2^*,

where the concepts of number, appliances, connected in parallel, and temperature are used in their ordinary grammatical meaning.

The formal axiomatic system contains the four variables V_1, V_2, V_3, V_4 and the axioms:

A_1: V_1 is the product of V_2 and V_3

A_2: V_1 is a constant

A_3: V_4 varies directly as V_2.

Application of a logical calculus to the axioms establishes the theorem:

If V_3 decreases, then an increase in V_4 is to be expected.

The formal theory is now loaded in the following way.

Let

V_1 = amount of voltage (volts) in the circuit

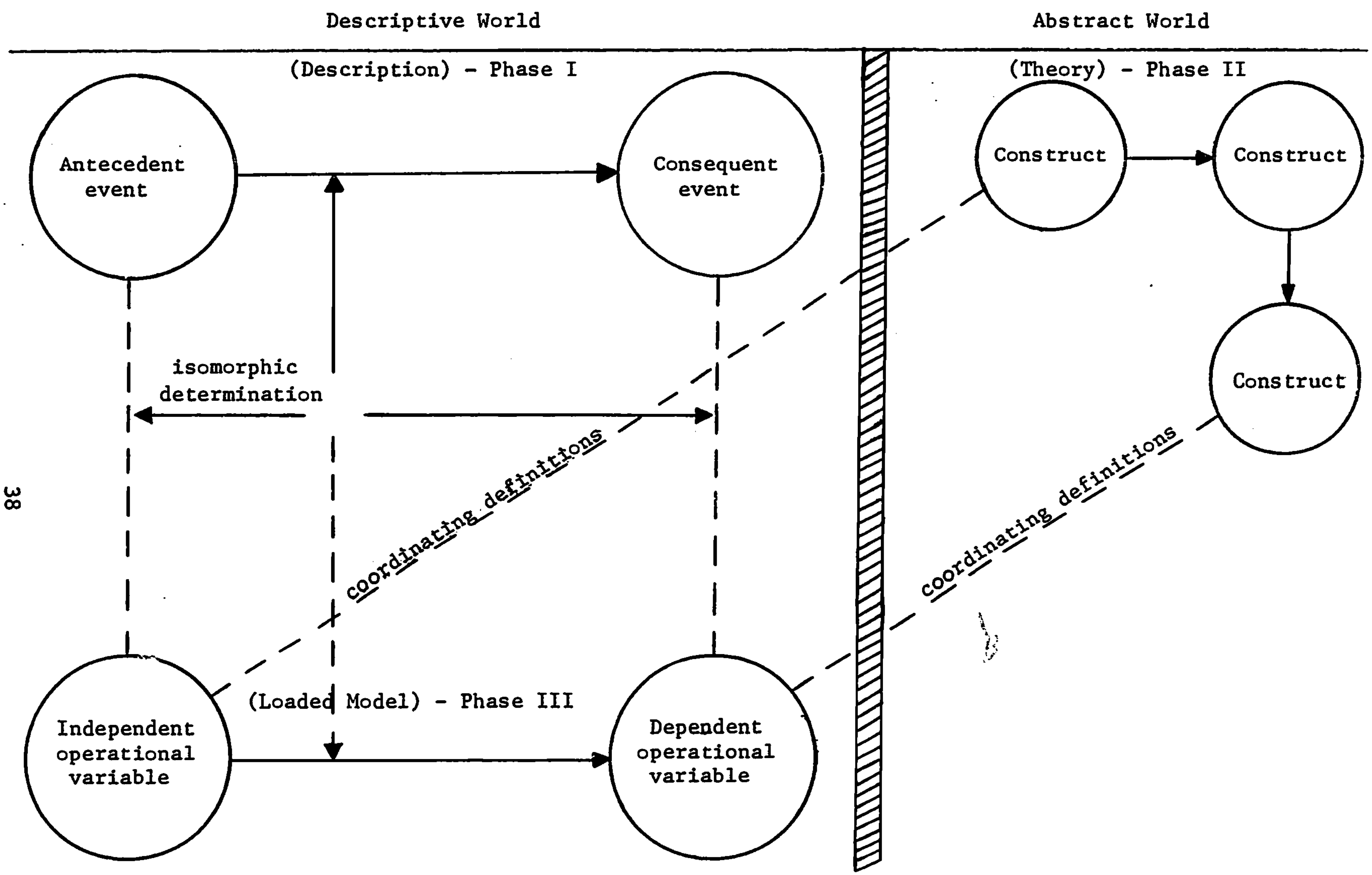


Figure 6. Three-Phase Explanatory Process

V_2 = amount of current (amps) in the circuit

V_3 = amount of effective resistance (ohms) in the circuit

V_4 = temperature of the circuit.

Consequently, loading the formal theory produces the model:

R_1: An increase in amount of circuit temperature is to be expected if the amount of effective resistance is decreased.

If it is assumed that increasing the number of household appliances connected in parallel corresponds to lowering the effective resistance, then the model R_1 is isomorphic with the description of the empirical situation, R_1*, and the description is said to have been explained by the model. The explanation provides an answer to "why" the circuit temperature increases by positing an idealized world in which an increased amount of current releases heat in the process of passing through the wire.

The system paradigm of explanation herein defined is offered as the procedure whereby man creates belief patterns which are imposed on his stream of perceptual experience in ways that allow understanding of the past, explanation of the present, and control of the future. Models as sets of beliefs or expectations about empirical situations are the sole means wherein man comes to know his world. Reality is revealed only through the mediational ascriptions of models.

Whereas models serve as predictors of specific empirical situations, theory as the implications of formal axiomatic systems pertains to a general class of empirical situations, i.e., to the phenomenon of inquiry. In the sense that models are maps of concrete, bounded networks of events, models can be regarded as observable manifestations of theories employed in specific time-place situations. Theory, then, is the fount of models. Taken collectively, theories provide the supportive rationale for man's claim to understand, predict, and control the flow of situations encountered as he transacts with his environment.

Theory as valid logical implications about a domain of inquiry is the result of a logical calculus applied to an axiomatic system. The logical calculus underlies the formation of theories and constitutes the "rules for rationality" that channel the reasoning process. Rationality, then, is simply the formation of theory according to formative rules. Rationality need not, indeed should not, be construed as the use of public rules of formal logic. The only condition for rationality is that the validity of a logical assertion (theorem) be determined by a consistent domain of rules.

Since explanation of specific event situations inherent in models is dependent upon purpose, it follows that not all models are equally useful. To be useful as an explanation, a model must be isomorphic to a given empirical situation. However, no model ever fits the data exactly, as the empirical situation is always richer in detail and variability than the proposed explanatory model. The important consideration is not that the model match every conceivable nuance of the empirical situation, but that the model mirror the significant structural relations sufficiently well to achieve the purpose for which the explanation is to be used. Thus, goodness of fit is relative and allows partial and incomplete systems to be used in a variety of situations in which an imperfect answer is better than no answer at all.

Purpose, then, makes oversimplification tolerable and expediency virtuous. The seriousness of aberrations and discrepancies resulting from errors of commission and omission must be evaluated against the purpose. Contrary to some exponents who advocate truth as the arbitrator and who hold that a single instance to the contrary is sufficient to determine falsehood of a statement, theories are generally not discarded at the first sign of imperfection. This is not to say, however, that the theory should be retained and data forced to fit regardless of the consequences. Ultimately, descriptions that cannot be suitably explained will necessitate modification or replacement of the axiomatic system that generated the theory.

System utility is established by empirical test. When it has been established by historical records, observation, or experimentation that induced change in a set of antecedent conceptual variables in an empirical situation does in fact produce the predicted change in a set of consequent conceptual variables within acceptable tolerances, the model is a bona fide explanation with established capacity to influence the empirical situation by deliberate action. Certitude of the theory, however, is dependent upon replication over situations. Those theories which produce useful predictions when applied to a variety of situations are treated as established explanatory systems.

The significance of theory as a belief about reality is dependent upon the scope, precision, power, and reliability of the explanation (Meehan, 1968). The scope of an explanation refers to the variety of empirical situations for which the explanation is applicable and depends primarily upon the generality of the concepts used to load the theory. Precision refers to the exactness with which concepts used to load the model are linked to empirical referents through measurement operations. Explanatory power refers to the degree of control provided over empirical outcomes and depends on the precision of the description and the completeness and precision of the explanation. Reliability refers to the consistency with which the explanation produces useful results over a range of situations. It is obvious that the evaluative factors are interdependent as, for example, reliability may be increased at a sacrifice in precision. Thus, significance of theory can only be resolved in the context of the use to which knowledge is applied.

The inquiry process whereby man knows reality is seen to consist of the complementary processes of description, explanation, and evaluation. (See Figure 7.) Since acquisition of knowledge is the generally acknowledged purpose of education, it follows that education should be concerned with the process by which knowledge is organized, transmitted, and expanded. That is, education should be concerned with the development,

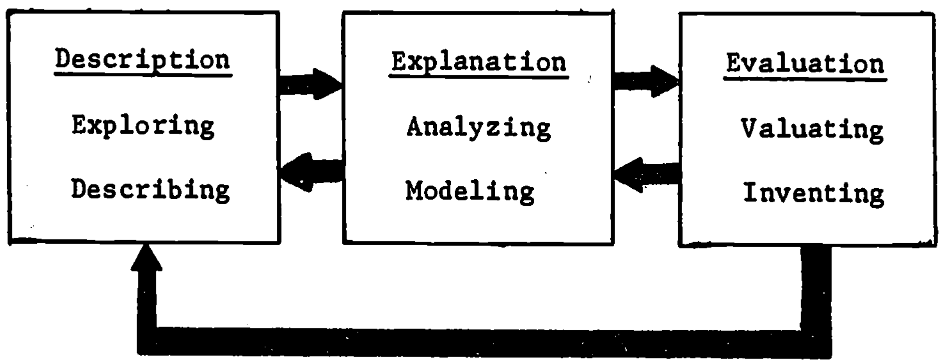


Figure 7. The Inquiry Process

use, and evaluation of the axiomatic systems, theories, and models that give form and meaning to the manifold content of human experience.

Education, then, is a study of the inquiry process. The study of any process is bi-phasic in that it requires (1) a study of structure, which is process frozen in time, and (2) a study of change in structure over time. The phases when applied to the inquiry process translate into a study of practice and a study of theory. The study of practice involves a structural analysis of formal systems used to explain a certain class of empirical situations. More specifically, the study of practice investigates the method used to create specialized knowledge in terms of the phenomena of inquiry, conceptual framework, conceptual and constructural variables, axiomatic system, logical calculus, theory, model, coordinating definitions, purpose, and means of evaluation. Study of theory involves study of formal axiomatic systems, their logical calculi, and the implication for theory generation. The intention is not to study a specific system and associated theory in isolation, but to analyze the formal properties of a variety of systems in order to establish general propositions about explanatory systems. In essence, the study of theory is the study of the invention of systems--an attempt to develop a meta-language and a meta-logic with which to compare and contrast the study of formal systems and to evaluate their implication for achievement of a desired purpose.

Thus, the study of education involves the study of practice (the study of the way in which theory is used) and the study of theory (the study of the way in which theory is constructed, evaluated, and reconstructed). Ignoring either has serious repercussions for the inquiry process. Emphasis on the study of practice at the expense of theory leads to indoctrination with the consequent development of an inflexible inquiry process that stifles the innovative capacity required to cope with change. Conversely, emphasis on theory modification at the expense of practice ignores the ultimate purpose of knowledge--control through direct action. It should be emphasized that practice is not to be construed as the absence of theory, but rather as the application of theory for the achievement of a desired purpose. Nor should the study of theory be regarded as independent of practice, for purpose achieved through practice is the ultimate justification of any formal explanatory system.

The process of inquiry as the root-process of education can be analyzed to determine the component activities of education that when related constitute the organized activity of educational achievement. Since the inquiry process is a tripartite process, it is a logical extension to analyze the subprocesses of description, explanation, and evaluation in terms of the general activities required in carrying out the process. The descriptive process is seen to depend upon the activities of <u>exploring</u> and <u>describing</u>; the explanatory process to involve the activities of <u>analyzing</u> and <u>modeling</u>; and the evaluation process to require the activities of <u>valuating</u> and <u>inventing</u>.

The descriptive process is manifested in time and space as an empirical situation described by a set of assertions. The form and kind of empirical situation created depend upon the chosen conceptual framework and the purpose of inquiry. The breadth and variety of situations encountered, however, depend upon a drive to explore new situations sustained by an interest in inquiry and a concern about its outcome. Explanation cannot be separated from the other processes for exploration must be guided by an awareness of the total context in which inquiry is taking place. In other words, exploration as an activity is meaningless in the absence of some conceptual framework to identify the objects and events of interest, to classify them into related sets, and to relate them in time and space, and in the absence of some purpose to justify their significance. Thus, the act of describing complements the act of exploring as it involves conceptualization of an area of inquiry, creation of an empirical situation, and symbolization of the intrinsic event relationships comprising the situation. Descriptive skills depend upon power of: (1) perceptual observation such as seeing, hearing, tasting, touching, and smelling; (2) conceptual operations such as identifying, classifying, collating, collecting, and relating; (3) manipulation of linguistic signs and symbols; (4) instrumental usage to augment man's observational capabilities; and (5) memory to conserve the observable results.

Explanation as process requires (1) that a formal axiomatic system be used to generate theorems which serve as a warranty for expectations about some aspect of the empirical world and (2) that the constructural variables of the system be loaded with conceptual variables deemed to be the empirical counterparts of their theoretical referents. The process of drawing tentative conclusions by reasoning from something assumed is termed <u>inference-making</u> and is at the heart of the use of axiomatic systems to generate expectations about the future. Analysis as the act of inference-making involves a set of assumptions about a non-observable world (axiomatic system) manipulated according to certain rules of rationality (logical calculus) to discover what hypotheses (theorems) not presently known are entailed by the assumptions. Thus, analysis is the act of expanding knowledge by reasoning from the known to the unknown within the context of a formal system. The theorems of the formal system are generalized "if . . . then . . . " statements about a pattern of constructural variables and are manifested as models of some specific organization of empirical events when appropriately linked with the empirical world. This linkage process is termed modeling and provides the bridge between the abstract cognitive world of formal systems and the concrete experiential world of empirical description.

The final step in the inquiry process is evaluation of the explanatory power of the model. As previously defined, an empirical situation is said to have been explained by a model if the model is isomorphic to the empirical situation. However, isomorphism is never perfect. Consequently, the degree of fit must be evaluated according to the purpose to be served. The act of valuating involves (1) direct intervention in an empirical situation according to the patterns of the model to induce a change in the value of a set of antecedent variables (independent variables), (2) observation of corresponding change in the values of a set of consequent variables (dependent variables), (3) comparison of the observed change in the dependent variables with the expected change, and (4) judgment of the significance of any discrepancy for attainment of a desired environmental state of affairs. Valuation, then, depends upon the skills to locate stable patterns between independent and dependent empirical variables to be explained, to intervene in the situation with sufficient finesse to alter only the independent variables of interest, to measure reliably the effects of induced change on the dependent variables, and to evaluate the significance of the difference. Significance of variations between observed and expected states of the dependent variable depends upon the criticalness for attainment of the desired outcome and can only be determined in the broader context that establishes the necessity for control. Confidence in the utility of the theory to explain empirical situations increases as a function of the number of successful replications. Theory that maintains its explanatory power over a variety of purposes achieves the status of an established belief accepted as a certainty that no longer requires continual validation.

Theories can remain inviolate, however, only at the risk of curtailment of intellectual vitality. New situations encountered and new problems posed continually challenge the explanatory power of existent theory and press for replacement with more expansive constructions. Thus, the highest and most complicated deliberative activity of education is that of inventing new theories to increase awareness of a wider world. The imaginative creation of new models is made possible by analysis within a formal system whose implications are other formal systems--a system for building systems. Innovation guided by systematic method removes creation from the singular, discrete act and argues for the educational development of inventive powers that allow man to envision what might be.

In summary, the basic notion advanced in this chapter is that the elemental operational activities of exploring, describing, analyzing, modeling, valuating, and inventing guide every act of inquiry and, when organized as depicted in Figure 7, constitute the inquiry process. The grand strategy whereby the basic operations of the inquiry process are formed, controlled, and focused on the production of an explanation that directs action in a specific situation is referred to as method. Method, then, refers to the procedures by which knowledge is produced and as such is the essence of doing any disciplined activity. The relevance for education is summarized by Belth (1965) who writes:

> In the study of education, the object is not to produce knowledge of some facet of gross, direct experience. The goal is to produce knowledge of the models and of the procedures, or methods, by which knowledge in each of the various disciplines is produced, in order to enable others to become competent in some discipline.

He goes on to state that:

> An effective way of identifying any discipline is to identify its method--the way in which the various elemental operations balance against each other in the performance of the discipline. These operations are distinctive because of their objectives, the material which they confront, and the laws which affect them.

The analogy to jobs is immediate. If a job as disciplined activity is regarded as an inquiry process, then the way in which the type and level of abstraction of the operational activities of exploring, describing, analyzing, modeling, valuating, and inventing are allocated against each other identifies a particular job; that is, these six activities provide the dimensionality for a factorization of jobs into clusters. The clusters are meaningful for curricular development in that they identify commonalities of method of inquiry across a variety of jobs that should be nurtured by the educational programs. The implication is that vocational education programs should be concerned with development of learner skills to construct, use, evaluate, and reconstruct theories of inquiry which structure the meaning of experience and direct consequent action. Collectively, these skills represent developed power to apply method over a field of related jobs and, hence, constitute a generalized vocational capability.

Activity 1 - Cluster Jobs According to Required Generalized Vocational Capabilities

A-1 - The 3rd edition of the Dictionary of Occupational Titles (DOT) has classified some 18,000 jobs according to the premise ". . . that every job requires a worker to function in relation to Data, People, and Things, in varying degrees" (Manpower Administration, 1965, pp. 649-652). Each of the three activities has been scaled on a nine-point scale as illustrated:

	Data		People		Things
0	Synthesizing	0	Mentoring	0	Setting-up
1	Coordinating	1	Negotiating	1	Precision Working
2	Analyzing	2	Instructing	2	Operating - Controlling
3	Compiling	3	Supervising	3	Driving - Operating
4	Computing	4	Diverting	4	Manipulating
5	Copying	5	Persuading	5	Tending
6	Comparing	6	Speaking - Signaling	6	Feeding - Off-bearing
7	No significant relationship	7	Serving	7	Handling
8		8	No significant relationship	8	No significant relationship

Data is therein defined as:

> Information, knowledge, and conceptions, related to data people, or things, obtained by observation, investigation, interpretation, visualization, mental creation; incapable of being touched; written data take the form of numbers, words, symbols; other data are ideas, concepts, oral verbalization;

People as:

> Human beings; also animals dealt with on an individual basis as if they were human;

and Things as:

> Inanimate objects as distinguished from human beings; substances or materials; machines, tools, equipment; products. A thing is tangible and has shape, form, and other physical characteristics.

For purposes of brevity, the descriptions of the activity levels given in the DOT are not repeated.

In the DOT classification scheme, each job is rated on each scale according to the highest level of activity required for job performance. Activity levels are hierarchically ordered from the simplest to the most complex so that each activity subsumes all the less complex levels and none of the more complex levels.

In addition to relationships with data, people, and things, the DOT also classified jobs according to worker traits which are defined as "those abilities, personal traits, and individual characteristics required of a worker in order to achieve average successful job performance . . . ."

The components of worker traits are:

a. Training time which consists of the general educational development and specific vocational preparation required to develop average job proficiency. General educational development embraces the levels of reasoning development, mathematical development, and language required for average job performance which is simultaneously scaled on a six-point scale. Specific vocational preparation pertains to the amount of time required to learn to perform a job and is scaled on a nine-point scale ranging from level 1--short demonstration only--to level 9--over 10 years.

b. Estimates of how much of each of the following aptitudes is required for average job performance: intelligence, verbal, numerical, spatial, form perception, clerical perception, motor coordination, finger dexterity, manual dexterity, eye-hand-foot coordination, and color discrimination. Aptitudes regarded as being of special significance for job performances are flagged in bold-faced type in the qualifications profile.

c. Significant preference areas expressed as five bi-polar interest factors.

d. Classification of types of occupational situations encountered.

e. Physical demands required of a worker classified according to six levels of physical activity.

f. Working conditions classified according to seven levels of physical surroundings.

The jobs in the DOT are classified into 114 clusters termed worker trait groups. Each worker trait group provides the following information:

a. Title of the trait group.

b. Three-digit classification indicating level of activity requirement for dealing with data, people, and things.

c. Brief description of work performed.

d. Clues for relating applicants and requirements.

e. Types of training generally required and the generally accepted method of entry.

f. Related worker trait groups.

g. Qualifications profile of ratings on worker traits.

While not explicitly linked in the DOT, the worker traits bear an obvious relation to the basic operational activities of the inquiry process and can, therefore, be regarded as the coordinated definitions for the generalized vocational capabilities. "Comparing" data, for example, primarily emphasizes the act of describing. Conclusions drawn from the data involve a minimal amount of inference-making (analysis) and evaluation since the axiomatic system serves as a series of self-evident truths that justify the use of certain relations between variables--as, for example, the use of the number system as the authority for the order relation "greater than." In contrast, the activity "synthesizing" primarily emphasizes the inquiry activity of inventing, which in turn involves all the other inquiry activities in a complex pattern whose form is governed by the method of inquiry characteristic of the job In like manner, level 6 of "reasoning development" requires the job incumbent to "apply principles of logic or scientific thinking to a wide range of intellectual and practical problems . . . ." Scientific thinking refers to the application of scientific <u>method</u> to determine form and nature of knowledge and as such represents a specialized organization of the inquiry process by which knowledge comes to be obtained. Level 1 requires only that an incumbent "apply common sense understanding . . . ." Thus, the distinction between level 1 and level 6 activities in reasoning development rests upon the distinction between science and common sense, a distinction which clearly revolves around differences in the methodology of inquiry. Similar arguments can be made for the associated mathematical and linguistic dimensions of general educational development.

(+) The DOT offers a comprehensive classification of the domain of jobs unmatched in coverage by any other source. The worker trait groups serve to classify jobs according to generalized vocational capabilities as well as to provide supplementary information. The worker trait components and Data-People-Things relationship can be interpreted in the broader theoretic context of a job as an inquiry process with consequent ramifications for curricular development. The DOT also provides a standardized classification job taxonomy.

(-) Restricted to the limitations inherent in DOT construction, i.e., subjective judgments regarding classifications, assumptions in scale construction, definitions used, method of establishing job clusters, and possibility of regional differences in job definitions.

A-2 - Develop tailor-made scheme to cluster jobs according to generalized vocational capabilities.

(+) Control of formative assumptions. Freedom to choose coordinating definitions of generalized vocational capabilities whereby concept is linked to educative theoretical base may increase relevancy for curricular development. More sensitive to regional and area differences in job structure.

(-) Large expenditure of resources required to match DOT in comprehensiveness.

Activity 2 - Establish a Rational Means of Linking Program Content to Job Families

A-1 - The worker trait groups of the DOT appear to offer promise as a means of effecting such a linkage.

Step 1. Assign the worker trait groups to one or more of the program areas used in Activity 2 of the Priority Determination section to classify vocational and technical programs. In the absence of a more specialized categorization, the seven vocational areas identified by OE appear to be a logical choice (Putnam and Chismore, 1967). The assignment is facilitated by using the DOT assignment of worker trait groups within areas of work (Manpower Administration, 1965).

Step 2. For each major program area, classify the selected aspects of subject matter and items of information presented in Putnam and Chismore (1967) into N topical curricular subject matter areas and assign each curriculum to one or more of the worker trait groups identified in Step 1 for which the subject matter coverage appears to be relevant in terms of work performed, worker requirements, clues for relating applicants and requirements, and training method of entry.

Step 3. Evaluate the desirability of developing a curricular program for each topical subject matter area identified in Step 2, taking into account major program area priorities discussed earlier in this report. Preferably, the evaluation should consider the current and projected employment needs for those jobs constituting the clusters associated with the curricular topical areas. Note that these priority assignments are for program areas, not for individual programs. However, the same procedures could be followed if data are available to enable estimation of future demand for the worker trait groups associated with each curricular program. In the absence of hard data, the only recourse is subjective judgment as to the employment demand for specific curricular subject matter areas.

Step 4. Develop curricular programs to implement those topical areas identified in Step 3. For the purposes of an EPD system, each curricular program should identify: (1) the year in which the program is to be first offered, (2) the grade level(s) at which the program is to be offered, (3) the estimated enrollments for each year in the planning span for which the program is to be offered, (4) the target population(s) to be served, (5) the minimum teacher proficiency level and subject matter knowledge required (see next chapter).

A-2 - Use procedure developed by OE for linking DOT jobs to instructional programs (National Center for Educational Statistics, 1967).

(+) Does not require effort for initial curricular development. Provides a content basis for modification to fit area needs.

(-) No guarantee that curricular programs will reflect personal educational philosophy.

A-3 - Link curricular programs to job clusters established according to tailor-made scheme.

(+) More responsive to local conditions.

(-) Large commitment of resources required.

ESTIMATION OF PROFESSIONAL DEMAND AND SUPPLY

Nothing can be said about the development of teaching personnel without first considering the role of the teacher as it interacts with curriculum and learner. With respect to curriculum, it was argued earlier that education should be concerned with the study of the methods by which theories of inquiry were invented, used, evaluated, and modified in the distillation of experience into meaningful form. In this context, curriculum comes to be regarded not as formed conclusions about human experience but as the modes of inquiry whereby conclusions are drawn and validated and wherein the learner develops the capability for personalized inquiry. Since it is the purpose of curriculum to capture in symbolic form at least the essence if not the actuality of the real world and to transpose it to the classroom, the inevitable question concerning the relationship between teaching and doing cannot be avoided.

That curriculum is a matter of content and, hence, pertains to the doing of a discipline is not to be denied. This is not to say, though, that curriculum should focus on the verified explanations of any discipline to be taught as a body of ultimately true assertions about the nature of reality. To the contrary, every discipline is to be regarded as a means of inquiry suited for specific purposes rather than a body of accumulated knowledge to be absorbed in passive acquiescence. In the sense that disciplines such as mathematics, history, mechanics, and accounting are regarded as unique means of inquiry, their teaching of others requires an exposure of the characteristic methods of inquiry--an exposure of the method in terms of an explanation of the nature and role of exploration, description, analysis, modeling, valuation, and invention in the inquiry process. Thus, curriculum is seen as a combination of the means of inquiry characteristic of a given job or discipline and the theories for the analysis and evaluation of these means.

It is precisely these ways of thinking about means of inquiry--theories for examination and creation of theory--that Belth (1965) has termed educational models and has classified as: dialogue, scholastic, nature, and experimental. Since these models shed some light on the teaching process, each will be considered briefly.

The dialogue as a form of educational inquiry follows a rather definite pattern. First, a question is posed for which there are conflicting beliefs held by two or more discussants. This is followed by a collective contemplation of the meaning of the terms agreed upon to relate to the problem under discussion. Meaning is assumed to reside in the mode of inquiry used and, hence, can be examined by a comparison of the implications of contrasting axiomatic systems. Axiomatic systems are examined by evaluating their implications according to whether some perceptual experience stored in memory can be recalled which will refute the implications. The purpose of the dialogue form is, thus, to nurture the power of analysis--a knowing by reflecting upon the quality of the statements implied by the axioms. The dialogue form is educational in that the intent is to increase learner awareness of the fundamental beliefs (axioms) and the rules of rationality (logical calculus) used to generate specific beliefs (theorems) about reality.

As contrasted with the dialogue, the scholastic form inquires into the absolute nature of truth. Whereas the dialogue form makes no special presumptions regarding the attainment of any ultimate insight, the scholastic form always ends with final assertions about the nature of truth. Formal systems are discredited by demonstrating that their implications contradict what is known a priori to be true. The method is deductive in that exact conclusions are drawn from a formal axiomatic system and a logical calculus whose veracity rests on the formal authority of tradition, dogma, and self-evident truths. Given that the axioms are truisms, all knowledge is implied by the system and is assured to be extractable by judicious use of deductive logic.

In yet another model form, nature is regarded as the ultimate sanction for knowledge. Order is assumed to reside in a deterministic reality where natural laws await discovery. Knowledge is gleaned by exploring and describing samples of specific situational contexts with the intent of inducing empirical generalizations which are invested with explanatory power. Authority for the characterization of objects and events is to be found in nature; i.e., all entities including man are assumed to have a natural disposition, and each is passively obedient in his own manner to the rigid laws of nature. Development is assumed to proceed in orderly stages where the learner is assumed to comprehend nature's ways by direct sensory experience. Feeling rather than thinking is the dominant emphasis. Thus, to adopt such a model limits education to a study of experience rather than inquiry.

In contrast to the nature model, the experimental form represents but does not copy reality. The intent is to develop an axiomatic system where the axioms are considered as pure inventions, not as empirical descriptors of nature's forms and patterns. The axioms are judged according to their capacity to generate expectations that warrant intervention in empirical situations. The ultimate utility is established by experimentation, a confrontation wherein the explanatory predictive power of theory is tested against the descriptive results of observation. It is obvious that the experimental model is synonymous with the inquiry process detailed earlier, and, hence, its explication need not be further belabored.

However, the implications for education are sufficiently important to warrant additional redundancy. If theory derives from axioms that are neither true nor false in an absolute sense, then the role of education is to nurture in the learner the capacity to invent new models; for it is the power to invent new theories to explain familiar experiences and to serve as the sources of the new that provides the potential for further inquiry. The object of education is not the pure distilled form of structure of nature but the methodology of inquiry whereby form and structure are shaped, evaluated, and modified to suit man's purpose. The educational implication of the experimental form is that education should be concerned with the ability to recognize axioms, to reason from axioms to implications, and to create and evaluate new axiomatic structures; for to think is to create new explanatory models, new experimental tests, and new purposes to be served.

The model forms can be further analyzed by highlighting the methodological distinctions. The dialogue form gives primacy to analysis with consequent emphasis on verbal, grammatical, and rhetorical skills. Exploration is confined to examination of the sequence of axioms while description is focused on a verbal recital of the logical relationships. Explanation is that of necessity and sufficiency of logical causality. Invention is revelation of the unknown through inspiration that results from continual absorption in the logical system. In contrast, the experimental form emphasizes physical as well as logical operations and skills. Exploration and description require encounters with empirical objects and events which must be physically manipulated and symbolically described. Valuation necessitates intervention by direct action in a physical phenomenon, and invention refers to the creation of new axiomatic systems which have not previously existed.

To recapitulate, education is herein approached from the Deweyian view of an inquiry process. The mission of education is seen as the nurturing of the power of reflective thinking embodied in the use, evaluation, and invention of explanatory models. From this, it follows that teaching should be regarded as the guiding of learners through the developmental process of description, explanation, and evaluation--the trinity of the inquiry process.

More specifically, teaching is assumed to be a dynamic system involving transactions between the occupants of the position "teacher" and that of "student." The sequence of transactions within the teaching system is referred to as the instructional process. The institutional purpose of teaching is to influence the student so as to develop his adaptive powers to cope with a changing world. At the risk of over-simplification, any transaction that results in a change in (a) the probabilities of choice of any course of action, (b) the number of available courses of action, (c) the outcomes attached to any course of action, (d) the probabilities of an outcome given a particular choice of action, or (e) the values associated with the alternative outcomes associated with a given course of action is said to have influenced the student. Although the power relation connecting the positions is such that the teacher has greater formal authority than the student, the communication process is bidirectional in that messages flow both to and from the teacher--hence, the notion of a transaction. Transaction implies an intrinsic influence relation between teacher and student. Just as there can be no selling without a buyer, there can be no teaching without a student. However, it does not follow that there can be no learning without a teacher.

The teacher is assumed to direct the development of inquiry by controlling the quality and quantity of the transactions according to certain activities (roles) which serve to pattern the interaction so as to achieve the desired ends. These procedural rules are termed strategies and serve to govern global teacher performance. Whereas strategies are plans for the attainment of relatively long-range general goals, tactical maneuvers for the attainment of strategy are compacted into discrete time-space units referred to as episodes which are the basic observational units of the instructional process.

The teacher transacts with students via an instructional medium--a communication channel. The messages initiated by the teacher are a function of curriculum as previously defined in that the content of the message is primarily dependent upon the nature of the subject matter models of a discipline, whereas the form is dependent upon the foundational education model that supports the teacher's educational activity. Instructional media involve mainly only two modes of communication--written and verbal. Since verbal behavior is the more rapid and most frequent mode of general communication, verbal inquiry is, therefore, assumed to be the primary transactional mode in the instructional process. Although acknowledged as a general communication mode, non-verbal forms of affective behavior are herein ignored as they are assumed to play a subordinate role in instructional communication. Attention is focused instead on the linguistic forms that a teacher uses in the course of the instructional process. Episodes in the instructional process can then be said to consist of ". . . one or more exchanges which comprise a completed verbal transaction between two or more speakers" (Smith and Meux, 1962). Emphasis on episodic verbal inquiry in the instructional process stresses the dynamic process nature of teaching--a quality that is submerged when such structurally static factors as teacher attitudes, skills, personality traits, values, and subject matter knowledge are considered in isolation.

Given the assumption that the study of teaching is the study of the systemic rules that guide behavior, a taxonomic scheme is required in order to identify transactional behavior as instances of a particular class of rules. Such a taxonomy is provided by Smith and Meux who have classified 3397 episodes into twelve major categories according to their logical features (Smith and Meux, 1962). The classifications are briefly defined as follows:

Defining -

Episodes concerned with how symbols are used to relate to objects or events. Generally pertains to identity of specific terms (concept symbols) and requires that object or event indicated by a name be described or otherwise identified or that the term be supplied as a response to its definitional characteristics.

Describing -

Episodes that require an accounting or representation of a suggested situation.

Designating -

Episodes that focus on the attachment of a name or symbol to some definite or indefinite object. If the object is definite, the designating is termed identifying; if the object is indefinite, the designating is termed specifying.

Stating -

Episodes that call for a sequence of axioms, theorems, conclusions, etc.

Reporting -

Episodes that call for a report, summary, or review.

Substituting -

Episodes that require a substitution in a formal system.

Evaluating -

Episodes that call for the estimation of value, worth, etc. of something.

Opining -

Episodes that require an affirmation or denial of an apparent conclusion or conjecture.

Classifying -

Episodes that require a particular member to be placed in the class to which it belongs.

Comparing and Contrasting -

Episodes that require the noting of the similarities or differences of two or more things similar or dissimilar to a given referent.

Conditional Inferring -

Episodes that require a response to a given antecedent condition.

Explaining -

Episodes that give a particular consequent consideration and require that an antecedent condition be given.

The categories identified by Smith and Meux bear a direct relationship to description, explanation, and evaluation, the three phases of the inquiry process. Defining, describing, designating, reporting, and classifying are obviously intrinsic operations in the descriptive process. Substituting, conditional inferring, and explaining pertain to an underlying formal logical system and, hence, can be classified as explanatory operations. Since it can be argued that evaluating, opining, and comparing and contrasting involve value judgments and value comparisons, they can be classified as evaluative operations. The classifications are not necessarily exclusive, as, for example, defining can be regarded as a descriptive operator if concepts are being defined or as an explanatory operator if abstract symbols in the formal system are being defined. The significant consideration is not the existence of a many-to-one correspondence between categories and phases, but that the categories for episodic classification can be meaningfully interpreted in the context of the inquiry process.

The import for supply and demand estimation is that a taxonomy linked to the inquiry process could provide a theoretic basis for an assessment and assignment of skill levels to vocational education teachers based on process rather than individual attributes. The supportive assumption for this argument is that evaluation of the teacher according to kind, quantity, and quality of episodic verbal transactions is held to be a more realistic appraisal of his developed potential to educate than assessment according to a psychometric measurement of static attributes and characteristics.

<u>Activity 1 - Establish Classificatory Skill Levels for Worker Trait Groups</u>

A-1 - Use the DOT as source information about worker requirements. It appears reasonable to conclude that developing generalized vocational capabilities which include "synthesizing" relationships with data; a "mentoring" relationship with people; and application of principles of logical and scientific thinking, knowledge of advanced mathematics, and comprehension required at a level to write original articles (i.e., a level 6 GED for jobs that necessitate over 10 years of specific vocational training) requires a greater expression of teaching skill than that required for the development of capabilities of comparing data, serving people, handling things, applying common sense understanding to carry out simple instructions, performing simple addition, and writing identifying information for jobs that require short demonstration in order to perform adequately.

Step 1. Classify the worker trait groups identified in Step 1, A-1, Activity 2 of Program Identification, according to skill level of generalized vocational capabilities.

a. Let

$$X = W_1 \text{ (9 - 4}^{th}\text{ classification digit)} + W_2 \text{ (9 - 5}^{th}\text{ classification digit)}$$

$+ W_3$ (9 - 6^{th} classification digit) + W_4 (Median GED level)

$+ W_5$ (Median SVP level),

where $(W_1, W_2, W_3, W_4, W_5) \geq 0$ are arbitrary weighting constants reflecting the degree of importance assigned to each generalized capability factor and where the 4^{th}, 5^{th}, and 6^{th} classification digits are, respectively, the scale scores for the relationships with data, people, and things.

b. Compute

$$\text{Range} = \text{Max } X - \text{Min } X$$

$$= 8\ (W_1 + W_2 + W_3) + 5W_4 + 8W_5.$$

c. Divide the range into M segments. These segments represent the skill levels and probably should not exceed 3-5 unless the range is large.

d. Within each major program area classification, rank the worker trait groups according to X scores. Assign each worker trait group to the j^{th} skill level such that

$$X_j \leq X < X_j + 1 \qquad j = 0, 1, 2, \ldots, M$$

where

$$X_o = X \text{ (Min)}$$

$$X_{m+1} = X \text{ (Max)}$$

and

X_j = the lower boundary for the j^{th} skill category

(+) Capitalizes on comprehensiveness of DOT listings.

(-) Limited to DOT categorizations.

A-2 - Develop tailor-made procedure based on analysis of skills required to perform generalized vocational capabilities identified in A-3, Activity 2, Program Identification.

(+) Greater freedom of choice for development.

(-) Greater development costs.

Activity 2 - Establish Procedure for Assignment of Teachers to Proficiency Levels

A-1 - Within the limitations of "state of the art" technology, the logical categories developed by Smith and Meux (1962) appear to be both theoretically relevant and practically significant for evaluating teacher behavior in the classroom since each major category of episode is analyzed in terms of the operations involved and the epistemic rules governing the use of the logical operations. Given the assumption that teaching is rule-governed action, it appears reasonable to evaluate teacher proficiency according to the frequency with which logical operations are appropriately used. Smith and Meux's epistemic rules can be used as the source of authority for judgment as to the propriety of teacher usage of logical operations. Theoretically, these logical operations can be regarded as the methodological manifestations of the use of educational models. Consequently, evaluation of teachers on their use of these logical operations is, in essence, an evaluation of their proficiency in using educational models in a classroom setting.

Step 1. Develop a procedure for observing and classifying classroom episodes. Since the purpose is to obtain as complete a record as feasible of teacher-student(s) transaction, audio-video recording appears to be the most desirable. Audio recording is an acceptable substitute if cost is a major concern. Taping and classification procedures are given in Appendices 3 and 4, respectively (Smith and Meux, 1962).

The obervational procedure should provide for (1) the kinds of logical categories used during an observational period of fixed length, (2) the frequency of use of the kinds of logical operators, and, when applicable, (3) an appraisal of the appropriateness of use, i.e., the degree to which the epistemic rules were followed in the use of the logical operators.

Step 2. Develop a procedure for scoring recorded protocols. For each protocol, compute the frequency of use over the observational period for each of the 12 major categories of logical operators. For each category, compute pi, the proportion of times that the i^{th} logical category is used. Score the protocol according to the weighted information measure

$$H = - \sum_{i=1}^{K} W_i \, p_i \log_2 p_i \, ,$$

where $W_i \geq 1$ is a measure of the judged overall appropriateness of the use of i^{th} category, pi is as previously defined, $\log_2$ is the logarithm to the base 2, and K is the number of logical categories used during the observational period. If no suitable epistemic rule exists for the evaluation of the appropriateness of use of the j^{th} logical operator, set $W_j = 1$.

The informational measure is deemed an appropriate scoring device in that it varies directly with the number of categories used, reaching its maximum when all categories are used with equal frequency. This has theoretic significance in that it is assumed that the larger the repertoire of logical operations a teacher can appropriately use, the greater the likelihood that the teacher will be able to develop student inquiry skills.

Step 3. In a manner similar to that used in Step 1, Activity 1, compute

$$\text{Range} = \text{Max }(H) - \text{Min }(H) = \log_2 12 \cdot \sum_{j=1}^{12} W_j .$$

Divide the range into M segments as in Step 2, Activity 1, so that each segment corresponds to a range of H scores regarded as equivalent with respect to proficiency level. It should be noted that each segment of the H-proficiency scale now corresponds to a segment of the X-scale of skill level, thus establishing a relation between level of generalized vocational capabilities and teacher proficiency level.

Activity 3 - Assign In-Service Vocational Educational Teachers to Proficiency Levels

Obtain H-scores for each in-service vocational teacher in the supersystem. Assign each teacher to the j^{th} proficiency level according to their H score such that

$$H_j \leq H \leq H_{j+1} \qquad j = 0, 1, 2, \ldots, M ,$$

where

$$H_o = H\ (\text{Min})$$

$$H_{m+1} = H\ (\text{Max})$$

and H_j is the lower boundary for the j^{th} proficiency category.

Activity 4 - Develop Teacher Subject-Matter Requirements

Whereas proficiency levels are an indicator of teacher skill in the analysis and evaluation of theory per se, subject matter knowledge can be regarded as an indicator of the teacher's proficiency to practice, to use a particular theory to achieve desired results. The assumption is that a teacher must know something about how-to-do in order to teach others. Of course, this is not to say that a teacher must be a master craftsman in order to teach crafts or a successful businessman in order to teach business administration. It does, however, argue that a teacher must have some rudimentary subject matter knowledge in order to be effective in nurturing the development of others.

Step 1. Develop a taxonomy of subject matter objectives. The taxonomy of the cognitive domain developed by Bloom (1956) appears relevant, especially the classification of subject matter knowledge. The remaining categories deal with intellectual abilities and skills, which for the purposes of this report are subsumed under the notion of teacher proficiency.

Step 2. Select a major program area. For each of the N topical curricular areas identified in Step 2, Activity 2, Program Identification, determine the subject matter knowledge required using the knowledge taxonomy developed in Step 1.

Step 3. Develop measurement procedures for testing for subject matter knowledge in the topical areas selected in Step 2. See Bloom's (1956) taxonomy for illustrative test items.

Step 4. Repeat Steps 2-3 for each of the remaining major program areas.

Step 5. Establish minimum level subject matter requirements for each of the N_i topical curricular areas in the i^{th} major program area in terms of minimal scores on subject matter knowledge tests. Repeat for each of the other program areas.

Activity 5 - Assess Subject Matter Knowledge of All In-Service Vocational Education Teachers

If it can be assumed that teacher assignments will be restricted to, say, the j^{th} major program area, then the assessment can be confined to the knowledge areas associated with the N_j topical curricula.

Activity 6 - For Each Major Program Area, Establish an Inventory of Professional Skills

For each in-service teacher, maintain a record indicating in addition to the normal personnel and administrative information (1) program area speciality, (2) the assigned proficiency level, (3) the subject matter knowledge score for each of the curricula in the major program area speciality, (4) current curricular program assignment, (5) grade level, and (6) experience and/or formal education in special education. Classification of in-service teachers according to proficiency index, topical curricular areas for which they are qualified (knowledge scores exceed minimal requirements), grade level, and exposure or nonexposure to special education will create an $M \times N_j \times 4 \times 2$ current supply matrix for the j^{th} program area.

Activity 7 - Establish and Inventory for Vocational Counselors and Administrative Personnel

Activity 8 - Estimate the Supply of Educational Professionals for the Planning Span 1971-1975

Step 1. Develop an annual estimate of professional entrants into the supersystem from (1) college and university programs, (2) persons employed in other occupations, (3) persons not in the work force, and (4) immigrants.

Step 2. Develop annual estimates of the losses from (1) deaths, (2) retirements, and (3) emigrants.

Step 3. Establish an annual estimate of projected future supply for each program area by aggregating the current inventory supply matrix (including counselors and administrative personnel) with the annual estimate of entrants and deducting annual estimates of losses.

In many instances, local data can be used to estimate entrants and losses. College entrants, for example, can be estimated by taking current enrollment data, projecting number of anticipated yearly graduates over the 1971-75 period, and applying a percentage factor representative of the expected proportion of graduates the enter the supersystem as vocational education teachers. In a similar fashion, prior data if available can be used as an indicator of the expected annual number of immigrants, emigrants, retirees, and deaths. Since no hard data will exist on which to base projections of teachers in various proficiency and subject matter knowledge categories, certain simplifying assumptions about the supply distribution across categories will have to be made.

Activity 9 - Estimate Professional Demands for the Planning Span 1971-75

Step 1. Assign the programs identified in the Program Identification Section to the year in which they will be first offered.

Step 2. On the basis of the program information (see Step 4, Activity 2, Program Identification), for each program area determine the total number of expected enrollees annually in each cell (category) of the $M \times N_j \times 4$ classification matrix, where M is the number of proficiency levels, N_j is the required number of topical curricular programs in the j^{th} program area, and 4 is the number of grade levels. That is, for each year of the planning span, 1971-75, establish a $M \times N_j \times 4$ triple classification for each program area where the (ijk) cell entry is the total number of students expected to enroll in the j^{th} curricular program at the k^{th} grade level which requires teachers at the i^{th} minimum proficiency level.

Step 3. Establish projected student teaching load factor for relevant curricular, grade level, and proficiency classification.

Step 4. Divide the cell entries in the matrix created in Step 2 by the appropriate student load factor. The result will be the estimated number of teaching personnel demanded in that classification.

Step 5. Establish projected student counseling and administrative load factors.

Step 6. Apply load factors to estimated total number of students annually enrolled in the supersystem. The result will be the estimated number of counseling and administrative personnel demanded over the planning span.

PREPARATION OF EPD PROJECT SPECIFICATIONS

An EPD project specification is an enumeration of the developmental requirements for the production of professional manpower. Each project should pertain to the development of a homogeneous set of educational personnel to meet a unique, critical educational program need. For the purpose of this report, educational manpower is restricted to vocational and technical education teachers, vocational guidance counselors, and administrators.

<u>Activity 1 - Establish Project Priorities</u>

Step 1. For each program identified in Step 1, Activity 9 of the preceding chapter, obtain the following informations: (1) minimum subject matter knowledge requirements, (2) minimum proficiency level, (3) total expected student enrollment over the planning span, (4) priority level for the general program area entailing the program established in the Priority Determination section.

Step 2. For each program in Step 1, record for each remaining year in the planning span the estimated supply of teachers whose (1) subject matter scores exceed the minimum subject matter knowledge requirements, and (2) whose proficiency index equals or exceeds the minimum required proficiency level. Count each teacher only once even though qualified for several programs. In these cases, special assignment rules must be selected such as assignment to that program for which the subject matter score exceeds the minimum requirement by the largest amount. It is assumed that all teachers are qualified for at least one program.

Step 3. For each program in Step 1, record for each remaining year in the planning span the estimated demand for teachers whose (1) maximum subject matter score exceeds the minimum subject matter knowledge requirement, and (2) whose proficiency index exceeds the minimum level.

Step 4. Create a program x-year matrix where the ij^{th} entry is the difference between demand for and supply of teachers for i^{th} program in the j^{th} year. The excess of demand over supply is defined as a measure of the <u>criticalness</u> of program personnel needs.

Step 5. For the i^{th} program p^i identified in Step 1, let

D_t = teacher demand for year t

S_t = teacher supply for year t

R = priority level for general program area

E_t = expected student enrollment in year t

$C_t = D_t - S_t$

$= 0 \qquad \text{if } D_t - S_t \leq 0 .$

The developmental priority (not to be confused with the program area priority R) for program P_i for the t^{th} year in the planning span is expressed as

$$V_t (P_i) = R \cdot C_t \cdot E_t .$$

The assumption underlying the priority formulation is that projected developmental priorities should reflect the criticalness of personnel need, the number of students to be served by the program, and the priority of the major program area classification. The restriction on C_t ensures that $V (P_i) \geq 0$.

Step 6. From the assignment obtained in Step 1, Activity 9 of the preceding chapter, rank the programs first offered during t according to $V_t (P_i)$.

Step 7. Order the priorities according to years maintaining the priority ranking within years. That is, all programs to be initiated in 1971 should have greater priority than those programs to be first initiated in 1972, etc. The priorities within each year are ranked according to $V_t (P_i)$ for all programs first initiated in year t. The priority assignment strategy assures that the most pressing staffing needs are for those programs that are to be initiated within the next year.

Activity 2 - Establish a Personnel x Program x Development Matrix Scheme for Classifying Developmental Requirements

Let there be three levels of personnel--pre-service teachers, in-service teachers, and ancillary (administration and guidance and counseling); two levels of programs--major program areas and supportive (cooperative, disadvantaged, handicapped, remedial); and three levels of developmental goals--primarily modification of proficiency level, primarily modification of subject matter knowledge, and primarily modification of both proficiency level and subject matter knowledge.

Activity 3 - For the First Year in the Planning Span, Say, 1971, Select the Program with the Highest Developmental Priority and Determine the Personnel Requirements to Meet the Program Needs

Step 1. Select the program with the highest developmental priority as determined in Step 7, Activity 1. Compare the minimum personnel requirements of the program with the current supply matrix for the appropriate year, say 1971. Since developmental priority is a function of the criticalness of need, demand for personnel who meet the program requirements will exceed supply. Therefore, program demands should be compared with the inventory supply matrix to determine the supply of professional personnel most nearly qualified to meet the program requirements.

Step 2. Select a supply category that most nearly matches the program requirements according to the following:

(a) Match proficiency requirements as closely as possible. The assumption is that it is easier to develop content knowledge than to increase teaching proficiency.

(b) If the program is supportive, select a supply category that reflects exposure to special education and/or experience. The assumption is that proficiency in dealing with special target groups is critical in teaching supportive programs.

(c) Whenever possible, select personnel to fill critical needs from the slack personnel categories. Slack personnel are those inventory supply categories for which supply exceeds demand. By virtue of the definition, these categories will have zero developmental priority.

Step 3. Determine the developmental requirements for the program which should include the following:

(a) The developmental objectives which should state whether proficiency, subject matter knowledge, or both are to be increased and the minimum performance levels of each to be obtained. In all cases, performance levels should be stated in terms of objective score categories.

(b) The personnel classification of those to be developed, i.e., pre-service, in-service, or ancillary. It should be noted that pre-service is an admissible personnel category only when there is sufficient lead time to implement changes in the formal educational programs. At least two years appears to be a conservative estimate of the lead time required.

(c) The number of personnel to be developed. This is obtained by subtracting the number of available personnel in the supply category selected for development from the number demanded by the program.

(d) The time requirements for development. It is assumed that in most cases time requirements for development of teaching proficiency will exceed that of subject matter knowledge. It is also assumed that developmental time is a function of the discrepancy between the current state of the personnel to be developed and the program requirements.

(e) Estimation of developmental costs taking into account the developmental objectives and the training time.

Step 4. Decrease the supply category selected in Step 2 by the number of personnel chosen to be developed and increase the appropriate supply category of the matrix corresponding to the year when development is completed.

Activity 4 - Classify the Program Developmental Requirements Developed in Activity 3 According to the Scheme Developed in Activity 2

Activity 5 - Repeat Activities 1-4 for Each Priority Program for the First Year

Activity 6 - Repeat Activity 5 for Each Successive Year

Activity 7 - Compute an Adjusted Supply Matrix for Each Year in the Planning Span to Reflect the Supply Adjustments Made in Step 4, Activity 4

Compare the adjusted supply matrix with the corresponding demand matrix for each year.

Activity 8 - If Major Demand-Supply Imbalances Exist, Reiterate Activities 1-8 Until a Satisfactory Balance Is Attained

Activity 9 - From the Classification of Program Developmental Requirements for Each Year, Develop the Project Specifications

Step 1. Cluster program developmental requirements within each category developed in Activity 2 according to:

(a) Developmental objectives. For example, it appears reasonable to constitute the developmental requirements for all programs that stipulate development of in-service personnel to a level of minimum proficiency into a single developmental project.

(b) Program subclassifications of major programs as, for example, the subclassification of the heading of major program areas into the corresponding major program areas.

(c) Personnel subclassifications as, for example, further division of in-service classification into newly-hired (no experience), newly-hired (experienced), and experienced teaching personnel.

Step 2. Let each cluster identified in Step 1 constitute an EPD developmental project.

Step 3. For each developmental project identified in Step 2, develop the project specifications which should include the following information:

(a) The behavioral objectives articulated as desired skills in the use of logical operators in the teaching process and/or desired knowledge and skill in the usage of content models and theories required for inquiry into a particular subject matter area.

(b) The number of personnel required to be developed.

(c) The time allotted for professional development.

(d) The classification of the personnel to be developed.

(e) The minimum proficiency level and/or subject matter knowledge required to be attained as evidence of successful professional development.

(f) The budgetary cost allocated to the project.

IDENTIFICATION AND EVALUATION OF DEVELOPMENTAL RESOURCES

The activation function of the EPD system involves resource identification, evaluation, procurement, and assignment to projects. Activities associated with identification and evaluation are the subject of this chapter. Procurement and assignment of developmental resources are covered in the next chapter.

Developmental resources are those resources available to the EPD system for the actual development of vocational and technical program teachers, administrative personnel, and counseling and guidance personnel. Availability of developmental resources depends upon identification of a pool of existent resources, evaluation of their acceptability, and a corresponding willingness of the approved resources to operate under EPD supervision.

Activity 1 - Identify a Resource Pool

These resources will generally be of the following kinds:

Business, industrial, and commercial organizations
Public service agencies
Private non-profit agencies
Governmental agencies
In-service training facilities
Technical institutes
Private schools
Community colleges
Colleges and universities

Activity 2 - Establish an Evaluative Measure of the Suitability of Each Resource Identified in Activity 1

Use a weighted function of the following variables:

Number and credentials of staff educators
Number of degrees offered in appropriate subject matter areas at the baccalaureate, masters, and doctorate levels
Accreditation standing
Local, regional, and national images
Geographic location
Current student enrollment
Unused educational capacity
Dollar value of fixed educational facilities/student
Dollar value of educational equipment/student
Financial stability
Financial accountability
Overhead rate
Adequacy of educational facilities and equipment

The weight may vary for different kinds of resources, i.e., governmental agencies may very likely have a different set of weights than colleges and universities as developmental resources.

The evaluative information should be obtained by voluntary cooperation from the resources involved. Lack of cooperation should be interpreted as prima facie evidence of non-suitability.

Activity 3 - Establish a List of Acceptable Developmental Resources

Step 1. Within each kind of resource identified in Activity 1, rank the resources according to their score on the evaluation resource developed in Activity 2.

Step 2. Select a minimum cut-off score for each kind of resource.

Step 3. Place all resources of a kind meeting or exceeding the established cut-off on a list of acceptable developmental resources.

Step 4. Repeat Steps 1-3 for each resource kind.

ASSIGNMENT OF RESOURCES TO PROJECTS

The EPD system is activated according to the following activities:

Activity 1 - Classify Kinds of Developmental Resources by Type of Developmental Program Offered or Potentially Capable of Offering

Step 1. Developmental programs may be classified, for example, according to whether they are:

Formal degree programs - recognized formal degree granted upon completion of program.

Formal certificate program - formal certificate given as evidence of completion of program.

Short-term programs - short courses, refresher courses, training sessions, institutes, etc.

Exchange or internship programs - formalized work experience in relevant environmental organizations.

In-service training programs - formalized work experience and training within supersystem.

Step 2. Assign resource kinds identified in Activity 1, preceding chapter, to program types identified in Step 1 as exemplified by the following assignment:

colleges and universities community colleges	formal degree program
colleges and universities community colleges technical institutes	formal certificate programs and short-term programs
public service agencies public non-profit agencies governmental agencies	exchange and internship programs

Activity 2 - From the Project Specifications Developed in Activity 9 of the Preparation of Project Specifications Section, Select for Each Project the Relevant Kind(s) of Developmental Resource(s) Required

Step 1. For each project specification, select the appropriate type of developmental program, taking into account:

(a) Statutory degree requirements.

(b) Level of developmental goals.

(c) Classification of personnel to be developed.

(d) Program classification.

(e) Time requirements.

(f) Grade level.

Step 2. From the resource kind-program type assignment developed in Activity 1, select the appropriate kind(s) of developmental resources.

Activity 3 - For Each Project Specification, Establish a List of Qualified Developmental Resources

For the relevant kind(s) of resources identified in Activity 2, use the list of acceptable resources classified by kind developed in Activity 3 of the preceding chapter to identify qualified resources.

Activity 4 - Establish a Budgeting System for the Planning Span under Several Funding Alternatives, say, (1) State and Maximum Federal Developmental Support, (2) State and Reduced Federal Developmental Support, (3) State Support and Minimal Federal Developmental Support

For each funding alternative, prepare a multi-year program and financial plan (see Overview). The plan should present on an annual basis the following information for each project identified in Activity 9 of the section on project specifications.

(a) Year initiated, which should reflect the developmental time lag in order to ensure that trained personnel will be available when needed.

(b) Year terminated, if to be terminated within the planning span.

(c) Accrued benefits measured in terms of desired number of developed professionals classified according to developmental goals, program type, and personnel type.

(d) Accrued benefits measured in terms of a weighted function of desired numbers and quality of developed professionals classified as in (c).

(e) Annual project costs.

(f) Federal contribution to (e).

(g) Ratio of accrued benefit (c) to cost (e).

(h) Ratio of accrued benefits (d) to cost (e).

(i) Kind of qualified developmental resource(s) required.

Activity 5 - On the Basis of the Best Available Information, Select the Most Likely Funding Alternative

Activity 6 - Given the Budgeting Constraints Established in Activity 5, Let the Selected Projects Out for Bid to Those Qualified Resources Identified in Activity 3

Step 1. Submit the project specifications to a selected list of resources (bidders) and invite them to submit detailed plans (proposals) for the developmental program stating:

(a) Description of content and activities for achievement of project objectives.

(b) Description of procedure for internal monitoring and evaluation of the developmental program.

(c) Management and administrative procedure.

(d) Developmental capabilities in terms of fixed educational assets.

(e) Budgeting information.

Step 2. Evaluate the proposals according to an established weighted criteria.

Step 3. For each project, let the contract to the most qualified bidder as established in Step 2.

MONITOR RESOURCE PERFORMANCE

The control function of the EPD system pertains to making certain that developmental resources perform according to project specifications. The subfunctions of control are defined as cost (budget) control, schedule (time) control, and performance (product) control. Cost and schedule monitoring are herein considered. Performance control was considered earlier.

Activity 1 - Appoint a Project Monitor for Each Project Identified in Activity 9, Step 2, Preparation of EPD Project Specifications

Document his authority and responsibility with respect to:

(a) Specification of de jure organizational authority and responsibility.

(b) Preparation of project specifications and bid requests.

(c) Approval of project scope, cost, and schedule.

(d) Allocation and expenditure of project funds.

(e) Relations with prime contractor.

(f) Exercise of financial management control over allocated project funds.

(g) Approval of contract negotiations.

(h) Supervision of subordinate EPD personnel.

Activity 2 - Establish Cost Control Procedures for Each Project

(a) Provide a record of project costs incurred by the contractor classified according to budgetary classes.

(b) Provide periodic comparison of incurred versus budgeted project costs.

(c) Facilitate flow of funds to prime contractor.

(d) Identify areas where incurred costs are exceeding or likely to exceed budgetary line classes.

Activity 3 - Prepare Project Schedules with Assistance of Prime Contractors

Step 1. Develop a network plan (see Systems Overview) according to some scheduling technique such as PERT. The plan should isolate major key events as critical actions deemed vital to the execution of the project.

Step 2. Identify critical developmental activities not completed or not likely to be completed according to schedule.

Activity 4 - Negotiate with Contractors to Reduce Schedule Slippage for Those Activities Identified in Step 2

EVALUATE DEVELOPED PRODUCT

Upon completion of the developmental program, vocational and technical education teachers and ancillary personnel should be evaluated to determine how they compare with the performance criteria stated in the project specification.

Activity 1 - Assign Vocational and Technical Education Teachers to Proficiency Levels

(See Activity 3, Estimation of Professional Demand and Supply.)

Activity 2 - Assess Subject Matter Knowledge in Those Areas Stipulated in the Project Specification

Activity 3 - For Each Project, Compare Actual Terminal Performance as Determined in Activities 1-2 with Criteria Performance Stated in the Project Specification

Step 1. If the proficiency level and subject matter knowledge equal or exceed criteria standards, adjust current supply inventory and personnel records to reflect increased professional competencies.

Step 2. If proficiency level and/or subject matter knowledge do(es) not exceed criteria standards, then

(a) Recycle through the development program;

(b) Terminate employment if in-service or do not hire if pre-service; or

(c) Accept present developmental level.

Step 3. Adjust current supply inventory and personnel records according to alternative taken in Step 2.

Step 4. Compute a failure ratio for each project, where

$$\text{Failure ratio} = \frac{\text{number of unsuccessful completion}}{\text{total number of completions}}.$$

Activity 4 - If the Failure Ratio Exceeds a Certain Critical Value

(a) Remove resource from list identified earlier,

(b) Renegotiate total project contract cost to reflect the reduced number of developed professionals with acceptable qualifications.

Activity 5 - Return to Activity 1 of the first section

SUMMARY

Because of the inverse relation between system specificity and scope of application, the specificity of the present system design is balanced against vagueness so as to provide relative freedom of choice of alternative means of effecting system activities. It is imperative that the development system herein proposed be regarded as a general model for implementation of a specific state system and not as a blueprint of a ready-made system to be installed without further developmental endeavor. Therefore, no attempt is made, nor indeed can be made at this stage of the design, to compare alternative systems with respect to development and implementation costs. Rather, it is held to be sufficient at this point simply to regard the model system as an impetus for a more systematic consideration of the process of educational professional development.

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