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BETTER PROJECT PLANNING AND CONTROL THROUGH THE USE OF SYSTEM ANALYSIS AND MANAGEMENT TECHNIQUES.

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THE COMBINED APPLICATION OF SYSTEM ANALYSIS AND MANAGEMENT TECHNIQUES IS DESCRIBED AS AN EFFECTIVE WAY TO ACHIEVE OPTIMUM RESULTS IN THE PLANNING AND EXECUTION OF PROJECTS IN THE FIELD OF EDUCATION. PROJECTS OF THIS TYPE ARE GENERALLY FINITE, COMPLEX, HOMOGENOUS, AND NONREPETITIVE. SYSTEM ANALYSIS OF A PROJECT INCLUDES ITS DISASSEMBLY INTO COMPONENTS AND ITS REASSEMBLY THROUGH A SYNTHESIS BASED UPON A LINEAR FLOW CHART APPROACH INCORPORATING TIME, COST, AND PERFORMANCE VARIABLES. SUGGESTIONS INCLUDE HOW TO THINK OF A PROJECT AS A SYSTEM, THE IMPORTANCE OF ESTABLISHING SPECIFIC GOALS, TYPES OF PROJECT CONTROL, AND THE CONTRIBUTION SYSTEM ANALYSIS CAN MAKE TO THE FUNCTION OF MANAGEMENT IN EDUCATION. THIS PAPER WAS PRESENTED AT THE SYMPOSIUM ON OPERATIONS ANALYSIS OF EDUCATION, SPONSORED BY THE NATIONAL CENTER FOR EDUCATIONAL STATISTICS (WASHINGTON, D.C., NOVEMBER 20-22, 1967). (JK)

BETTER PROJECT PLANNING AND CONTROL THROUGH THE USE OF SYSTEM ANALYSIS AND MANAGEMENT TECHNIQUES

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Better Project Planning and Control Through the Use of System Analysis and Management Techniques[1]

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Introduction

It was my good fortune this August to have been able to attend a five-day course at UCLA focusing upon a critical appraisal or state-of-the-art review of management information systems as they are now developing in the area of our society most commonly referred to as the military-industrial complex. The forces of fate, or just some simple clerical operation, resulted in my roommate being a technical representative (i.e., salesman) from one of the leading data processing hardware manufacturers in the country. During the course of a heated session (i.e., the room temperature was up and the speaker boring), my roommate uttered an appraisal of the program by stating that while he was not learning much new at least the speakers and participants were using the right set of "buzz" words in their presentations, discussions, and conversations. In my best academic manner so that any naiveté and innocence would not be betrayed, I cautiously inquired as to what he meant. My companion replied that in almost any professional field there is always a current set of terms that one must use in his speeches, cocktail conversations, and business dealing to show that he is <u>with it</u> or <u>in</u>. It was comforting to me to learn that fields other than education have a problem similar to the one with which we are faced.

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Education is beset with its own set of "buzz" words plus those from outside of education. The list of such words is relatively long and hence I should not use the time allocated to me to cover all of them. For those of you not familiar with some of the terms and/or the "buzz" word game, I would call your attention to an opportunity of being initiated which is presented in the September issue of the Phi Delta Kappan (10) wherein there is an opportunity to devise your own set of buzz words on a somewhat random basis.

I am sure that the symposium which you are now attending has already presented, and will continue to present, its contribution to the pool of buzz words. The purpose of the symposium is not, however, to introduce new words into the language of the educational situation. Instead, it is a recognition of the fact that certain words have already become part of the educational language. It is necessary therefore to give some attention to both the clarification of such words and to the possible role that the realities represented by the abstract word might have in the present and future of education.

In this paper, I propose to deal only with a selected set of "buzz" words derived from the more general one called Operations Analysis (working on the perhaps tenuous assumption that it is the generic term). The specific words that I would like to discuss are those of system analysis, management techniques, and project planning and control. My single purpose is to indicate how these concepts can be related to and used in an activity which has and is consuming more and more energies of professional educators--that activity is the preparation and execution of research and development projects.

Defining Project Planning and Control

What is a project?[2] In view of a lack of consensus as to a single definition, Gaddis (5) provides a useful one for our purpose.

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2 Much of that which can be said here about projects applies also to Programs. Major differences might be in scope, magnitude and duration.

> A project is an organization unit dedicated to the attainment of a goal - generally the successful completion of a development product on time, within budget, and in conformance with predetermined performance specifications.

While the above quotation provides the essential description of a project, the definition presented has a limitation for our use since it only relates to development projects. I should like to expand the definition to include the broader spectrum of research and engineering efforts as well as product development activities.

Projects of the above types have several common characteristics or features (8). In general, projects can be said to be <u>finite</u>, or having a definite end point; <u>complex</u>, in that a mix of human and material resources is used to do a series of linear or parallel-related jobs; <u>homogenous</u>, in the sense that one project can be marked off from another project or from the environment within which it exists (we will return to this characteristic later in this paper); and <u>nonrepetitive</u>, in that it is usually a one-time effort and therefore often has some uncertainty associated with it.

<u>Planning</u> is used here is its most general sense as described by Emery (4) - that of outlining the future and/or deciding in advance what is to be done. The output of the planning process is a plan which may take the form of a budget, rules, programs, schedules, and similar items. As Emery notes, the purpose of a plan is to bring about behavior that leads to desired outcomes. To accomplish the latter, the plan must (a) describe <u>actions</u> (some synonyms are procedures, process descriptions, and activity specifications) and <u>outcomes</u> (some synonyms are declaratives, state descriptions, or product specifications) and (b) serve as a formal tool or vehicle for management.

<u>Control</u> is used here in its most general sense of a monitoring function to make sure the plan is being effectively and efficiently carried out. The control formula of noting deviations from plan, taking necessary corrective

actions, and recycling is included within the concept for purposes of our present discussion.

Defining System Analysis

The concept of system analysis presents some difficulty in being defined because of some confusion existing in the field at the present time. Let me start by noting first of all that the term system is being used in its singular and not in its plural sense. There is much confusion today in education, and perhaps even in other fields, relative to the use of the plural "systems" as an adjective and/or noun. Educators talk about systems approaches, instructional systems, and even systems analysis but one is not sure whether the singular or plural is being intended.

System as used here refers primarily to the orderly (i.e., logical) arrangement of interdependent components or parts into a connected or interrelated whole to accomplish a specified goal. So defined, it is assumed that a system can be factored or resolved into a series of subsystems and each subsystem itself can be further factored or resolved (11).

As for a meaning of analysis, the ideas presented by Starr in his book on production management (12) are useful to us. Starr defines analysis in terms of the principle of disassembly. Under this principle, analytic behavior consists of operations that involve division, dissection, classification, partioning, and similar actions. The operations of summation, integration, unification, and similar actions relate to a principle of assembly, are the act of synthesis. For many of my educational colleagues, it will be reassuring for them to know that synthesis has elements of Gestalt psychology associated with it.

Combining our concepts of system, analysis, and synthesis we can now define system analysis as that process of disassembling some objective-oriented whole into its component parts. System synthesis consists of putting the parts back together again into some kind of a whole. Figure 1 shows these two concepts in a graphic manner.

Figure 1. System Analysis and Synthesis

System Analysis	System Synthesis
Disassembly into:	Assembly into:
Parts	Wholes
Units	Entities
Subsystems	Networks
Activities	Total Systems
Functions	Flow Diagrams
Tasks	

Definition of Management Technique

Management technique is not quite so difficult to define as the previous terms. Any attempt to define what is meant without a prior reference to the nature of management would be somewhat premature. Basically, management can be considered as a process which involves the functions of planning, organizing, directing, and controlling the personnel and other resources needed to accomplish an objective or goal. It is generally recognized that a manager's principal role is to make decisions with regard to each of the functions noted above.

Many techniques (or systems) have been developed in order to make the manager's task of carrying out the above role an easier one. In their recent book on management systems, Archibald and Villoria provide a useful definition of such a system (1).

> We may define a management system as a set of operating procedures which personnel carry out to acquire needed information from appropriate sources, process the data in accordance with a pre-programmed rationale, and present

> them to decision makers in a timely, meaningful form. Most contemporary systems involve manual data collection and input, machine processing, tabular and graphic output production, and human analysis and interpretation. Thus we can say that the systems collect, synthesize, process, transmit, and display information, which flows from a primary source, through an editing, computation, and selection process to the manager.

Two principal ideas are highlighted in this definition. First, management systems are designed to provide information. Second, the decision-making operation is left to the human manager. Some sophisticated systems do have what is called pre-programmed decision-making (i.e., rules) as an inherent part of them. Most systems, however, still rely upon the use of humans to make what in effect are non-programmed decisions. Most of the systems developed are primarily aimed at facilitating the control function of a given manager's job. In view of the definition and ideas presented above, it is perhaps more appropriate to talk about management information systems rather than management systems. There is a general consensus that managers operating within the project context require data or information relative to time, or schedules; costs, or resources; and performance, reliability, or quality of objective accomplishment. Of these three types of basic data, the most common data obtained and used in a project situation is that relating to time or schedule.

A wide variety of numerous management systems or techniques have evolved over the past several decades to facilitate the manager's task. Three general types of systems have been developed. One group relates to the quality characteristics of a product, a second category relates to the operations involved in producing the product, while a third group relates to the administrations involved in carrying out the operations. The selection of a particular technique for a particular situation is not easy because a system designed for one purpose may not be suitable for a different purpose. I have chosen to delimit my definition of management techniques to that group of selected operations-related systems known as network techniques which have become increasingly popular during the past decade because of their relatively high degree of success in carrying out research and development activities within the military-industrial complex of our society. The application of such techniques to the field of education is just beginning but their value has already been demonstrated (3).

To summarize briefly, definitions have been provided for three current buzz words from the general area of Operations Analysis in education. Project planning and control was defined in terms of pointing out a concern with the planning or outlining of the future for a goal directed activity which is finite, complex, homogenous, and nonrepetitive in nature, plus monitoring and correcting deviations from the plan. System analysis was defined in terms of the analytic procedure involved in disassembling a goal-oriented whole into its component parts and then re-constituting it or synthesizing. Management techniques were defined in terms of their role of providing managers with information needed to control the accomplishment of the project effort within established time, cost, and performance parameters.

Toward Project Improvement

Having defined the three essential terms of concern in this paper, albeit briefly and simply, let me now present or develop the major point or thesis of this paper. It is contended that a sizeable number of projects in the field of education have been inadequately planned in their initial development and improperly executed once started because the initiators of such projects were just not simply aware of the new tools and techniques available to them for project planning and control. It is further contended that the combined applications of system analysis and management techniques would be of immense value in producing better planned and controlled educational projects than has been the case in the past.

The basic premise for this position set forth is that the typical research, development, or engineering project in education can and should be fundamentally thought of as being a system. Viewing a project as a system can be justified primarily on that project characteristic referred to earlier as homogeneity. Any project can be visualized as being made up of a series of parts, units of activities which belong exclusively to that project. Hence, one can speak of the project as being an entity possessing edges and boundaries that help to distinguish it from the rest of the environment within which it operates. As one writer put it ". . . a project has a greater density of dependency within itself than between it and its surroundings" (7). The suggestion is made further that the boundary zone can be approximated where there are relatively few activities leading outward - that is, where there seems to be relatively natural perforation. Even though it can be distinguished from the rest of the environment, the project still operates within an environment which affects it or which the project itself affects. Under this definition or characterization, the concepts of system analysis and management techniques assume validity and become useful tools for project planning and control. The question now is when, where, and how are they applicable? To answer these questions, let us first examine the general steps in planning and controlling a project.

The initial step is to establish the goal or objective. The subsequent steps are to do a project definition, develop a project plan, and establish a schedule. The second step of project definition is essentially a process of disassembling or breaking out the many jobs which have to be accomplished to reach the stated objective. Putting it another way, we do an analysis of the system--or a system analysis. The end product of this definition or analysis step usually takes the form of a hierarchial plan or chart showing several levels of prime and supporting functions and tasks[3] (i.e., objectives) which have to be accomplished in order to accomplish the goal of the project. Functions or tasks can be further factored so that smallest unit for planning purposes is established. Project definition through system analysis should not be thought of as an easy task. One difficulty is a clear establishment of that set of hierarchially ordered tasks or functions which helps to establish the boundary between the project and the environment within which it will operate. Another difficulty is the inability to define the measurable goals of the project. If the goal is a product, then the process to be defined by the analysis to achieve the product becomes quite tenuous if that original product is defined loosely.

Having defined the project by use of analytic techniques, the project plan can now be developed by employing a graphic representation of the order in which the many functions or tasks have to be accomplished in order to reach the project objective. For this purpose, we can capitalize upon one of two methodologies system personnel have developed for representing any given system under consideration. One methodology involves the use of mathematical models or equations. While highly useful and very sophisticated to some system analysts, the set of equations has limitations in that it fails to portray in a readily comprehended form the structure of a system as a whole (7). The second methodology for a system structure representation takes the form of various flow-graphs, more commonly called "flow charts", "block diagrams" and similar terms. The purpose of such diagrams is not necessarily to portray the things that comprise the system but rather to show the various operations that the systems performs upon the stuff it processes. Huggins has referred to flow graphs as a kind of mathematical Esperanto for system analysis, design, and simulation. They have the advantage of permitting a human to perceive quickly a total pattern plus the

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3 The hierarchial plan could be established using variables other than tasks or functions but the latter are the ones fairly commonly employed.

relationships existing therein as well as being more palatable to the relatively unsophisticated person than are mathematical models.

The flow graph model which appears to have high relevancy for system representation is that one composed of a network of branches that connect at nodes or points. Each branch may be thought of as originating at one node and terminating at another node with direction from one node to the next point being indicated by an arrow. For our immediate purpose, each of these branches can be equated to or identified with the functions or tasks which must be accomplished to reach the goal.

Flow graph methodology permits one to achieve a synthesis of the functions identified through analysis. This technique helps to assemble together that pattern of relationships, dependencies, and sequences which might be established as the most efficient way of "moving through the project." This "moving through the project" refers to the idea expressed earlier that flow graphs show how we intend to process the "stuff" that goes through the system. In a project, this "stuff" is most probably the intellectually-related activities required to accomplish the project objective. We are not able to portray graphically the intellectual processes involved in any of the functions or tasks but we can show how we intend to organize and sequence our thinking and related activities as we move through the project in so far as the tasks and functions identified reflect such intellectual or cognitive processes.

Within system analysis techniques, a "functional flow diagram" is often employed to show the functions to be performed and the flow of these functions in meeting the objectives which have been identified (9). The functional flow diagram has limited use as a management tool for making sure that the several functions and tasks are accomplished during the execution phase of the total project effort.

The concept of flow-graphs to represent a system is somewhat of a recent origin. A very similar idea, however was advanced by Gantt in the development of bar charts during the first World War (2). Gantt charts served a useful purpose but they had the limitation of not fully integrating the parts of the system into a component whole. Partial analysis was achieved through Gantt charts since the diagnostic synthesis perhaps served as a forcing function on what was analyzed. The analysis did however usually miss the interaction relationships. Other techniques using a visual or graphic representation of a function or task breakout were developed subsequent to the Gantt chart but time does not permit a discussion of them. The most recent innovation has been the conceptualization and development of management systems which utilize the system analytic and synthesizing procedures combined with the flow graph concept of nodes and branches. The general terms for such systems is network techniques with PERT/CPM being the most commonly known systems.

Network systems such as PERT/CPM usually require as a first step that the project objective be identified. Then the elements of the total project are identified and placed in some type of hierarchial order. This essentially analytic procedure results in a product most generally known as the workbreakdown structure. Within network techniques, the workbreakdown structure most often represents the end products (either in the form of hardware or software) of tasks or functions rather than a representation of the tasks or functions themselves. There is no, however, reason to believe that such a product orientation must always obtain. Workbreakdown structures can be composed of tasks and functions just as easily as products. In either case, the workbreakdown structure represents the project definition phase of total project planning. Based upon the work-breakdown structure, a network consisting of activities or functions (our original branches) and events (our original nodes) is developed with a uni-directional flow (usually from left to right). The network integrates the constituent elements of the project into their necessary sequence and dependency relationships (inter-actions) much as the functional flow diagram does in system analysis. Once the network is established, PERT/CPM have provided procedures for securing time estimates for the completion of each of the several activities or functions. These activity time estimates are then used to derive estimated start-completion times for the start or completion of functions, including the final node in the network. Schedules are then developed for the accomplishment of events or activities after careful consideration of resource availability and/or allocation.

Once the project definition phase involving analysis has been completed, the workbreakdown structure prepared, the process of syntehsis accomplished through the network or flow graph procedure, and the time estimates/schedule procedure completed, the essential steps of project planning have been accomplished. The result is a plan for the future--a graphical representation of the project tasks as they are to be accomplished in order to achieve the project objective. It should be noted here that we have approached the problem as if there is only one way to reach the project objective. Actually, there are alternative ways of reaching the goal. Each alternative with its associated project definition, project plan, schedule is a separate system. If we prepare several alternatives for consideration, each may be considered as a separate system and thus we are approaching the <u>systems analysis</u> concept developed by Hitch and McKean (6). Preparation of alternative systems to reach the project goal for management decision requires information relative to the associated costs for each system.

The network with its associated schedule provides us with a means of managing the project to make sure that the several functions or tasks are being completed in proper sequence and that we are staying on our time target. If the progress through the project is normal and on schedule, we can feel safe in assuming that the initial analysis and synthesis operations plus the time estimating procedure have been fairly well done. Should we begin however to observe malfunctions in the system, as represented by nodes or events not being reached on schedule or there is frequent modification of the plan in that new tasks are continuously inserted into the flow graph, such an observation might indicate that there was perhaps a failure to do a complete and through analysis and synthesis operation in the initial development of the project plan. Under this situation, valuable project time would be lost as resources were redeployed to conduct the necessary replanning operation. A schema illustrating the suggested relationship between system analysis, management, and project planning and control steps is presented in Figure 2. The middle box shows the steps in project planning and control while the relationships to system analysis are shown on the left and to management techniques on the right. The schema points up rather clearly that there is a great deal of similarity between the generalized sequence of steps under system analysis and synthesis and the steps of work-breakdown structuring and networking under network based management systems. Putting the results of the above steps into a time frame puts us into the realm of management control systems.

Summary

The purpose of this paper has been to show how two current buzz words employed in educational circles - those of system analysis and management techniques might be employed in combination to produce better planning and controlling of educational research and development projects. Experience with the use of these techniques has demonstrated that better planned and controlled projects result than might otherwise be the case.[4] The employment of network techniques, such as

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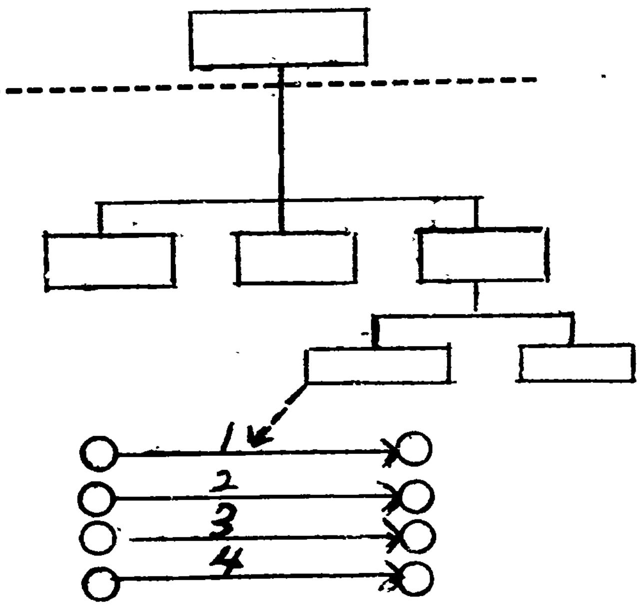
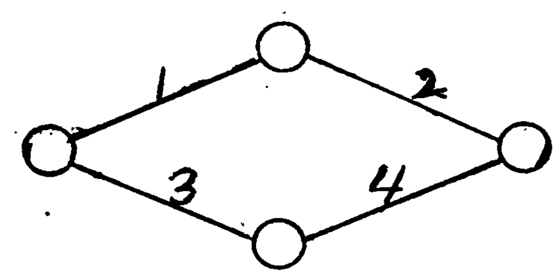
[4] For example, the joint work of the author with that of R. Kaufman, B. Corrigan, and D. Miller on the use of systems analysis and synthesis techniques and management systems in preparing educational planners for the state of California.

Figure 2. Schema for Integrating System Analysis and Management Systems with Project Planning and Control Steps

System Analysis	Steps in Project Planning and Control	Management Sytems (Network Based - PERT/CPM)
A. System Objective - Purpose	Project Objective(s)	Objective 
B. System Analysis by hierarchial factoring into levels of functions Profile: 1.0 2.0 3.0 Functional Analysis	Project definition in terms of subsystems, products, functions, and so on.	Workbreakdown structure Activity (task) definition (means-end)
C. System synthesis through flow graph methodology (functional flow diagram) 1.0 → 2.0 → 3.0	Project plan	Network 
(No Provisions)	Scheduling	Activity time estimates, event times, slack, resource allocation, etc.
D. System Feedback Loops Iteration	Controlling-Evaluating	Deviations, management actions, decisions, recycling

PERT and CPM, for project planning and control, not only have advantages in and of themselves but they also provide a very useful vehicle for an initial orientation into some rather complex operations - those of system analysis and synthesis procedures and the representation of existing and proposed systems through flow-graph methodology.

The temptation to employ just one more buzz word cannot be resisted. The essential position in this paper is that the combined use of system analysis and management techniques will have a synergistic effect upon project planning and control. As I understand synergistic, it is that the effect of the two techniques operating in combination produce an effect that either one would or could not produce by itself. The simple contention of this paper is that the synergistic effect from using system analysis and management techniques in project planning and control cannot be other than beneficial provided that such procedures are fully understood and properly applied. While not curing all ills, they can go a long way in helping with the stresses and strains exhibited under a bad case of "projectitis" under such programs as ESEA Titles I and III.

Let me close with a quotation which appears to be relevant both to the intended tone of this paper and the general topic of the symposium. It is a quotation from Alice's Adventures in Wonderland by Lewis Carroll.

> 'Speak English', said the Eaglet, 'I do not know the meaning of half those long words, and what's more I don't believe you do either.' And the Eaglet bent down its head to hide a smile; some of the other birds tittered audibly.

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