DOCUMENT RESUME

ED 046 214 EM 008 629

AUTHOR	Carpenter, Polly
TITLE	A New Kit of Tools for Designing Instructional Systems.
INSTITUTION	Rand Corp., Santa Monica, Calif.
PUB DATE	Dec 70
NOTE	14p.
EDRS PRICE	EDRS Price MF-$0.65 HC-$3.29
DESCRIPTORS	Audiovisual Aids, Flow Charts, *Instructional Aids, Instructional Design, *Instructional Media, *Instructional Systems, Mass Media, Models, *Teaching Models
IDENTIFIERS	ADIS, Aid for Designing Instructional Systems

ABSTRACT

To assist planners of instructional media systems, a combination of analytical and synthetical processes are being devised. This "kit of tools" is really a model of Instructional System Design, not a model of any particular instructional system. The policy-making process is displayed in a table and then explained. The communication media to be considered are shown in another table which is self-explanatory. A flow chart illustrates the process of choosing a media class. Next to be completed is a formulation of rules for media system design and an assemblage of cost-estimating relationships. The model being developed may be extended to such functions as class scheduling and curriculum planning. (MF)

A NEW KIT OF TOOLS FOR DESIGNING INSTRUCTIONAL SYSTEMS

Polly Carpenter, The Rand Corporation

December 1970

GENERAL DESCRIPTION

We are currently developing a set of tools to assist planners in designing instructional systems. By "planner" we mean any person contemplating instituting a new course of study, or revising the methods by which a standard subject is taught, and desirous of exploring ways to match the needs of the students, the subject matter, and the local educational institution, in order to select a plan that makes effective use of available resources. Curriculum experts, educational technologists, and classroom teachers may all assume this role.

As the title implies, we are devising a combination of a variety of analytical and synthetical processes that, taken together, will assist in Instructional System Design. Our initial focus is on communication systems because communication is fundamental to most aspects of instruction. Also, the emphasis on a single function within the instructional process delimits the work so that we may fashion a complete kit within a reasonable period of time. The result will be an aid to planning for the use of communication media in instruction.

Logically, the first steps in designing an instructional system should be to determine what is to be learned and what kinds of students are to do the learning. If the instructional process were well understood, this would be sufficient to specify optimum system design within a given set of resources. This latter step cannot be taken at present because many of the relationships between the inputs to an instructional system and its outputs defined in terms of student learning are not known. To fill this void, we are building a structure that will explicitly integrate the judgment of the planner into the design process.

To use the aid to Instructional System Design that we are developing, the planner must have already established a curriculum of sequenced learning objectives and divided it into lessons and parts of lessons. We will then help him to prescribe those instructional methods he believes will be the most effective in teaching what he wants to teach to the kinds of students that will be taught.

This tactic will allow the planner to follow a more logical process of communication system design than has been possible in the past. Typically, past work has begun by specifying the communication system (such as closed-circuit TV) to be used and then has sought to determine how to use it in the given school, thereby begging the question of whether such a system is appropriate to the need or indeed if any communication medium is needed at all.

In order to make the design process as generally useful as possible, we avoided building our own prescriptions for effective instruction into the analysis. There is no single best way to teach everything to everyone; rather, the best ways must be tailored to subject matter, students, and available resources. Even for a given set of these parameters, there are multiple alternatives. Thus, by relying on the planner's judgment, we hope to have devised tools that will be useful for planning instruction in almost any teaching situation.

The design tool we are developing will help assure first that the instructional designer clearly analyzes his *need* for communication media, then that he recognizes the various alternative systems which he may use to fit this need, and finally that he is informed as to which of these alternatives are the most practicable within the limitations of his local environmental resources and constraints. Since no single designer or design team can have had enough firsthand experience to know all possible alternatives, or to choose wisely between them, the use of this tool will probably improve the efficiency of instructional systems anywhere. The rest of this paper will describe the tool we have been discussing.

On Fig. 1, which displays the general structure of the design process, the four major phases are indicated as shaded blocks. We have been discussing the general rationale for including the determination of instructional policy as part of the design process. To provide an idea of what the policy determination involves, suppose that the planner is designing a course for teaching typing, much of which will require drill for the development of typing skills. One of the decisions he must make will concern how these drills are to be paced. For example, he may elect to have all students drill at the same rate for every

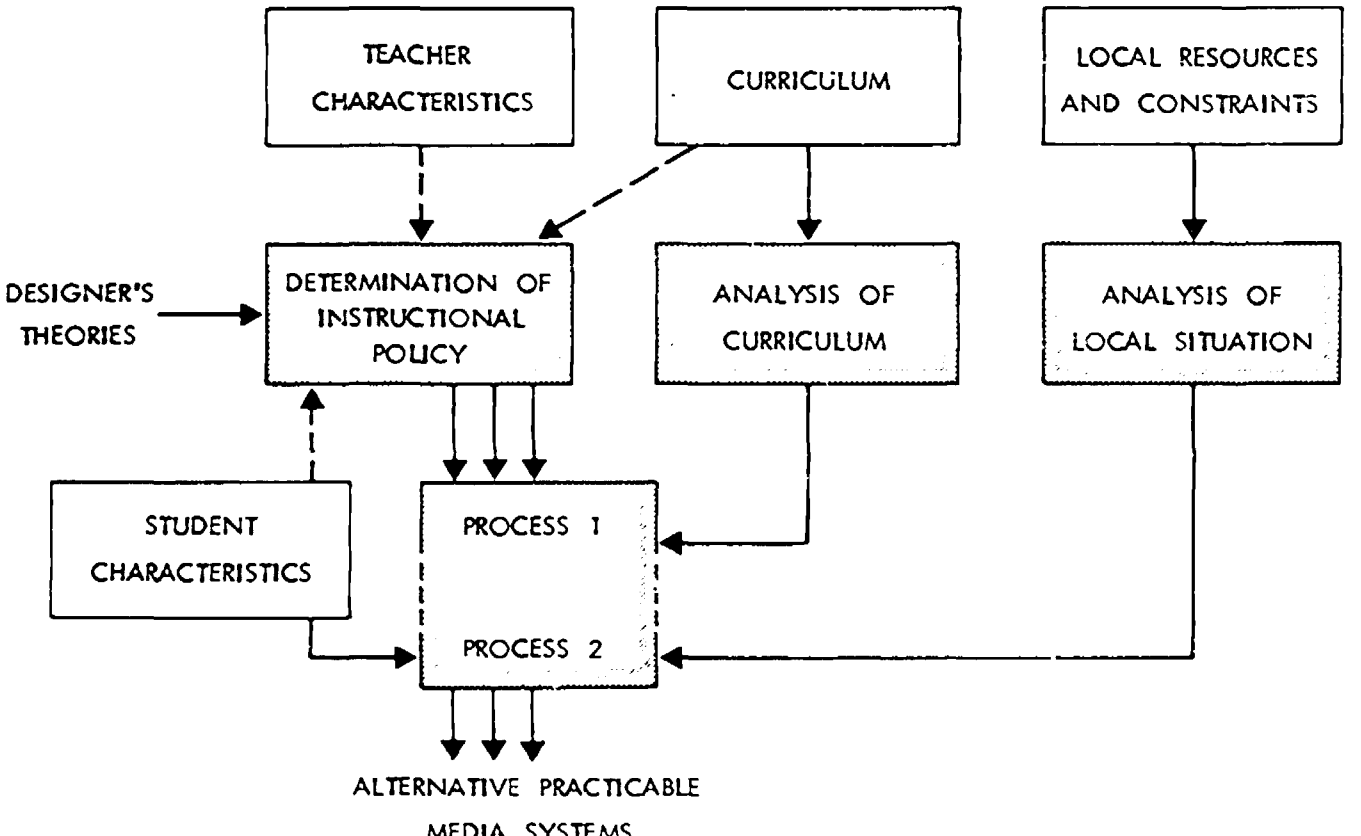

Fig. 1—ADIS—an Aid for Designing Instructional Systems

drill session, or he may allow individual students to drill at variable rates until they have learned the basic motions and then bring them all up to acceptable typing speed together. During individual drill at variable rates, the students themselves may set the pace, or some kind of device may be used that records student responses and adjusts the presentation of drill stimuli accordingly. The instructor may then pace the class for final "speed drills."

The policy-setting process is a logic tree with each decision point a logical consequence of the decisions that have preceded it. To use it, the planner will have two aids--a time-shared computer program which performs the logical bookkeeping, and a manual that presents the pros and cons in making choices at each decision point and also presents the logical consequences that will follow from each choice. This manual will be useful in itself as a compilation of practical considerations of Instructional System Design.

Another, much less complex, logic tree has been devised to assist the designer in analyzing the curriculum he plans to teach, lesson segment-by-lesson segment. By responding to a set of interrelated questions presented on a tally sheet, the designer will provide the data needed to describe each lesson segment for the first process in final system design. A *lesson segment*, a portion of instruction during which a single instructional activity is going on, is better defined by example than in words. In the teaching of typing, at least three lesson segments might be needed to teach a student the placement of letters in the second row where the hands would normally rest. The first of these, typically, would be a demonstration wherein the instructor (or a communication medium) would show the student what letters are on the second row and which fingers rest upon which letters. Next could come a drill session, in which the student practices striking the letters in turn to develop the capability to strike each letter as it is called for. A third segment could be used by the instructor to determine whether the student has learned the placement of the letters.

Data describing the student population and the local resources and constraints will also be gathered by means of a logically structured set of questions. These data will include the number of students that

will be enrolled in the course at any given point in time; the number of classrooms, laboratories, or other facilities available for use by these students; the existence of communication equipment such as television receivers installed in the classrooms; the geographical distribution of students, that is, whether they are all in one building or scattered throughout a campus or city; the number of instructors available; and so on. The resulting description of local resources and student loads will be used to design specific practicable media systems in the second process of the final analysis.

The final analysis comprises two processes whereby all of the information is put together to obtain alternative practicable media systems, along with instructors, facilities, and other resources required to support the instructional policy that has been established. The first process combines the instructional policy with the analysis of the curriculum to obtain the simplest media classes appropriate for teaching the subject matter. The second process designs specific media systems that fall within the appropriate media classes and that are fitted to the available resources. We have labeled these *practicable media systems*. There may be several or many such media systems, each of which will give rise to requirements for resources such as production personnel, instructors, transmission and receiving equipment, printed materials, and so forth, and ultimately to costs for investment and for annual operation. All of these data describing each system will be presented to the planner so that he may choose that system which best fills his needs within political, economic, or other constraints. If he is dissatisfied with all of the systems designed for him, he may alter policy decisions or revise the description of available resources or student load to obtain a system more to his liking.

From the foregoing description it should be clear that our kit of tools is really a model of Instructional System Design, not a model of an instructional system, per se. The design process uses models of some aspects of an existing instructional system--instructional resources, student population, and curriculum--and relates these through processes determined by instructional policy to design practicable communication media systems.

DETAILED DESCRIPTIONS OF COMPLETED PORTIONS

The basic work on the processes for determining instructional policy, for analyzing the curriculum, and for selecting the appropriate media classes (the first step in the final system design) is essentially complete. We shall discuss these techniques in more detail.

The general logical structure of the policy-setting process is displayed on Table 1. Illustrative decisions that must be made at each point in the outline will help clarify it. Beginning with decisions that affect the course as a whole, a number of them concern the overall management of the course. These involve such areas as formal evaluation of student progress, the provision of special sessions with the instructor for student counseling and tutoring, and other matters.

Table 1

OUTLINE OF POLICY DECISIONS

I. Overall Course
   - A. Course management
   - B. Adaptivity of objectives
   - C. Variability of pacing
   - D. Types of instruction

II. Instruction Types I and II
   - A. Instructional management
   - B. Complexity of instruction
   - C. Presentation

III. Instruction Type III
   - A, B, and C as in II
   - D. Special requirements
     - Facilities
     - Equipment
     - Safety
     - Teamwork

The next step is to decide whether the objectives of the course are to be tailored to the needs and goals of the students. Although adaptivity of objectives is being stressed in many of the more innovative schools, in some fields such as vocational or military training each student must master the same set of objectives as every other student. Even if all students will be expected to achieve the same

objectives by the time they have completed the course, the designer must still decide whether the *way* in which students attain given objectives is to be adapted to each student's individual needs. For example, one student may require fundamental background material before he can comprehend and master a particular objective, whereas another student may be able to master the same objective without additional preparation.

The next major decision concerns whether or not each student will master objectives at the same rate or at variable rates. Variability of pacing in some or all of the course may be highly desirable, especially where saving student time is both possible and economical. On the other hand, there may be situations in which a minimum speed of response is an objective in itself for all students, such as in the teaching of typing. Finally, in some cases, as in many sports, it may be impossible to vary the pace of instruction for individual students because students must work together as a team.

The main types of instruction to be used in teaching the subject are next identified. When we began working on the determination of instructional policy, we had originally typified instruction in the traditional way, that is, by type of learning objective--cognitive, psychomotor, and so on. We quickly discovered, however, that this classification was not as useful for considering the practical aspects of Instructional System Design as we would like. For example, we had difficulty finding major differences in system requirements between teaching cognitive skills and teaching certain psychomotor skills. Learning to add columns of figures is a cognitive skill, whereas learning to pronounce foreign words would be a psychomotor skill. Yet, each of these skills may be taught without using special facilities or equipment, and therefore would have the same general requirements for instructional system support.

Rather than trying to identify major types of instruction with descriptive words, we chose simply to denote them as Types I, II, and III. Types I and II are what we normally think of as "classroom" instruction. If little or no drill or practice are required, the instruction is Type I; otherwise, it is Type II. Note that the distinction between these two types of instruction is contingent upon student

capabilities as well as upon the subjects to be taught, because some students may require drill when others do not. If the instruction requires special facilities such as a gymnasium or a laboratory, or special equipment such as a simulator or an engine, it becomes Type III instruction.

The designer must decide how he will handle instruction of each type. In setting his policy he determines the roles that instructors, student leaders, communication media, and individual learners will play in each type of instruction, including the parts that individuals will play in the management of instruction. Referring again to Table 1, we will discuss in more detail the three main aspects of Types I and II instruction, for which the decision process is essentially the same. Setting policy for the management of instruction requires such decisions as whether drill sessions are to be conducted at scheduled times under supervision, or whether they are to be assigned for independent study, or whether a combination of supervised and independent drill is to be used.

Next, the designer must identify the complexity of the instruction to be given. Instruction involving simple material, each item of which can be mastered independently of the others, we identify as "relatively simple." If the student must master several items that must be interrelated in order to master the final skill, we identify the instruction as "relatively complex." For example, memorizing a list of French nouns is a relatively simple task because the memorization of a given word in the list does not depend on the memorization of any of the others. Translating a sentence from French to English, however, requires that the student master the vocabulary involved and relate the word meanings via the sentence structure to derive the English equivalent of the sentence. This would be a relatively complex task.

The heart of the analysis is the determination of presentation policies, because these policies will determine the mix of communication media, instructors, and other elements, that will be required to carry the burden of communication for the course. Presentation policies include determination of whether an instructor or student leader will do the presenting, or whether students will use a communication medium,

working individually or in a class. The planner also decides whether stimuli for overt student response will be integrated with the presentation. If so, he must determine whether the student response will be "selected" (that is, the student selects from among presented responses such as true-false, multiple choice, and so forth), or "constructed" (that is, the student must devise the response himself). In some instances, such as in the pronunciation of foreign words, constructed response is required. This possibility is also accounted for in the decision logic. The designer must decide how the responses are to be scored--whether by a human being or by a machine or not at all--and whether the student will be given the correct answer after his response so that he may see for himself how well he knows the material. The interrelationships among these decisions are all built into the process.

Type III instruction requires many of the same kinds of decisions as do Types I and II in addition to its special requirements. For example, if laboratory facilities or facilities for team sports are needed, the types of communication systems that can be used as well as the cost of the instructional system will be affected. The instruction may require equipment which may be relatively small, as in teaching cooking, or relatively large, as in teaching piloting of airplanes. Monitors may be needed to assure the safety of students and instructors. And, finally, it may be necessary for students to work together in teams, as in the removal of an aircraft engine. All of these requirements affect the cost of the systems and also place limitations on the kinds of instruction that may be carried out. For example, the students working as a team to remove a jet engine must be monitored by someone who is aware of the safety hazards involved, and communication media probably will be of little use during this activity. On the other hand, the student learning to bake a cake traditionally follows a recipe in a book which is, of course, the most ubiquitous of all communication media.

To summarize the description of the policy-setting process, let us describe the "inputs" from which the planner must draw when he makes his decisions, as suggested on Fig. 1. He will have theories of effective instruction which will relate to the characteristics both of the

subject matter and of the students he expects to be teaching. Important characteristics include the students' maturity in responding to learning situations, their average capabilities with respect to learning the subject, and the heterogeneity of these capabilities. The planner must be aware of the course content in each lesson segment so that he may identify the types and complexity of instruction that he will need. In addition, the planner knows within which school policies he must operate and where he has freedom to devise his own policies. And finally, the planner should have some idea of the capabilities of the available teachers so that he can decide at what points he can rely on them and at what points communication media will be more effective. The primary outputs of the policy-setting process (in addition to specific policies for management of the course) will be presentation policies tailored to the type and complexity of instruction that will be called for, and the capabilities of the students that will be involved. These will be displayed for the planner at the conclusion of the policy-setting process.

To illustrate the role that instructional policy decisions play in the system design process, suppose that the planner has decided that whenever a complex skill is being taught, the initial demonstration of the skill will be carried out by a communication medium that has stimuli for student response integrated with the presentation. This we call a "follow-me" demonstration. In the curriculum analysis all lesson segments for demonstrating a complex skill have been tagged, the amount of time required for each such demonstration has been estimated, and the simplest appropriate media class has been established. The program will add up all of these segments to arrive at the requirement for follow-me demonstrations by classes of communication media for the entire course. In this way, the planner's judgment of effective instruction has been made an integral part of the system design.

The first process in final system design, the determination of the appropriate media class for each lesson segment, has been documented in Rudy Bretz's *Selection of Appropriate Communication Media for Instruction* (R-601-PR, December 1970). Figure 2 shows the communication media being considered. The media are grouped into eight major classes;

TELECOMMUNICATION	Sound	Picture	Line Graphic	Print	Motion	RECORDING
CLASS I: AUDIO-MOTION-VISUAL						
	X	X	X	X	X	Sound film *
Television *	X	X	X	X	X	Video tape * Film TV recording *
	X	X	X	X	X	Holographic recording
Picturephone	X	X	X	X	X	
CLASS II: AUDIO-STILL-VISUAL						
Slow-scan TV Time-shared TV *	X	X	X	X		Recorded still TV *
	X	X	X	X		Sound filmstrip *
	X	X	X	X		Sound slide-set *
	X	X	X	X		Sound-on-slide *
	X	X	X	X		Sound page *
	X	X	X	X		Talking book *
CLASS III: AUDIO-SEMIMOTION						
Telewriting *	X		X	X	x	Recorded telewriting*
Audio pointer *	X		X	X	x	
CLASS IV: MOTION-VISUAL						
		X	X	X	X	Silent film *
CLASS V: STILL-VISUAL						
Facsimile		X	X	X		Printed page *
		X	X	X		Filmstrip *
		X	X	X		Picture set *
		X	X	X		Microform
		X	X	X		Video file
CLASS VI: SEMIMOTION						
Telautograph			X	X	x	
CLASS VII: AUDIO						
Telephone * Radio *	X					Audio disc * Audio tape *
CLASS VIII: PRINT						
Teletype *				X		Punched paper tape

* Media currently used in instruction

Fig. 2—The Communication Media

any medium within a given class may substitute for any other medium within that class as far as effectiveness of presentation is concerned (with some exceptions). Figure 3 presents a highly simplified version of the process of choosing a media class. The first question to be answered is whether media could be used at all for a particular lesson segment. For example, if the segment involves no message transmission, as would be the case in team play, no media will be required. The next step is to determine whether or not the representation of some concrete object or event is required. For example, if the student is learning to recognize birds by their manner of flight, or if he is learning to distinguish between the style of Beethoven and that of Mozart, a concrete representation is required. If he is learning to use a wrench, he is again learning something concrete, but because this requires a sense other than sight or hearing--namely, the kinesthetic sense--no communication medium currently available can transmit this information. (Note that a communication medium can be used to *demonstrate* the use of a wrench--in a demonstration lesson segment--even though the student cannot learn what the skill should *feel* like from such a medium.) If no concrete subject is being learned, we assume the subject to be abstract. Communication media are used in very different ways for communicating abstract subjects. For the concrete subjects, an audio, visual, or audiovisual medium may be essential; for the abstract subjects, audial or visual elements may be largely or only supportive.

The questions within the diamonds on Fig. 3 are settled on the basis of sets of criteria that will assist the planner in determining whether or not the subject is visual, audial, and so forth. As indicated, "yes" or "no" answers to these questions eventually lead to the simplest appropriate media class for the particular lesson segment being analyzed. Three media classes are inapplicable to concrete subject matter because they are neither audial nor visual. On the other hand, all media classes are applicable to abstract subjects, including print, by which we mean teletype or typed printout. This is a useful medium for subjects taught by computer program, and is different from Class V (still visual, of which the primary member is the printed page) because Class V admits of still-picture reproduction.

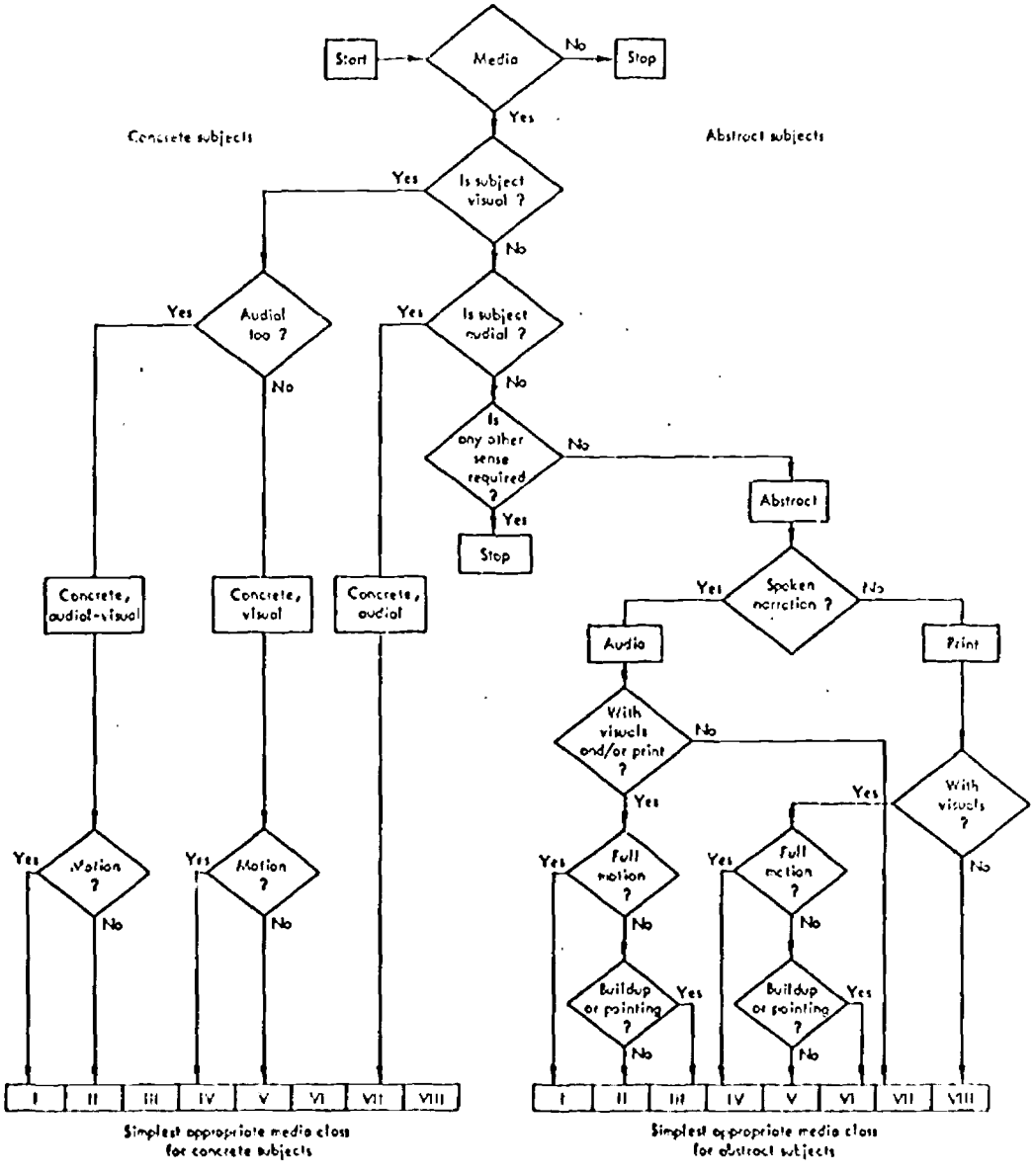

Fig. 3—Selection of the Simplest Media Class for a Lesson Segment

NEXT STEPS

We must next complete the formulation of rules for media system design and assemble the cost-estimating relationships that are needed for Process 2 in the final design stage. Then the final design stage will be ready for batch-process programming. At the same time, some of the design process can be tested now by applying the analysis of curriculum to specific courses and by encouraging interested educators to work out their preferred instructional policies for these courses. We have several potential customers, among them Technical Schools in the Air Training Command, the AF Human Resources Laboratory, institutions of higher education, and people in HEW. We hope that working with these people will enrich the model and, at the same time, prove its usefulness.

We would like eventually to extend the model in a number of directions. Many of the instructional policies (such as variability of pacing) considered could have significant impacts on other functions within the instructional system, such as class scheduling. Identifying the impacts of changes in teaching methods upon such functions would be a valuable next step.

In another vein, logical and quantifiable design techniques could be used to replace some of the designer's judgments that the model must now rely on. Many aspects of curriculum planning such as the sequencing and repetition of lesson segments could be handled in this way, for example.