



**DESIGNING AN ADVANCED INSTRUCTIONAL
DESIGN ADVISOR: CONCEPTUAL FRAMEWORKS
(VOLUME 5 OF 6)**

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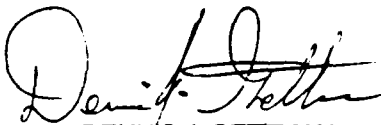
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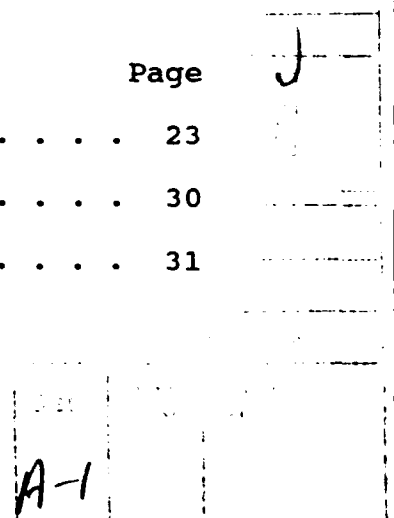
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PREFACE

The work reported herein was done for the Advanced Instructional Design Advisor project at the Air Force Armstrong Laboratory (AL/HRT). The substance of this research was done under contract to Mei Associates, Inc., the primary contractor on the Advanced Instructional Design Advisor (Contract No. F33615-88-C-0003).

This work was done as part of the first phase effort on the Advanced Instructional Design Advisor. The initial phase of this project established the conceptual framework and functional specifications for the Advanced Instructional Design Advisor, an automated and intelligent collection of tools to assist subject matter experts who have no special training in instructional technology in the design and development of effective computer-based instructional materials.

Mei Associates' final report for the initial phase will be published as an Armstrong Laboratory Technical Paper. In addition, Mei Associates received 14 papers from the seven consultants working on this phase of the project. These 14 papers have been grouped into six sets and edited by AL/HRT personnel. They are published as Volumes 1 - 6 of Designing an Advanced Instructional Design Advisor:

Volume 1: Cognitive Science Foundations (AL-TP-1991-0007)

Volume 2: Principles of Instructional Design (AL-TP-1991-0017)

Volume 3: Possibilities for Automation (AL-TP-1991-0008)

Volume 4: Incorporating Visual Materials and Other Research Issues (AL-TP-1991-0017-Vol-4)

Volume 5: Conceptual Frameworks (AL-TP-1991-0017-Vol-5)

Volume 6: Transaction Shell Theory (AL-TP-1991-0017-Vol-6)

This is Volume 5 in the series. Mr. Dennis Gettman wrote Sections I and IV. Dr. Robert M. Gagné wrote Section II. Dr. Robert D. Tennyson wrote Section III.

SUMMARY

The Advanced Instructional Design Advisor is an R & D project being conducted by the Air Force Armstrong Laboratory in response to an Air Training Command (ATC) Manpower, Personnel, and Training Need calling for improved guidelines for authoring computer-based instruction (CBI) (MPTN 89-14T).

Aggravating the expensive and time-consuming process of CBI development is the lack of Air Force personnel who are well-trained in the areas of instructional technology and educational psychology. More often than not, a subject matter expert with little knowledge of CBI is given the task of designing and developing a computer-based course. Instructional strategies that work in a classroom are often inappropriate in a computer-based setting (e.g., leading questions work may work well in a classroom but are difficult to handle in a computer setting). Likewise, the computer offers the capability to present instruction in ways that are not possible in the classroom (e.g., computer simulations models can be used to enhance CBI).

The Advanced Instructional Design Advisor is a project aimed at providing subject matter experts who have no background in computer-based instructional systems with automated and intelligent assistance in the design and development of CBI. The goal is to reduce CBI development time while insuring that the instructional materials are effective.

I. INTRODUCTION (Gettman)

The Advanced Instructional Design Advisor is an R & D project aimed at providing automated and intelligent assistance to inexperienced instructional designers who have the task of designing and developing computer-based instruction (CBI). The particular problem being addressed by this line of research is the need for more cost efficient methodologies for the design and development of CBI. Current methods for developing CBI are expensive, time-consuming, and often result in ineffective instruction due to the general lack of expertise in computer-based instructional systems (Spector, 1990).

The Advanced Instructional Design Advisor project is divided into four phases:

Phase 1: Conceptualization & Functional Specifications

Phase 2: Conceptual Refinement & System Specifications

Phase 3: Prototype, Field Test, & Refinement

Phase 4: Technology Demonstration & System Validation

The first two phases have been performed by Task Order Contracts. The third phase is being accomplished via a Broad Agency Announcement (BAA). The fourth phase will be funded by a fully specified contract. The work reported herein concerns the first phase.

This volume presents two very different, yet complimentary views of design, development, and delivery (DDD) for an AIDA system. Gagné's Chapter II expresses the "what" of instructional design with less emphasis on the "how" of integration within an actual AIDA system. The primary focus of Tennyson's Chapter III is the "how" of implementing the DDD phase of an AIDA.

Gagné appropriately sets the stage with an excellent description of the essential variables involved with technical training. He follows with a discussion on the information required for training, the content of the learning desired (capabilities learned) and the integration of those capabilities. Tennyson further illuminates these requirements by overviewing the "main phases" of instructional system development (ISD). He describes four generations of ISD, with the fourth, a cognitive model, presented as most appropriate for an AIDA.

Gagné proceeds with his concept of an AIDA Executive and its requirements. The multi-dimensional nature of the executive function is described. In this conception, selection of

strategies is determined by requirements which are variations of the "characteristics" of the training environment (trainees, environment, task, and content). Tennyson compliments this theme with an in-depth description of the use of existing computer technology to handle the many possible interactions of the critical ISD variables and the variability in level of ISD sophistication that exists from one user to the next.

Gagné includes a discussion of specific examples of the stages of instructional communication such as, set-up, initial presentation, and practice. Instructional strategies and differences among them are discussed with potential strategies for each of the stages of instruction, for all capabilities.

Tennyson argues that AIDA should be based on strong cognitive theory (as opposed to behavioral psychology theory) for both the ISD content and the user interface. Both authors agree that AIDA should be easily used by novice instructional designers. Both also agree that the user should have some ISD experience in order to successfully use an AIDA.

Gagné provides an explanation of a sequential, four step process for selecting instructional strategies: 1) proper media selection, 2) integrative control, 3) learning capabilities classification, and 4) selection and ordering of proper strategies for each capability to be learned.

Tennyson provides a detailed description of how current computer technology could be used to evaluate an instructor's model of ISD and advise novice instructional designers how to proceed through a particular instructional development task. He provides an easy to follow description of an AIDA system framework by explaining how the intelligent tutorial system would be implemented, component by component.

Gagné's description of the concept of instructional design guidance in a computer-based environment and Tennyson's description of how such a concept might be implemented provide a fairly comprehensive view of the system requirements involved in an automated instructional design advisor.

Most of these requirements have been adopted in the design of an experimental AIDA. Merrill's transaction theory (see Volume 6 in this series) accounts for any deviations or variations from the requirements identified in the next two chapters.

II. AIDA -- CONCEPT OF OPERATION (Gagné)

General Assumptions

What is desired as an ultimate goal of AIDA is a computer-based system that advises inexperienced personnel who are engaged in designing technical training in the application of methods and procedures of instructional design. The AIDA system aims to make use of any and all available technological developments in computer and media delivery subsystems.

The operations to be described make the assumption that the instructional designers score at or above the 75th percentile on the Academic scale of ASVAB. They should also be experienced in categorizing job-tasks into learnable capabilities.

Information

The design of instruction for technical training requires information about (a) characteristics of the trainees who are to receive the training; (b) the setting or environment for the training to be designed; and (c) the nature of the task or job for which training is being given. These different kinds of information will influence the choice of instructional strategies (to be described later).

Trainees. A great variety of trainee characteristics can be assessed. Among others that may occur to the instructional designer are such personality characteristics as achievement motivation, locus of control, anxiety tolerance, and others of this general variety; current motivation to learn; spatial orientation ability; perseverance. In line with the work of Snow (Corno & Snow, 1986; Snow & Lohman, 1984), I assume that, except in cases of particular and unusual tasks, these personal characteristics of trainees need not be taken into account. The amount of difference any of them would make in the choice of instructional strategy is very small.

In contrast, some characteristics of trainees as learners are likely to make considerable difference in the choice of instructional strategies. Two of these are (1) Reading Ability, that is, ability to comprehend prose like that of the Reader's Digest; and (2) Reading Comprehension Test score, as measured by well-known standardized tests. Fortunately, these two abilities are captured by a single test score, such as the Word Knowledge subtest of ASVAB. Reading Ability in its first meaning is critical because the instruction being designed is going to be delivered largely by prose statements. The second meaning, Reading Comprehension Test score, is a measure that correlates highly with what may be called "learning aptitude". It therefore carries implications about the relative ease with which new ideas can be learned by the trainee, when they are presented in

connected discourse form. While a continuous range of Word Knowledge scores is available, the important distinction is assumed to be the dichotomy between good readers and poor readers, which I call Reader - Non-Reader. On this basis, reasonable choices of instructional strategy can be made.

Environment. The assumption is made that most instruction will be delivered to the individual trainee via a station containing a TV monitor, a sound delivery system, and a console of keys (or an alternate mechanism). It is assumed that provision will be made for trainees to interact with these components not only individually, but also in learning pairs, or perhaps by interconnected small groups. However, the delivery of some parts of instruction in an instructor-led class is not ruled out. The introductory portions of courses, and instruction designed to establish attitudes, are examples of instructional types for which instructor presentations may be most effective.

With respect to micro-instruction having specific and singular objectives, three parts of the learning environment need to be distinguished, because they require different sets of instructional strategies. The first is setup, the second is initial presentation of the material to be learned, while the third is the practice period. The setup period is to assure learner readiness. Initial presentation includes the display of the stimuli to be responded to by the trainee (such as an instrument panel, a technical order) and a set of directions that tell the learner what he is expected to do. This period of initial presentation ends at the point when the learner actually executes the targeted performance, initially.

The practice period provides a number of additional occasions in which the trainee carries out varied instances of the activities he has learned to do. This period is one which strengthens the learned capability, refines it, and endows it with elaborations. Provision is made in this period for the feedback which gives reinforcement to the learned capability. This may be done in an automatic fashion, or it may require the judgment of a teacher, or it may be provided by other trainees, when practice is done in pairs or teams.

In summary, the critical values for the learning environment, assuming that most learning takes place at an individual station, are (1) a setup period which sets the stage for learning, (2) initial presentation period, and (3) practice period. The first two of these can be accomplished by almost any medium of delivery, while the third requires a situation which can provide interactive feedback.

Task. In considering the range of activities involved in technical training, it is necessary to recognize as an initial caution, that some training is being given for tasks in which

there are serious consequences for error (for example, piloting an aircraft, disarming an explosive device, fire fighting). When such tasks occur, transfer of training to the job situation must be 100%. Such tasks require, during the practice period, practice on the actual equipment or on a simulator (Reiser & Gagné, 1983). Otherwise, task characteristics that have implications for instructional design pertain to the stimulus mode inherent to the task. Is the trainee learning to respond to (1) shapes, (2) spatial configurations, (3) objects or pictures of objects, (4) people, (5) information presented aurally, (6) information in printed form, or to some combination of these? These task characteristics will determine the stimulus mode in which major portions of instruction are presented, particularly during the period devoted to practice. For example, if the task is one which includes replacing a transformer in a larger assembly, the assembly and the transformer, or a suitable picture of them, will be required as displays during the period of practice.

Summary - Information. Table 1 presents a summary of the forms of information required in the planning of instruction for technical training.

<u>CLASS</u>	<u>CHARACTERISTICS</u>
TRAINEES	READER NON-READER
ENVIRONMENT	INDIVIDUAL STATION INSTRUCTOR-LED SETUP PERIOD INITIAL PRESENTATION PRACTICE PERIOD
TASK	SERIOUS ERROR CONSEQUENCES STIMULUS MODE SHAPES SPATIAL CONFIGURATION OBJECTS, PICTURES OF OBJECTS PEOPLE AURAL PRESENTATION PRINT PRESENTATION

TABLE 1: CLASSES OF INFORMATION FOR AIDA

The first column lists the kinds of information needed, while the second indicates the characteristics to be considered, and variations of them.

Content

What information is needed by AIDA to describe the "content" to be acquired by trainees in the technical training area? The entities that are learned are stored states called capabilities (sometimes, dispositions). Capabilities make possible different sorts of performances, as may be required by the task or job. For a number of reasons, both theoretical and practical, it is convenient to distinguish several types of capabilities, corresponding to different types of performance or learning outcomes (Gagné, 1985, p.67). The major distinctive types of capabilities are listed in Table 2, along with examples. Some alternate designations for these five types of capabilities are shown in parentheses.

<u>TYPE OF CAPABILITY</u>	<u>EXAMPLES OF PERFORMANCE</u>
INTELLECTUAL SKILL (PROCEDURAL KNOWLEDGE)	IDENTIFYING OF TRANSFORMER DEMONSTRATING A PROCEDURE FOR TESTING A TRANSFORMER
VERBAL INFORMATION (DECLARATIVE KNOWLEDGE)	(1)MATCHING A CAPACITOR WITH ITS NAME (2)STATING THE FUNCTION OF A TRANSFORMER
COGNITIVE STRATEGY (CONTROL PROCESS)	USING SPLIT-HALF TO CHECK MALFUNCTION IN ELECTRIC CIRCUIT
MOTOR SKILL	MAKING A FINE ADJUSTMENT OF A VOLUME KNOB
ATTITUDE	CHOOSING TO WEAR GLOVES IN POURING CAUSTIC LIQUID

TABLE 2
TYPES OF LEARNED CAPABILITIES, WITH EXAMPLES

The nature of content. If the five kinds of capabilities of Table 2 represent what is learned, what has become of "content"? The answer is, the conception of "content" is not useful. If what is referred to is the presentation made to the learner, it is evident that this is not the same as content to be learned. Communications to the learner such as "Notice the resistor in the top part of the diagram" are guidance for the learner, but they are not what is learned. Likewise, a verbal definition such as "the locus of points equidistant from a given point" is not desired as a statement to be learned; instead, the hoped-for learning is the capability of demonstrating the meaning of the concept "circle". It happens that there are a few instances of correspondence between "what is said to the learner" and "what is learned" such as the names of days of the week, or months of the year. But in general, the "content" of communications to the learner do not become "content" that is learned. What is learned are capabilities for performance.

The integrative control capability.

Besides the single capabilities listed in Table 2, another important capability is one that integrates them and controls their application to some unitary activity. This may be called an integrative control capability. For example, an airman who has responsibility for maintenance of a particular airborne radio set must have learned capabilities like the following: (1) verbal information, the names of the radio set and its components; (2) intellectual skills such as the measurement of resistance, the procedure for adjusting RF gain; (3) cognitive strategies for finding malfunctions; (4) an attitude of using safety precautions with high voltage circuits. Assuming all of these single capabilities have been well learned, they must still be integrated into a total purposive activity. Integrative control is provided by a "radio-functioning schema". This schema continues to remind the mechanic that maintaining the radio in working order requires using all of these capabilities in such a manner as to meet the goal. The schema that performs the function of integrative control consists of more than a single capability; it is an integrated complex of capabilities, organized around the central concept of the goal. In view of the purposive nature of activities to be engaged in by graduates of technical training courses, the schema that must be acquired may be categorized as an enterprise schema (Gagné & Merrill, in press). Summarizing, what needs to be learned by trainees in technical training are five kinds of capabilities (Table 2), and the capability of integrative control representing a productive goal, called an enterprise schema.

The AIDA Executive

The function of the executive is to identify instructional strategies and to categorize them so that they can be selected to

achieve the most effective learning. Selection will be determined by the requirements generated by variations in the characteristics of (a) trainees, (b) environment, (c) task, and (d) content (capabilities to be learned).

This becomes a multi-dimensional operation, however. Strategies for optimal learning differ with the stage of instruction being designed (see Table 1). What is presented to the learner, and how it is presented, obviously depends on whether the designer is making preparations for learning (setup), introducing the item to be learned and getting the learner to show what he has learned (initial presentation), or providing for feedback that will reinforce a performance (practice). Whatever is to be learned, the communications made to the learner go through a number of stages. These stages have been described as the nine events of instruction (Gagné, 1985, pp. 246-256; Gagné, Briggs, & Wager, 1988, 194-198). For present purposes, I will deal with the somewhat abbreviated set of stages already mentioned, and listed as factors of Environment in Table 1.

Stages of Instructional Communication

The following paragraphs describe stages of instruction that require different instructional strategies:

Stage A: Setup. The instructional events of this period include gaining learner attention, informing learners of the learning objectives, and stimulating recall of prior learning. The latter two purposes may in most cases be combined in the establishment of an enterprise schema that integrates previously learned knowledges and skills and communicates a scenario delineating the goal of the learning.

Stage B: Initial Presentation. This stage includes the instructional events of presenting the stimulus situation, providing guidance to learning, and eliciting an initial performance. Some of the most critical instructional strategies are brought to bear in this stage. Also, the differences in instructional strategies appropriate for different learned capabilities (Table 2) take on particular significance during this stage (Gagné, 1985, pp.246-256).

Stage C: Practice. During this stage, practice provides additional occasions for performance by the learner, in each case followed by informative feedback. Number of performances involved in practice may be few or many, depending on the capability. Performances may also be elicited after some designated time period (retention) and in some novel contexts (transfer). Also, some of the performances will provide the basis for evaluation.

Instructional Strategies

The factor that determines differences among selected instructional strategies is, above all, the type of capability being acquired (in the AIDA guidance material, called "content characteristics"). Strategies have to be identified for each kind of capability (Table 2, and also for an enterprise schema); strategies must also be selected for each of the stages A, B, and C of the instruction. The need for a matrix is seen, but it is a very complex one, requiring a large spatial array. The tactic adopted here is the following: Potential strategies will be listed and described for each of the stages of instruction, intended to cover any and all capabilities (Table 2 and enterprise schema). Then, in a following section, the selection of strategies will be described, for each kind of capability objective.

Possible strategies for Stage A.

The setting-up stage, Stage A, has the following strategy possibilities:

A1: Grabber. An event (statement, picture, demonstration) that commands attention by capturing the trainee's interest.

A2: Scenario. A verbal description, and demonstration, of what the learner will be able to do when learning is complete, and how that performance relates to the system or organizational goal. Importance of accomplishment of the goal is emphasized.

A3: Reminder. A verbal statement beginning "You remember that...", reminding the learner of previously acquired knowledge that is in the general area of the job (for example, measuring voltage is in the general area of "circuit testing"). The knowledge should be chosen to be as familiar as possible to the learner.

A4: Recall. Present examples of the concepts or procedures that are prerequisite (components) of the skill to be learned, each requiring the trainee to make a response.

Possible strategies for Stage B

The presentation stage, Stage B, has the following strategy possibilities:

B1: Statement. A verbal statement of a rule, procedure, principle, or definition (Merrill calls this a generality). "A triangle is a closed figure with three sides" is an example. "To increase resistance, decrease the diameter of the conducting wire" is another. Verbal statement may be accompanied by a picture or diagram, when clarity of comprehension is judged to be

aided thereby.

B2: Example. A particular instance of a concept or principle is described verbally, pictured, or both. "Figure XYZ (diagram) is not a triangle, because it is not a closed figure". The statement can be made so as to require a learner response.

B3: Label. Actual objects, pictures, or diagrams, are associated with labels that name them. The parts of a piece of equipment may each have a label; different knobs may be associated with such names as "volume, "frequency", "power", etc.

B4: Mnemonic. A sentence, meaningful phrase, or picture, to assist the verbatim memorization of a set of labels, or labels in a series. GSC45V can be remembered using the mnemonic "General service cart, Victory in '45".

B5: Discourse. A series of sentences that are logically and meaningfully connected. The discourse may be relatively short, as in "Small resistors have three colored bands", to quite long, as in a description of the connectedness of the parts in a complex electric circuit.

B6: Analogy. A verbal statement such as "_____ is like _____" presents the analogy. An example is "Constricting the flow of water in a pipe is like inserting a resistor in the conductor of electric current".

B7: Elaboration. Verbal discourse which relates a concept, rule, or set of ideas in a discourse to other things or events that are likely to be highly familiar and easily remembered. "Magnesium oxide is formed rapidly in a bright flash, whereas iron oxide (rust) forms slowly". A picture may be employed.

B8: Model's Choice. Presentation or description of a respected human model. After being identified, the model states and/or demonstrates a choice of personal action that reflects a targeted attitude. For example, an attractive male model chooses to be a "designated driver", refusing alcoholic drinks. An aircraft mechanic (model) refuses to "give up" until he is convinced that a replaced component works well.

B9: Question. A statement is presented that requires the trainee to respond by making a choice, completing a statement, or otherwise showing that something has been learned.

Possible strategies for Stage C.

The practice stage, Stage C, has the following strategy possibilities:

C1: Practice. Presentation of examples (of a concept or

rule), few or many, each one different in its characteristics, and each a previously unencountered instance requiring a learner response. Each learner response is given feedback with correction. Number of examples required depends on the complexity of the learning task, and is arrived at by judgment based on experience with similar tasks. Also, increased precision in motor skills is attained by increased practice.

C2: Assessment. Additional trials of practice, without accompanying feedback, are given to permit assessment of performance.

C3: Telling. The learner is asked to tell the gist, or main points, of a discourse that has been presented. This may be done by presenting partial cues, as in a test requiring the trainee to fill in the blanks.

C4: Transfer. The trainee is required to apply learned concepts or procedures to a novel problem, or in a novel situation. Example: applying the rules of trigonometry to the task of sailboat tacking. Evaluation may also be carried out with transfer trials.

Selecting Instructional Strategies

The selection of strategies for particular learning objectives (capabilities) requires consideration of characteristics of the trainees, the environment for training, and the nature of the task. Since these determinations are complex, I propose that they be done in sequence. The proposed sequence is described here in terms of steps to be taken by the instructional designer. Presumably, each step will be aided by an advisory communication from the AIDA advisor.

In the following, Step 3 asks the instructional designer to classify each capability listed in the job-task analysis which is to be included in the training. Two assumptions are made here, and I know of no simple way of avoiding them:

Assumption 1: A job-task description has been done, and is available to the instructional designer.

Assumption 2: The designer has had sufficient training and experience to be able to classify specific job-tasks in the categories of Table 2.

Step 4 indicates the instructional strategies applicable to each category of capability being learned, in the order for their employment. For example, when instruction is being designed to teach a Concept, the designer begins with A1: Grabber, then proceeds to A2: Scenario, to A3: Reminder, and so on, taking note

in each case of the advisory that is displayed.

Step 1. Choose Media

Readers: Provide pictures when judged to aid comprehension and recall.

Non-readers: Use pictures and diagrams whenever possible.
Use audio communications when possible.

Consequences of Error Serious: Use real equipment or simulator.

Step 2. Establish Integrative Control

Present the enterprise schema.

Describe, demonstrate, the purposive activity aimed for as a result of training.

Reminders of relevant concepts, previously learned.
Reminders of relevant rules and procedures, previously learned.

Reminders of relevant cognitive strategies, previously learned.

Reminders of suitable attitudes, previously acquired.

Note: If the relevant concepts, procedures, and attitudes have not been previously learned, design remedial training for them, as outlined in the following steps.

Step 3. For Each Enterprise, Classify the Single Capabilities To Be Learned

See job-task descriptions. See Table 2.
Reflecting the enterprise scenario, place the capabilities to be learned in a suitable order for learning.

Step 4. Select and Order Appropriate Instructional Strategies for Each Capability

In following the sequence of strategies for each capability, use an informal conversational style. Strive for a coherent, interactive set of communications with the trainee, helping to carry him from the setup stage (A) on to presentation (B) and into practice with feedback (C).

Concept (Identify).

A1 Grabber. Omit if considered unnecessary

- A2 Scenario. Include, unless enterprise schema is well recalled
- A3 Reminder. Include, unless Recall (A4) is necessary
- A4 Recall. Include to strengthen prerequisite learning
- B1 Statement. State, or demonstrate. Order can be B2,B1.
- B2 Example.
- B3 Label. Include if not already known
- B4 Mnemonic. Include for a set of concept labels, or a series.
- C1 Practice. Use variety in examples and non-examples
Use novel examples, not previously employed
- C2 Assessment.

Procedure

- A1 Grabber. Omit if considered unnecessary
- A2 Scenario. Include, unless enterprise schema is well recalled
- A3 Reminder. (Or A4)
- A4 Recall. Include unless A3 is sufficient
- B1 Statement. Describe or demonstrate
- B2 Example. Order can be B2,B1
- B4 Mnemonic. Include if necessary for recall of sequence
- B6 Analogy. Include if helpful for recall
- B7 Elaboration. Include if helpful for recall;
consider picture, diagram
- B9 Question.
- C1 Practice.
- C2 Assessment.

C4 Transfer. Use a novel problem, novel situation

Verbal Information (Label)

A4 Recall. Distinguish some other labels, previously learned

B2 Example.

B4 Mnemonic. Include if helpful for recall

B7 Elaboration. Include if helpful for recall.
Consider picture, diagram

B9 Question.

C1 Practice.

C2 Assessment.

C4 Transfer. Ask question in novel setting

Verbal Information (Discourse)

A1 Grabber. Include if necessary to arouse interest

A2 Scenario. Describe, demonstrate relationship of discourse to enterprise

A3 Reminder. Remind learner of larger meaningful context into which discourse fits

B5 Discourse. Use pictures for clarity, to aid recall

B6 Analogy. Include if helpful for recall

B7 Elaboration. Include if helpful for recall

B9 Question. Ask for recall of main idea

C3 Telling. Ask for another recall of the gist

C4 Transfer. Application of discourse in a novel situation

Cognitive Strategy (Control Process)

A1 Grabber. Include if necessary to arouse interest

A2 Scenario. Describe, demonstrate how cognitive strategy relates to job-task

- A3 Reminder. Remind about concepts and procedures involved in the activity to which the cognitive strategy obtains
- A4 Recall. Include unless A3 is sufficient
- B1 Statement. Describe or demonstrate
- B2 Example. Order can be B2,B1
- B6 Analogy. Use if appropriate
- B9 Question.
- C1 Practice.
- C2 Assessment.
- C4 Transfer. Use a new problem, new situation

Motor Skill

- A1 Grabber. Omit if considered unnecessary
- A2 Scenario. Include unless enterprise schema is well recalled
- A4. Recall. Ask for recall of prerequisite part-skills
- B1 Statement. Demonstrate the procedure involved in the motor skill
- B9 Question. Ask trainee to execute the procedure involved in the motor skill
- C1 Practice. Continue repeated trials until adequate precision is attained
- C2 Assessment.
- C4 Transfer. Ask for execution of skill in new setting

Attitude

- A1 Grabber. Emphasize attitudinal aspects of the enterprise
- A2 Scenario. Relate attitude to the enterprise
- A3 Reminder. Remind trainee of human model who is attractive, credible, powerful
Remind about concepts or procedures

involved in the action to be chosen

B7 Elaboration. Describe, demonstrate the situations in which the targeted choice behavior is usually made

B8 Model's Choice. Model describes, demonstrates the targeted choice of personal action
Display or describe the achievement and satisfaction of the model

B9 Question. In a described situation, ask trainee to make the appropriate choice of personal action

C1 Practice. Present additional situations for choice of personal action

C2 Assessment.

C4 Transfer. Present an unfamiliar situation calling for targeted choice of action

III. FRAMEWORK FOR AN ISD EXPERT SYSTEM (Tennyson)

Background

This chapter presents framework specifications for an instructional systems development (ISD) expert system. The goal of the proposed ISD expert system is to improve the means by which educators design, produce, and evaluate the instructional development process. In the past several decades, research and theory development in the fields of instructional technology and cognitive science has advanced the knowledge base for instructional design theory such that learning and thinking can be significantly improved by direct instructional intervention. Unfortunately, these advancements have increased the complexity of employing instructional design theory, making instructional development both costly and time consuming. I am proposing that through the application of expert system methods, it is now possible to develop an intelligent computer-based ISD expert system that will enable educators to employ instructional design theory for curricular and instructional development. Presented in this chapter is a framework for the development of an ISD expert system that will assist both experienced and inexperienced instructional developers in applying advanced instructional design theory.

Introduction

Advancements in cognitive psychology and instructional technology in the past three decades have aided in the building of a literature of instructional design theory that can provide educators with sophisticated means to improve learning in all levels and conditions of education and training (Tennyson, 1990d). However, with this theoretical growth in instructional design has come the problem of instructional developers (i.e., any educator producing teacher-independent instruction) learning how to apply the new knowledge.

In response to this growth in the field of instructional design theory and practice, universities have developed graduate programs to produce instructional design (ID) experts. Even at the masters' level, these graduate programs require at least two years of full-time study. Therefore, if the educational community is to employ this body of knowledge to improve learning, it must either (a) develop in-service training programs to teach instructional design theory and practice or (b) develop a means by which educators can employ the knowledge without necessarily having to become ID experts.

This rapid growth in the instructional design field has also occurred in hundreds of other technical fields. To help maintain high levels of sophistication and to bring into application the most advanced knowledge from their respective fields, many of

these other fields have employed expert system methods. An expert system is a computer-based representation of the domain-specific knowledge of an expert in a form that can be accessed by others for assistance in problem solving and decision making. An implication of this definition is that an inexperienced person can with the aid of an expert system perform tasks that would normally require the direct involvement of a domain-expert. Proposed in this chapter are framework specifications for the development of an expert system to help instructional developers (i.e., authors) use the most advanced knowledge in the field of instructional design theory when designing and producing curriculum and instruction.

Instructional Systems Development

The process of designing, producing, and evaluating instruction is referred to in the literature as instructional systems development (ISD). The main components of ISD include (a) analysis of the instructional (and/or curricular) problem/need, (b) design of specifications to solve the problem, (c) production of the instruction, (d) implementation of the instruction, and (e) maintenance of the instruction. Embedded in each component of ISD are specific types of evaluation to insure quality control (Tennyson, 1978).

There are in the current literature several examples of computer-based tools intended to improve the productivity of the ISD process. Hermanns (1990) describes Computer-Aided Analysis (CAA), a computer program which aids in job task analysis. Based on a hierarchically-organized list of job tasks entered by the instructional designer, CAA produces as output a set of preliminary terminal learning objectives that can be further reviewed and edited by the developer. Ranker and Doucet (1990) describe SOCRATES, which allows the user to fill in information that is used by SOCRATES to create an instructor's lesson outline including objectives, events of instruction, samples of student behavior and test questions. Perez and Seidel (1990) present an overview of their specifications for an automated training development environment that will be based on the Army Systems Approach to Training (SAT) model of instructional design. The main features of the environment are a set of tools for developing the components of instruction and an expert design guide for assisting the designer in using the tools. Merrill and Li (1990) propose ID Expert, a prototype rule-based expert system for instructional development that makes recommendations about content structure, course organization, and instructional transactions (tutor/student interactions) based on information supplied by the designer.

The systems just referred to differ greatly in function and scope and in the degrees to which each makes use of expert system methods to reduce the level of knowledge required of

instructional designers. This chapter proposes framework specifications for an ISD expert system that would employ intelligent interface techniques to allow even the most inexperienced author to immediately begin to develop quality instruction. Labeled ISD Expert, the proposed system would make expert knowledge about the most sophisticated ISD methods readily available to potential authors, thus minimizing or eliminating the need for formal instructional systems development training.

The ISD model proposed for ISD Expert (see Figure 1) was developed to reflect an application model rather than a teaching model. That is, most ISD models are based on learning ISD, thus they resemble a linear process that attempts to include all possible variables and conditions of ISD. The result is that they do not take into account any other ISD situations other than complete start to finish instructional development. The assumption is that in all ISD situations, ISD starts at the analysis phase and proceeds step-by-step to the final completion of the implementation phase. The proposed ISD model, in contrast, views the author's situation as the beginning point of any possible ISD activities. For ISD Expert, the proposed ISD model is an associative network of variables and conditions, that can be addressed at any point in instructional development depending on the given situation.

This chapter does not provide complete specifications for ISD Expert: instead, it provides a framework from which specifications can be designed and developed. The content of this chapter includes both the philosophy of the proposed ISD Expert and the framework specifications. Given the complexity of ISD and the effort necessary to develop an expert system, hopefully, this chapter will also serve as a means for extending the dialogue on the concept of automated ISD systems and tools (e.g., see Merrill, 1990).

Philosophy of AIDA

Expert systems are designed for domain experts to aid them in dealing with complex processes that are either time consuming or which they do not have specific experience (e.g., in a sub-domain). In practice, expert systems have been successful when the content is narrowly focused and when the situations have clear rules for decision making (Smith, 1984). Because of the range of experience and training in ISD among instructional developers, I am proposing an expert system that will be designed for authors who are content domain experts but not necessarily ISD domain experts. This is not a contradiction of previous expert system efforts, but a reflection of the fact that the user of ISD Expert will not be an ISD expert initially; rather, the proposed ISD Expert would take into account a range of expertise and experience in instructional design theory and practice.

To accomplish this goal, I am further proposing an expert system that would employ intelligent human-computer interface techniques. The intelligent ISD Expert would operate at two basic levels: First, a coaching expert that would direct inexperienced authors through the acquisition of ISD skills while helping them deal with their specific situation; and, second, an advising expert that would assist experienced authors by making recommendations for their specific situation. For example, for an inexperienced author, the coaching function would deal with basic ISD skills and direct the development effort. In contrast, ISD Expert would function as an advisor to an experienced author, making recommendations while the author controlled the actual ISD decision making. In this environment, both inexperienced and experienced authors will be exposed to opportunities to increase their individual expertise through a process of learning ISD while using the system (Schiele & Green, 1990).

The importance of the distinction between the coaching and advisement functions is based on a review of research findings in expert systems. An example from this body of research is Clancey's (1979; 1983) work with MYCIN, a medical diagnosis consultant program, and GUIDON, a tutorial program designed to make use of MYCIN's rule base for teaching purposes. Clancey found that the rules encoded in MYCIN were inadequate for teaching because the knowledge required for justifying a rule and explaining an approach was lacking. He found it necessary to add additional components to GUIDON to help organize and explain the rules (Clancey, 1989). In a similar fashion, ISD Expert will have the ability to support and explain its recommendations and prescriptions in the language of ISD, not merely by enumerating the rules applied to make a recommendation. An example of one approach to providing this ability can be found in Swartout (1983). Swartout combined declarative and procedural knowledge, in the form of domain principles, to create the knowledge base for XPLAIN, a drug prescription consultant which provides detailed justification of its prescriptions.

Although ISD Expert can not be considered a means for teaching ISD, the very nature of the system's philosophy which assumes that authors will gain knowledge with experience, will result in continuing improvements in ISD applications. That is, as authors gain experience in ISD, the system would exhibit the characteristics of a conventional expert system. Therefore, it should increase the efficiency of instructional development and help in those areas where even experienced ISD authors initially lack specific expertise.

ISD Expert intelligent author-computer interface

ISD Expert, as proposed, would operate as an expert system employing intelligent author-computer interface (ACI) methods between the author and the system (Anderson, 1988). The ISD

Expert intelligent ACI model (see Figure 3) would consist of four modules: the author's model of instruction, an ISD tutor (with both coach and advisor capabilities), an ISD knowledge base, and an instructional content knowledge base. Both knowledge bases would have knowledge acquisition capabilities. The ISD Expert tutor would be responsible for the interface between the individual authors and specific activities associated with developing their respective instructional needs.

ISD Expert system

In addition to the intelligent ACI component, the ISD Expert system would have three functions (see Figure 2). The first function would be to aid in the diagnosis of a given author's situation. This diagnostic function would evaluate the current situational condition(s) of the author (e.g., does the author want to prepare a computer-based graphic program for use in a lecture; does the author want to design a new course?). Following the situational evaluation, the second function would recommend prescription(s) along the lines associated with the level of author experience. That is, instead of trying to force all situations into a single solution, the prescription(s) would be individualized, based on situational differences and ISD experiences of the author. And with the third function, ISD Expert, through the system's tutor, would help the authors in accomplishing the prescriptions. As authors become increasingly more sophisticated in using ISD Expert, they will be ready to accept increasingly more advanced variables and conditions of instructional design theory and practice.

ISD model

The proposed content for ISD Expert is the fourth generation ISD model (Tennyson & Christensen, in press). This ISD model is designed to adjust to future growth in instructional design theory and therefore does not become obsolete as new advancements are made, unlike earlier models. Figure 1 presents an illustration of the fourth generation ISD model. Briefly, the four generations of ISD models can be described as follows:

-First generation (ISD 1, Figure 1, Appendix A). The main focus of the first generation model was the implementation of the behavioral paradigm of learning (Glaser, 1966). The system consisted of four components: objectives, pretest, instruction, and posttest. The system was completed with an evaluation loop for purposes of revision.

-Second generation (ISD 2, Figure 2, Appendix A). Advancements in instructional technology led to the need to increase the variables and conditions of the ISD model. The second generation adopted systems theory to control and

manage the increasingly complex ISD process (Branson et al., 1976). The behavioral learning paradigm remained, but was of secondary importance to the focus of the system: developing instruction.

-Third generation (ISD 3, Figure 3, Appendix A). In practice, the ISD process was too linear and did not account for situational differences among applications (Tennyson, 1977). To account for situational differences, the external control of the system (i.e., the boxes and arrows) gave way to phases of ISD, that could be manipulated in any order by the instructional designer. This model assumed that ISD was an iterative process that could be entered at any point depending on the current state of the author's situation (Allen, 1986). Learning theory was still considered behavioral but cognitive theory was making some appearances (e.g., use of simulations for acquisition of cognitive skills in decision making).

-Fourth generation (ISD 4, see Figure 1). Advancements in cognitive psychology have made major changes in many of the ISD variables (e.g., content analysis, objectives, measurement, instructional strategies), making the ISD model yet more complex (see Tennyson, 1990a,b; Tennyson & Rasch, 1990) technological developments from the field of artificial intelligence, the fourth generation model handles the complexity of ISD with a diagnostic/prescriptive system. Extending from the second and third generations, the ISD 4 model provides the knowledge base for the proposed ISD Expert system.

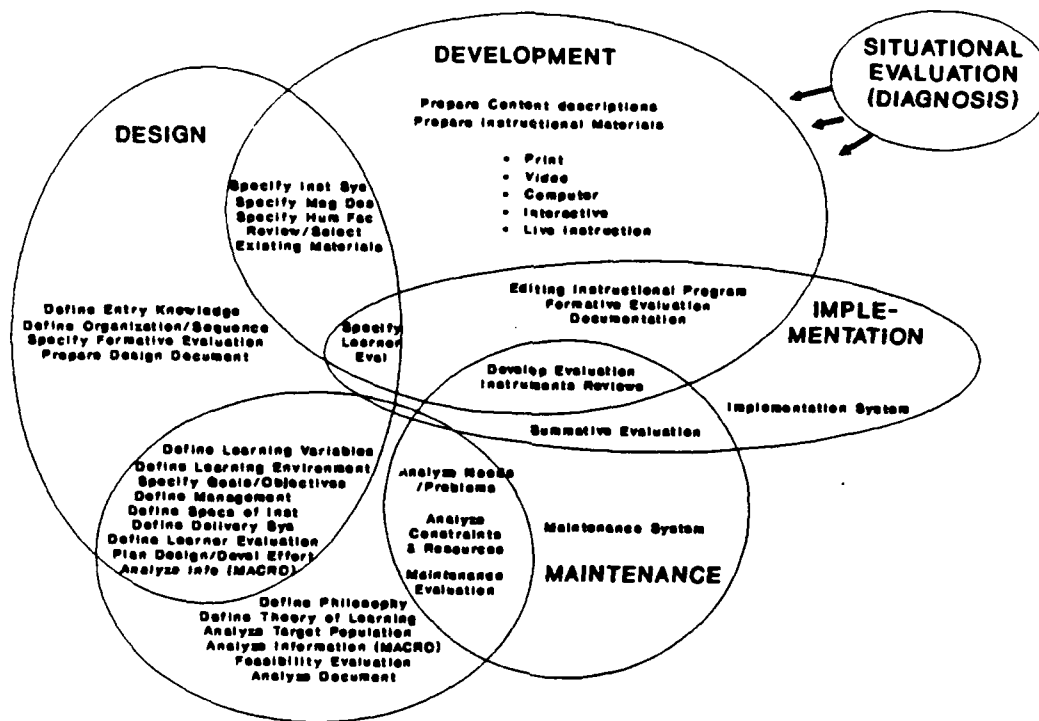


FIGURE 1. 4th GENERATION ISD MODEL

Cognitive theory

With growth of research and theory in cognitive psychology (Bonner, 1988), ISD Expert will exhibit a strong cognitive learning theory basis in both its ISD content and its approach to author-computer interaction. Early ISD models had a strong behavioral paradigm as their learning theory foundation (e.g., the first generation ISD model). The instructional strategies embedded in the first generation ISD models followed closely the behavioral paradigm of small incremental steps with emphasis on reinforcement of correct responses. For example, a task analysis in the ISD 1 paradigm favored a sequential approach that included student exposure to all possible attributes in a domain of information. For the most part, situational context and higher order cognitive knowledge and strategies were not considered because they did not fit the behavioral paradigm that dealt only with temporal content and observable performances (Brown, Collins, & Duguid, 1989).

In many other aspects of instructional development, the first generation ISD models also incorporated the behavioral paradigm, especially in the evaluation of learners. The focus of learner evaluation was on attainment of performance objectives that were isolated from meaningful applications or situations. By the 1970s, however, the ISD models exhibited more characteristics of systems models, the result being a separation of ISD procedures from a given learning theory paradigm. This growth in the "systems" of ISD was referred to above as the

second generation ISD model.

Although the learning theory foundation of the ISD 2 models remained basically behavioral, the inflexibility of the flow-chart nature of the models limited their utility. In response to this inflexibility, the ISD 3 models actually proposed the elimination of the linearity of ISD by including phases of development that could be manipulated according to the unique conditions of given situations. The third generation ISD model identified phases of ISD that included direct links to specific forms of evaluation (see Figure 3, Appendix A), and therefore allowed user control of the procedures based on situational need. The third generation focused on an increased emphasis on evaluation without basic changes in the learning theory foundation, although the flexibility of the model made it possible to include the growing literature in cognitive psychology.

By the end of the 1980s, there had been sufficient empirical and theoretical work in cognitive psychology and instructional technology to once again see the possible effects of learning theory on ISD (Glaser & Bassok, 1990). The effects can be seen in such things as the importance of macro (i.e., curricular) level activities in ISD, contextual analysis of the information to be learned, evaluation of the learners, employment of interactive media, instructional strategies for higher order thinking, employment of structured and discovery instructional methods, effect of the affective domain on the cognitive, influences of group interactions on learning, and context and situational variables on knowledge acquisition (Tennyson, 1990b). The result has been the development of fourth generation ISD models that resemble a schematic structure (see Figure 1) and have a cognitive learning paradigm foundation for the various procedures of instructional development. As stated earlier, Tennyson and Christensen's (in press) fourth generation ISD model is proposed for the knowledge base for ISD Expert.

Along with a cognitive learning foundation for the ISD content, I am proposing that the human-computer interface of ISD Expert exhibit a cognitive approach as opposed to a behavioral one. The contrast between the two approaches is the assumption made in regard to the interaction between the author and ISD Expert. In a behavioral approach the interaction between the author and the ISD expert system would be made at a reductionist level, that is, small incremental steps in linear sequence of instructional development in which the author is simply, and constantly, filling in requests for information without understanding the individual ISD tasks in relationship to the given situation. This is a common approach employed in expert systems for novices where the task is relatively concrete and the user is simply filling in information. However, it must be assumed that the ISD task is complex and requires an author who

can intelligently use the system more productively as he/she gains experience. Therefore, a cognitive approach assumes, even initially, that the author can connect the individual ISD tasks with his/her given situation.

To summarize, a cognitive psychology implication for ISD Expert is an expert system that assumes that the author can from the start function in the role as an instructional designer. This implies that even at an initial level of ISD, the author will have a real instructional problem/need and that he/she will be able to solve the situation with the prescription(s) offered by the ISD Expert system. And, as the author becomes more experienced with ISD Expert, he/she will be able to make increasingly sophisticated use of the system. ISD is a complex process, but the complexity is in part due to the given situation. Thus, for the initial, inexperienced author, the potential employment of ISD Expert will focus on noncomplex situations, but with the author feeling that he/she is participating in real ISD decision making.

This approach to the author should limit training for ISD Expert to a set of basic software functions and activities. Instead of viewing training on ISD Expert in the conventional linear fashion where the author works through a set of meaningless practice situations, the training will be embedded in the initial individualized ISD situation. For example, if the author wants to develop a test, his/her initial entry into ISD Expert will deal with test construction. In other words, training and gaining experience will be driven by the individual author's situation. Rather than a two year graduate program as prerequisite to being an instructional designer, the author will be an instructional designer with ISD Expert beginning with his/her first time situation. Because ISD is a complex environment and the needs of individual authors will vary at any given time, over an extended period of time, the individual authors will acquire more ISD knowledge as situational needs occur.

Computer technology

Because ISD Expert is intended to improve the performance of instructional designers, rather than to advance the state of the art in expert systems techniques and methods, it is most productive to make use of existing, standard computer hardware and software architecture whenever possible in the development of ISD Expert.

Certain restraints are imposed on the hardware and software choices by the requirements of the environment in which ISD Expert will most often be applied. These requirements are summarized as follows:

- Support for several simultaneous authors at both local and remote sites;
- Large data storage capacity for knowledge bases and programs;
- Sophisticated graphics capability
- Provision for incorporating special-purpose programs (for example, to support research projects) into ISD Expert on an ad hoc basis;
- Employment of interactive media.

Where hardware is concerned, a basic decision is whether to implement ISD Expert on a central mainframe or minicomputer, or on microcomputers. Simons (1985) and Harmon, Maus, and Morrissey (1988) address the expanding role of the microcomputer in AI development, citing growing hardware capacity, wider availability of sophisticated software tools and increasing user familiarity with microcomputers as the forces contributing to the growth in expert system development for microcomputers.

I am proposing that ISD Expert be implemented in a network of PC's connected to a central network and file server with one or more large-capacity (perhaps 300 megabytes) hard disk drives for program and knowledge base storage. While there are a number of physical network topologies that could be used to implement ISD Expert, Figure 4 represents the general concept. There are some tradeoffs involved in using this configuration as contrasted with a network of "dumb" terminals connected to a single, central mainframe and data storage. For example, transmitting large quantities of data to/from the central file server to the PC's does require system overhead. However, the advantages outweigh the drawbacks. Given the local processing power of PC's, the intelligence of the system will be distributed throughout the system, minimizing the demands on the central unit. There is a large and growing quantity of AI software available for microcomputers at relatively low prices in contrast to mainframes. PC graphics are superior to all but the most sophisticated and expensive mainframe graphics systems.

The software used to create ISD Expert must provide an open architecture. That is, it must be practical to write local programs for special purpose functions (e.g., as research projects) and link them into the standard software with a minimum of effort. Also, the knowledge bases must be accessible to local programs as well as to the standard software. Expert system development is done either by using expert systems shells, which are commercially-available skeleton systems that can be instantiated with the specific domain knowledge required for an application, or by writing the expert system from scratch in a

general or special purpose programming language. Harmon et al. (1988) report that of 115 expert systems surveyed by them in actual use in the United States in 1986, 92 were produced using shells while 23 were written using programming languages (chiefly LISP).

Proposed is that ISD Expert be implemented using commercially-available expert system shells. However, in view of the fact that ISD Expert must also support customization, the shells that are chosen must support what are termed "own-code exits" to facilitate the linking in of custom programs. These custom programs must be written in a high-level computer language, preferably one with extensive AI features (e.g., LISP; PROLOG).

Summary

To establish a framework for ISD Expert, it is important to clearly specify the philosophy of the system (Morgan, 1989). A well specified philosophy will help keep the system under control during development and later when doing revisions. Proposed in this section is that ISD Expert have a foundation in cognitive psychology (Newell & Card, 1985). And, that this foundation specifies for the system both the content and the author-computer interface (Norman, 1986). Specific areas of the proposed philosophy are as follows:

- An expert system that has both diagnostic and prescriptive functions
- An expert system that will serve experienced and inexperienced authors
- An intelligent ACI system with both advising and coaching capabilities
- Knowledge base content will employ the fourth generation ISD model
- Employment of interactive media
- Cognitive learning theory as the foundation of the ISD procedures
- Cognitive paradigm approach to ACI
- Entry to system based on individual author situation
- Training as a concurrent activity with ISD activities
- A computer-based network system with remote capabilities

- Software tools that provide an open architecture
- Employment of a high-level language (e.g., an AI language)
- Commercial shells that include access to own-code programs
- Data dictionaries for knowledge acquisition components

The above discussion on a proposed philosophy for ISD Expert provides the foundation for the following section on framework specifications. The next section presents a basic framework for ISD Expert.

ISD Expert: System Framework

The purpose of this section is to propose framework specifications employing the above described philosophy of an expert system for instructional systems development. Because of the range in authors knowledge of ISD, I am proposing that ISD Expert be designed according to the methodology of intelligent human-computer interface systems. That is, rather than either attempting to teach ISD to the author or to develop a system around one linear approach that restricts and narrows the richness of ISD, my proposal is the design of a system that begins with the individual author's given situation. In this proposal, the intelligent ACI method will be concerned with improving both the authors application of ISD and their own models of instruction. As such, it will employ coaching and advising methods of human-computer interaction.

Furthermore, the proposed system will encourage the growth of the authors knowledge of ISD, but with the complexity of ISD being transparent. The purpose of ISD Expert will be to diagnosis the given situation of the author and then prescribe recommendations for dealing with his/her individual situation. It is assumed that each author will present a different situation and, therefore, will require a unique prescription. To accomplish this goal, the employment of heuristics is proposed for programming ISD Expert (see Bonnet, Haton, & Truong-Ngoc, 1988; Waterman, 1986). Two important features of the heuristic method, as contrasted, for example, with production rules, are (a) the flexibility needed to implement prescriptions in conditions of uncertainty or novelty (i.e., prescriptions are established in real time by integrating best available information from the system's knowledge base) and (b) the elimination of the need for an exhaustive reduction of ISD content knowledge to production rules.

One of the serious problems in expert systems design for nonstatistical areas has been the attempt to reduce complex and

abstract concepts to production rules (e.g., Merrill's ID Expert, 1986). Even though I am proposing the use of a network and file server (with large capacity disk storage) system for the operation of ISD Expert, it is the programming time involved in trying to apply the reductionist approach to an environment as complex as ISD that rules out the exclusive use of the production rules programming methodology. The software architecture of ISD Expert must be open to allow for future extensions. The production rule method is not suitable for this type of complex situation (Clancey, 1983). So much of the ISD process is context bound; therefore, the system must be adaptable, allowing for prescriptions to be finalized by the author.

Proposed for ISD Expert is an expert system with four main components: an intelligent author-computer interface component, a diagnosis function component, a prescriptive function component, and an instructional production guide component (Figure 2). The intelligent ACI component will be the means by which authors will interact with ISD Expert. Rather than use a menu driven system, I am proposing a tutorial interaction between the author and ISD Expert. The diagnostic component will function as the evaluator of each author's situation and provide an evaluation report (Guba & Lincoln, 1986). This report will serve as the guidelines in preparing the prescription. Additionally, the prescription will be based on the author's ISD model as well as the diagnostic report. The fourth component will provide the author with assistance in the production of materials from the prescription(s). The level of assistance will again be influenced by the author's ISD model.

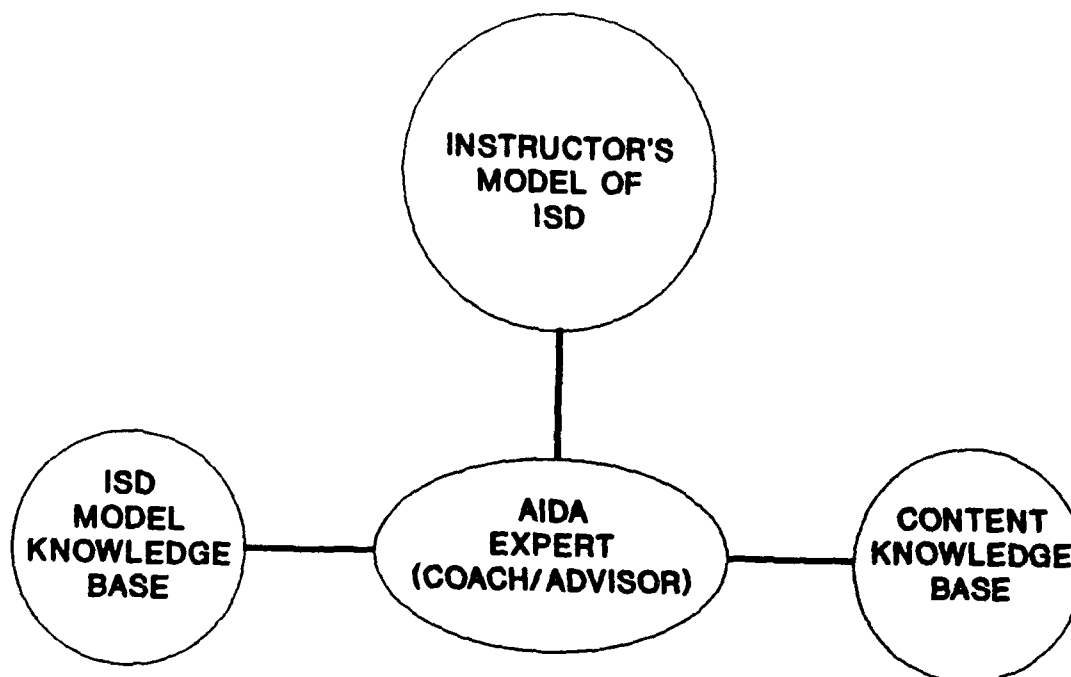


FIGURE 2. AIDA INTELLIGENT TUTORIAL MODEL

Intelligent Author-Computer Interface Component

The intelligent ACI component for the ISD Expert is illustrated in Figure 3. The main modules are as follows: (a) an author's model of ISD; (b) the ISD tutor; (c) the ISD knowledge base model; and (d) the content knowledge base. I will now discuss the role of each component of the ISD Expert tutor.

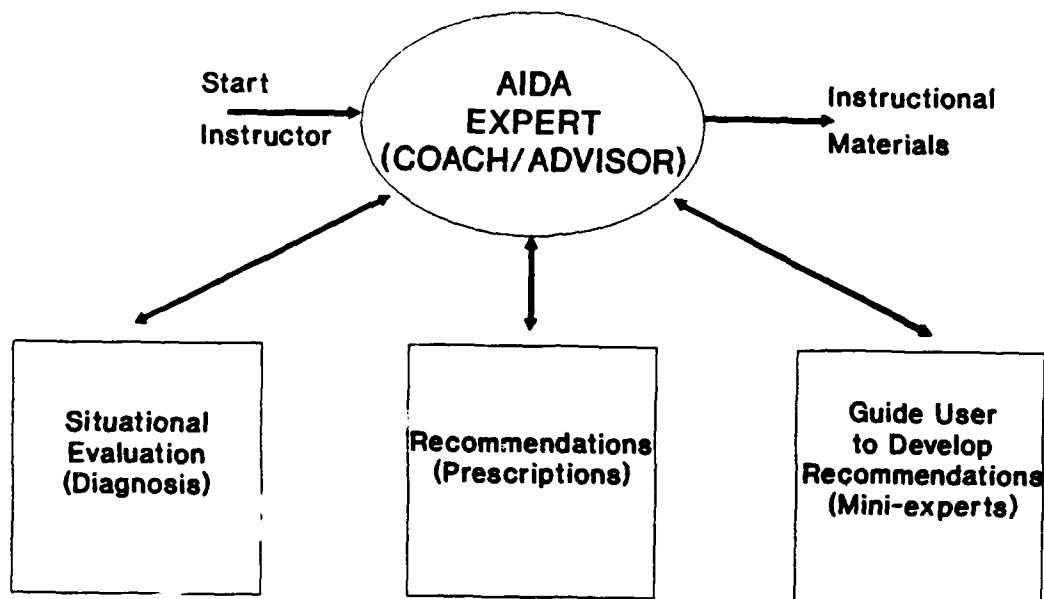


Figure 3. AIDA Expert System Components

Author's model of ISD

The purpose of this module is twofold: (a) to establish the level of ISD expertise of the author and (b) to help the author improve his/her own model of instruction. This is necessary because no formal attempt is to be made to directly train the authors in ISD. The individual author's model will be updated with each use of the system. This profile of the author will help the system in its prescriptive recommendations. For example, experienced authors will have a narrow and limited knowledge of ISD and, also, of the ways in which their instruction could be improved; thus, prescriptions would be at

their level of understanding. On the other hand, more experienced authors would be able to use more advanced prescriptions. It is important to keep the ISD prescriptions at the level of the author's experience and also to provide an opportunity for creativity and the possible use of different ideas generating from the author (Russell, Moran, & Jordan, 1988). A key feature of the proposed ISD Expert is the power of the author to disagree with a given prescription and still to be able to continue with the ISD process.

ISD tutor

Intelligent HCI systems work on the premise that a meaningful dialogue must be established between the user and the system. An important feature of the dialogue is the mixed initiative, where the user has an opportunity to query the system as well as being controlled by the direction of the system. The ISD Expert tutor will approach the diagnostic function from the context (situation) of the author. Personalizing the diagnostic activity will provide the opportunity for the tutor to search the content knowledge base to include specific references in the prescription to available existing materials and resources.

Because of the range of knowledge and experience in ISD of potential authors, two basic modes of interface are proposed. At one extreme will be authors who are completely inexperienced in ISD. For these individuals, a coaching mode is proposed. The coaching mode is a well established method of instruction used in intelligent computer-assisted instruction (ICAI). This mode assumes that the author will need direct and controlled assistance in dealing with his/her given situation. The function of the tutor as coach is to approach the ISD activity in a disciplined way while helping the author develop ISD skills. Prescriptions for the situation are specific and the coach is responsible for the decision making. In contrast is the advising interface. For the experienced author, the tutor as advisor would offer alternative prescriptions, with the final decision(s) in the hands of the author.

The tutor, as part of the intelligent ACI component, is the point of contact between the author and the other ISD Expert components (see Figure 2). In the proposed design, the tutor gathers information about the author's specific situation and, by interaction with the Situational Evaluation component, prepares a report of the given problem/need. This evaluation report is sent to the Recommendations component where a prescription(s) is prepared. When the prescription(s) is prepared, the tutor presents it to the author; at that point, depending on the mode of the tutorial interaction (i.e., coaching or advising), there may occur a dialogue between the author and the tutor to finalize the prescription. Once a final prescription is prepared, the tutor interacts with the ISD model knowledge base to set up the

authoring activities. The tutor also assists the author in certain aspects of materials production through the fourth component of the ISD Expert system. Updating of the author's model will be the continuing role of the tutor in ISD Expert.

ISD model knowledge base

The content knowledge of ISD Expert will reside in the ISD model knowledge base (KB) (see Figure 1). Once the prescription(s) is decided upon, the necessary authoring activities are compiled by the tutor from the ISD model knowledge base and presented to the author. (Authoring activities of the knowledge base are presented in Appendix B.) Information within this KB will be stored as structured data files, organized as an associative network. The purpose here is to efficiently locate information without the restrictions of rigid production rules. That is, the ISD model knowledge base should exhibit the heuristic search characteristics of an information retrieval system.

Content knowledge base

The fourth module of the proposed intelligent ACI system for ISD Expert, the content knowledge base, is a source from which curricular and instructional materials resources may be obtained. These materials may be included in the implementation of prescriptions developed by ISD Expert or they may stand alone. For example, if an author wants a simulation for a given lecture, he/she could query the content knowledge base to see what might be available. In another situation, ISD Expert may develop a prescription and obtain the necessary materials from the content knowledge base without the author explicitly requesting the action. Access to the content knowledge base may be either by direct author query via the tutor or indirectly as a result of the implementation of prescriptions.

The content knowledge base will help eliminate duplication of effort in instructional development by providing a catalog of available materials. Information in the content knowledge base would come from two sources. Material that is developed on ISD Expert as a result of instructional development can be added to the content knowledge base. Material may also be input from sources external to ISD Expert. For example, many materials and resources that are developed in R & D efforts independently of ISD would be useful in course applications if authors had access to them. General information manuals and other media-based resources (e.g., video disk materials) are another example of materials from external.

Situational Evaluation Component

The first activity in the proposed ISD Expert system is

the evaluation of the given author's situation. The assumption is that each author will have a different need or problem, depending on his/her given situation. As the ISD Expert tutor establishes the author's model of instruction (see Figure 3), the Situational Evaluation Component will diagnosis the situation employing AI techniques. Again, it is assumed that the tutor will determine the experience level of the author and in turn adjust the report of the evaluation. For example, if the tutor determines that the author is experienced in ISD, and the situation is to develop a lesson on trouble shooting, the report would indicate those two conditions, which would influence the type of prescription(s) recommended. By focusing on the given situation, ISD Expert can employ the complexity and richness of the fourth generation ISD model without directly training the author about the entire model.

Recommendations Component

The purpose of ISD Expert is to help authors improve their instructional product development by applying the most advanced variables and conditions of instructional design theory. This is made possible by the recommendations component, which interacts with the ISD knowledge base to interpret the situational evaluation diagnosis and recommend a prescription to deal with the given instructional situation. Also, the prescription is adjusted to the author's level of experience. This is an important feature of the proposed ISD Expert because it prescribes an effort of development that can be efficiently accomplished by the author. For example, if an inexperienced author is presented with a prescription that would fit an experienced author's profile, the novice author would not be able to adequately follow the production activities (Component 4). The result would be that the prescription is implemented inefficiently or not at all. Presentation of the prescription will likewise be based on the experience of the author. The experience level of the author will determine the program control (i.e., coaching or advisement) employed in the production component.

Production Component

The term production is used here to reflect a variety of different types of instructional situations that might occur. ISD includes, in addition to instructional development, test development, computer-based management development, print materials development, instructional aids, visual aids, etc. The function of this component is to guide the author in the production process. As such, this part of the expert system directly interacts with the tutor. Because of the range of ISD activities, this component would be composed of mini-experts, each reflecting a different authoring activity (see Appendix B).

That is, the mini-experts would be the various activities within the ISD model. For example, if the situation is to develop a test for trouble shooting, the author's model indicates an experienced author, and the prescription recommends a simulation, a mini-expert on design of simulations within component 4 would guide the author in the production of an appropriate simulation. An important feature of ISD Expert will be to facilitate the employment of knowledge iterative technology for instructional delivery. For example, for computer-based instruction, this component would directly produce the courseware (Tennyson, 1990c).

Once the production effort is completed, component 4 would send a report back to the tutor to update the author's model and to reference the effort in the content knowledge base. To further improve the efficiency of ISD Expert, instructional strategy (IS) shells will be accessible by the mini-experts to do the actual product development: IS shells would only require that the author enter into the system content information and the system would develop the product.

The above four components of the proposed ISD Expert system would be designed and programmed as independent expert systems so as to allow for future additions and elaborations. This is necessary because of the continuing growth in the instructional design theory field. That is, most expert systems are designed for specific, contemporary applications; when changes occur, a new expert system is designed and implemented.

Central Network System

In this section, I propose for the computer-based environment a configuration for a centrally-based network and file server for both local and remote PC workstations. Because of the proposal for a content knowledge base (see Figure 3) with acquisition capabilities and an author's instructional model within ISD Expert, a large capacity disk storage should be an integral part of the system. Also, given the computing power of PCs, much of the intelligent interfacing would take place at the workstation.

Although there are a large number of commercially-available shells for program development (e.g., HYPERcard), most do not allow for "own-code" exits. With such software, the development effort becomes constrained by the closed architecture of the given shell; the shell becomes a methodology in itself rather than a tool to be used in implementing multiple methodologies. I am proposing that ISD Expert be programmed in a high-level language with artificial intelligence features, but that commercially-available shells be used when feasible to augment the system features.

Development Plan

The framework specifications presented in this chapter offer a complete expert system for automating instructional development. To produce such a system, there are two possible approaches. The first would be to develop the ISD Expert system as presented. The second would be to follow an incremental approach in which an initial prototype is developed that only has a minimal set of features and is aimed at an experienced author. That is, an ISD Expert that would only have an advisor level tutor and the situational evaluation and recommendations components. The content knowledge base and acquisition features of the intelligent interface tutor and the production component would be added in subsequent elaborations.

Although the first approach seems possible, there are a number of problems that need to be considered that might favor the second approach. An initial problem is the cost factor. As stated earlier the majority of expert systems are developed using commercial shells. Cost in terms of software is the time required to produce a product that will be timely and profitable. That is, the proposed ISD Expert would most likely be a software product that would need to generate income within a reasonable timeframe. Rapid prototyping is a procedure to develop software employing shells that are linked by some general language (Hewett, 1989). Thus, instead of five years to produce a complete version of ISD Expert, an initial prototype could be developed in much less time.

A second major problem in producing a complete ISD Expert in the first approach is the necessary research needed for the new system. There has been minimal empirical research to date on instructional variables and conditions associated with the extension of cognitive learning theory to instructional design theory. Even though it is possible to develop an initial prototype, research in cognitive instructional design theory needs to be done as well as the interaction of media within this theoretical framework. A third problem area relates to the specification of the human-computer interaction variables and conditions necessary to run and manage the complex environment of ISD Expert.

Within the constraints defined above for approach one, I recommend the following incremental approach to ISD Expert development.

1. Framework specifications. This step conceptualizes the idea or vision of the expert system. This chapter serves as an example of the first activity in producing an automated instructional development system.
2. Functional specifications. From the initial outline of the basic system, the specific functions provided by the system need to be defined. From this step a rapid prototype can be developed

as follows:

- Write functional specifications;
 - Summarize what is known/not known about the functions;
 - Estimate the complexity of the functions;
 - Based on the summary and estimates, group the functions into ISD Expert 1 (i.e., a prototype), and then prioritize the functions for successive implementations for versions ISD Expert 2, ISD Expert 3, etc. Each version would add layers of functions and increased use of a high-level computer language.
3. Logical design. Starting with the prototype, define the logical components that provide the specified functions.
 4. Physical design. Define the software modules which implement the logical design of the system.
 5. Programming. With the prototype, rapid software development is recommended while with the successive versions, the software procedures defined in this chapter would be followed.
 6. Testing. Once the prototype is developed, it should be tested following standard computer software benchmark criteria.
 7. Implementation. Complete the remaining tasks to implement ISD Expert while simultaneously accumulating the experience and research findings needed to produce ISD Expert 2.
 8. Incremental development. Basically starting with number 3 above, iteratively build ISD Expert towards a system that includes all of the functions defined in numbers one and two.

Cycling through an incremental approach to development of ISD Expert would produce an initial product for employment and research within the constraints of costs and system knowledge. The initial prototype (or ISD Expert1) would exhibit many standard characteristics of the third generation ISD model (see Figure 3 Appendix A) with successive versions taking on more of the ideas associated with the fourth generation ISD model (see Figure 1).

Summary

The purpose of ISD Expert is to improve learning by aiding authors in the employment of contemporary instructional design theory. This chapter presents framework specifications for an expert system to implement the concept of ISD Expert. Because of the experience range of authors for ISD Expert in terms of instructional design theory and practice, I am proposing an expert system that employs an intelligent human-computer interface system. That is, ISD Expert will interact with authors

on an individual basis according to their respective experience with principles and variables of instructional design theory. ISD Expert will dialogue with authors along a continuum of decision control ranging from system control (coaching function) to complete author control (advising function). Inexperienced authors will be coached to develop basic ISD skills while the more experienced authors will be advised on the employment of advanced instructional design variables and conditions.

An author's instructional design model is a necessary module for an intelligent human-computer interface component because it replaces the need for a separate training program for authors. The sophistication of ISD Expert's prescriptions will be directly influenced by the author's instructional design model. Therefore, both ISD novices and experts will be able immediately to use ISD Expert. That is, the proposed system would take into account experience in instructional design theory and practice.

Proposed for the ISD knowledge base is the fourth generation ISD model (see Figure 1). The initial set of authoring activities for the ISD knowledge base is presented in Appendix B. The content knowledge base is proposed as a data base for instructional materials within subject matter areas. Both knowledge bases will have acquisition capabilities.

The basic proposed ISD Expert system will have four interactive components: (a) an intelligent author-computer interface component; (b) a situational evaluation component (diagnosis), (c) a recommendations component (prescriptions), and (d) a production component. Proposed is that ISD Expert be designed for a computer-based network system using a high level AI type language and expert system shells. The system will also employ a large capacity disk storage for the two knowledge bases (i.e., ISD model and instructional content and materials); both knowledge bases will employ acquisition capabilities.

To implement the concept of the fourth generation ISD model, the situational evaluation component of ISD Expert will diagnose each author's given problem and/or need. This will make the system application orientated rather than the conventional lock-step system that is most suited for the teaching of ISD. From the diagnosis, ISD Expert will generate a prescription. For those authors who seek assistance in implementing the prescription, especially those requiring the development of instructional materials, the fourth component will guide the production effort. This production component will be composed of mini-expert systems that have specific functions (e.g., instructional strategy shells).

Because of both development costs and gaps in instructional design theory, I recommend an incremental approach

to the development of ISD Expert. Initially, the project should begin with rapid prototyping techniques to produce a version one of ISD Expert. Subsequent versions would be elaborated according to the functional specifications as outlined in this chapter and from on-going research findings.

In conclusion, I am proposing an expert system that will bring the power of instructional design theory and practice to educators who would not normally have the opportunity to employ such knowledge in their instructional efforts. The proposed ISD Expert will improve learning by making instructional development both effective (i.e., by employing the most advanced principles and variables of learning and instructional theories) and efficient (i.e., by reducing the time and cost of conventional methods of instructional development).

IV. CONCLUSION (Gettman)

Both Gagné and Tennyson have addressed critically important issues for AIDA. Even though there is a great deal of overlap, Gagné primarily addresses the need for a description of a useful instructional model and of an instructional model selection algorithm to match learning objectives, knowledge types, instructional settings, and instructional strategies. The very function of Gagné's AIDA Executive is to identify instructional strategies and categorize them to achieve the most effective learning. The algorithmic process of selecting training strategies based on variations in the characteristics of the training situation does a good job of responding to this AIDA requirement.

Tennyson's description of the main phases of ISD and his "Fourth Generation" ISD model help provide useful instructional models for AIDA. Along with instructional design requirements, there is a need for a modular description of AIDA and an analysis of the role for artificial intelligence in an AIDA. Tennyson's vision of using techniques borrowed from artificial intelligence appears one practical way to accommodate a range of user experience. He describes four modules for an AIDA system which take into account a range of ISD knowledge (from novice instructor to ISD expert) and allows for coaching at lower levels and options to employ various alternatives at higher levels.

Spector (1990) calls for an integrated AIDA approach which selects the best ISD models and incorporates them into course design mini-advisors. He further recognized the need for an organizing strategy that works at the level of a group of lessons, a course module. Tennyson's view of AIDA responds to the need for an integrated approach by providing: 1) the instructor's model of instruction, 2) the ISD expert tutor (both coach and advisory), 3) an ISD knowledge base, and 4) an instructional knowledge content base. Tennyson envisions an AIDA with three major functions. The functions would be: 1) provide the user with aid in diagnosing a given instructional development task, 2) make prescriptions based on the situational diagnoses, and 3) serve the instructor as a coaching or advising mechanism for a variety of ISD applications.

The educational and instructional design principles presented by both Gagné and Tennyson serve to enhance our understanding of what an AIDA requires and how it could be designed within the constraints of current computer technology. An instructional design advising system which fails to incorporate Gagné's stages of instructional design or fails to provide Tennyson's integrated ISD assistance is not likely to be usable by military training specialists responsible for developing computer-based instructional materials.

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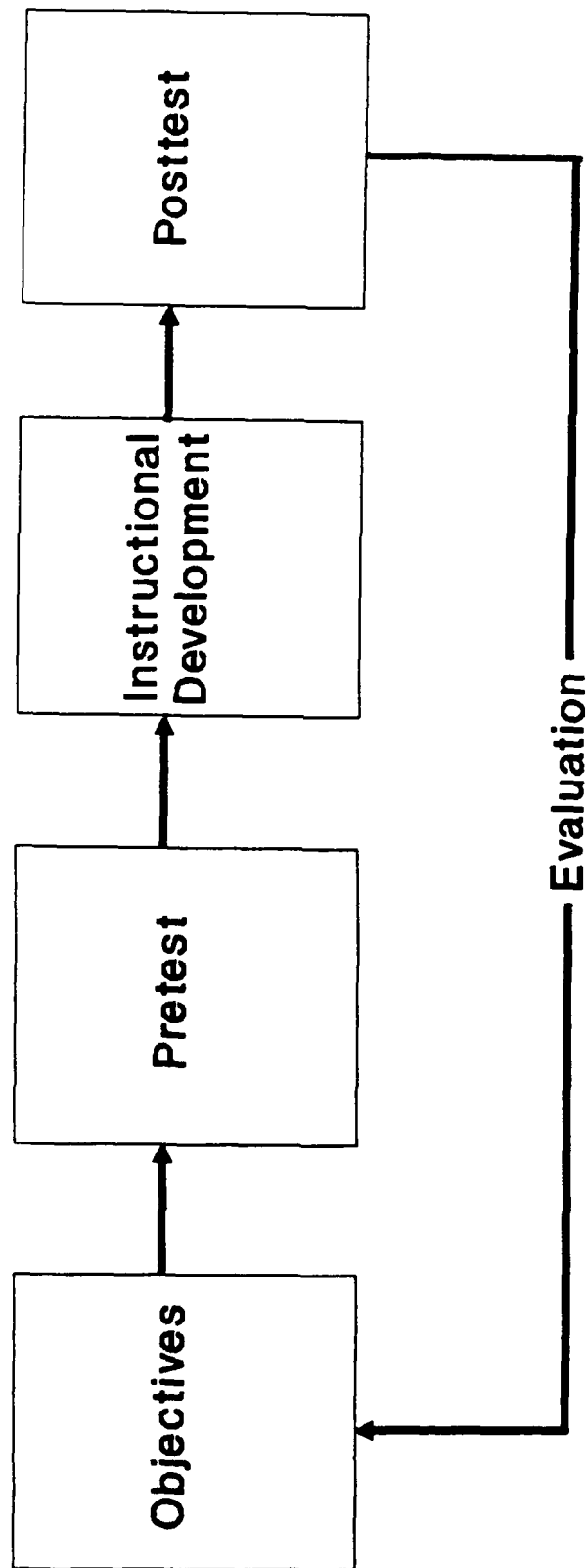
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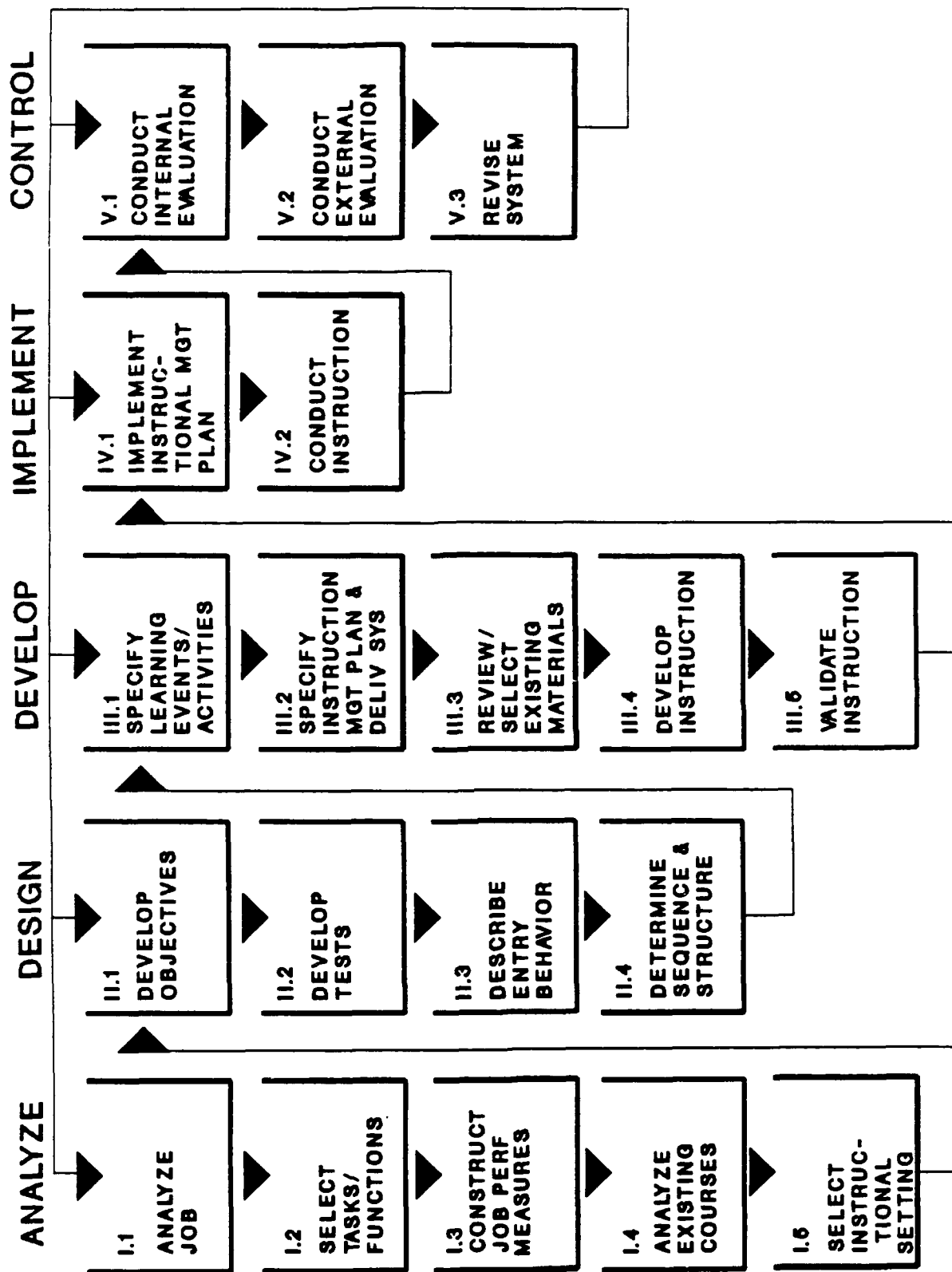
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Appendix A:

- Figure 1. 1st Generation ISD Model (1960s).
- Figure 2. 2nd Generation ISD Model (1970s).
- Figure 3. 3rd Generation ISD Model (1980s).



1ST GENERATION ISD MODEL (1960s)



2ND GENERATION ISD MODEL (1970S)

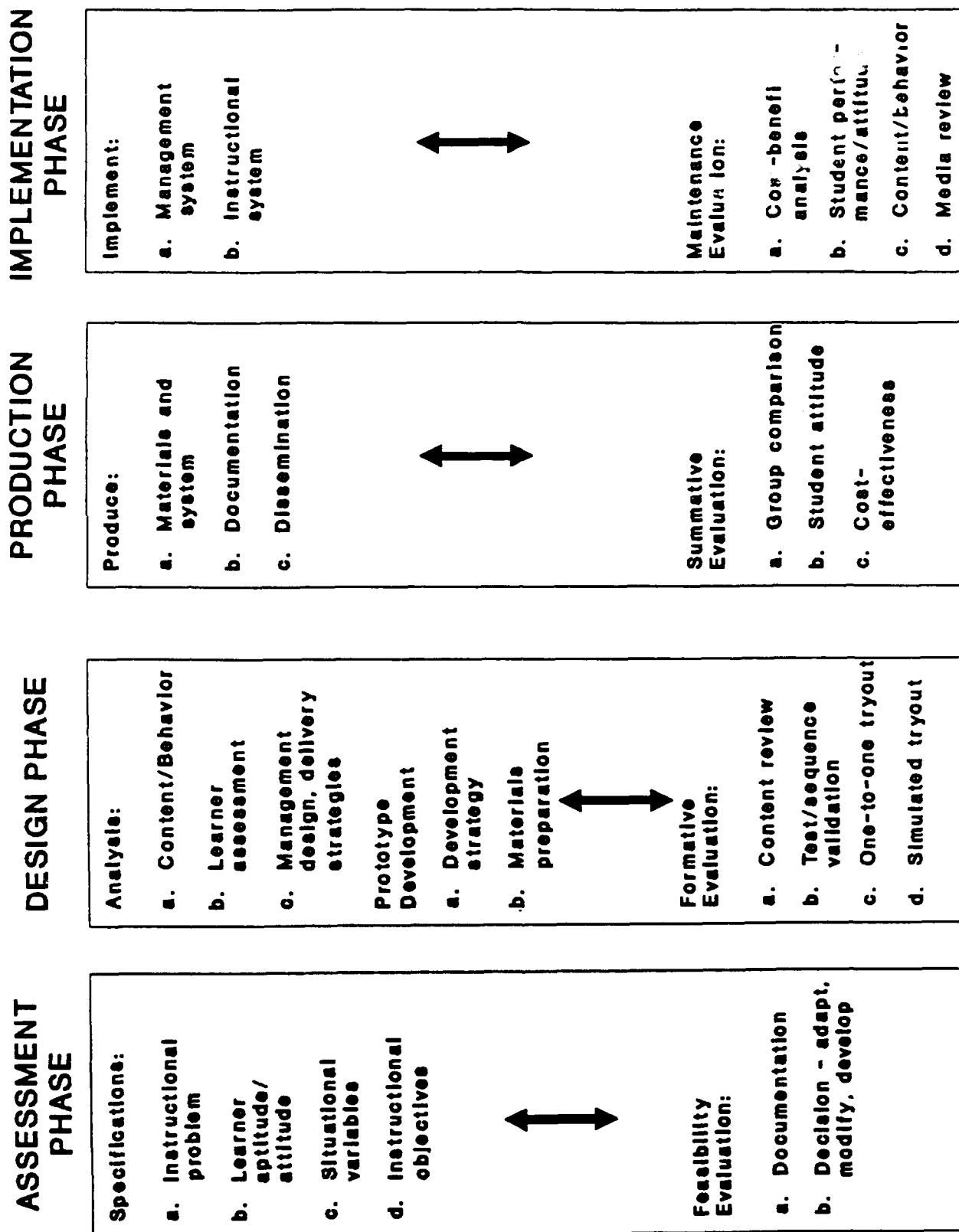


FIGURE 3: 3rd GENERATION ISD MODEL (1980s)

Appendix B:

Authoring activities knowledge base for 4th generation ISD Model
and AIDA expert tutor.

Analysis

Define philosophy and theory
of learning conditions

Analyze target population

Feasibility evaluation

Analysis-Design

Define learning variables

Define the learning environment

Authoring Activities

These conditions
influence each
step in the ID
process. Thus, the
generic steps are
adjusted to account
for the defined

Determine learner
characteristics:
geographic location,
age,
ability,
need for motivation,
present skill levels,
number of students
Determine learner
differences: cognitive
style, aptitude
learning style,
personality factors,
motivation,
perception

Validate the analysis
process

Identify specific
information to be
learned

Establish scope and
constraints of the ID
process

Analysis-Design

Specify goals

Specify learning objectives

Define management and delivery system

Define specifications of instruction

Authoring Activities

State abstract descriptions of what knowledge is to be acquired (levels of knowledge--declarative, conceptual, and procedural)

State objectives for learning program, specifying: desired conditions of learning (e.g. verbal information, intellectual skills, cognitive strategies, motor skill, attitudes)

Establish role of computer in management of the learning environment Identify basic goals for computer delivery of instruction (and identify other alternative systems; e.g., interactive video)

Document conditions and specifications of program: length, structure, proportion presented by allowable media, target population description, definition of constraints, goals and information to be covered, levels of program intelligence within management and instructional system

Analysis Design

Plan design and development effort

Analysis information (micro)

Analysis-Maintenance

Analyze learning needs and/or problem

Define constraints restricting resolution of learning and performance discrepancies.

Maintenance Evaluation

Authoring Activities

Consider whether to: buy and use existing materials, modify an existing course, develop a new course, or discontinue development effort Estimate costs and resource requirements for each alternative

Knowledge engineering activities: Identify organization of information Establish knowledge base Determine schematic structure from knowledge base (referenced to conditions of learning) Determine schematic structure from semantic structure Determine semantic structure for content attribute characteristics

Identify discrepancies between desired and actual learning and performance. Determine consequence of learning and performance discrepancies

Identify the scope of the need/problem (i.e., curriculum, course, module and /or lesson)

Design

Define entry knowledge

Define organization and
sequence of information

Specify formative evaluation
system

Prepare design document

Design-Development

Specify instructional system

Specify meta-instructional
strategies

Authoring Activities

Identify and determine
learner entry knowledge
and behaviors
Determine learner
(student) model:
Background knowledge,
associative knowledge,
prerequisite knowledge,
prior knowledge.

Determine sequence of
information through:
a) course, b) module,
c) lesson

Outline strategy for
validating learning
materials

Document all design
decisions to guide
development of
prototype learning
materials

State Meta-
instructional strategy

Specify use of meta-
instructional strategy
variables: drill
variables, placement of
items, display time,
label

Design-Development

Specify mode of interaction

Specify screen management

Specify presentation modes

Specify computer-based
enhancements

Specify methods of management

Specify message design

Authoring Activities

definition, context,
best examples,
expository examples,
interrogatory
examples, strategy
operation, attribute
elaboration

State level of system
interaction: program
initiative, mixed
initiative

Determine screen
layout, positioning,
sizing, etc.

select input/output
modes: keyboard,
positional, speech

Select computer-based
enhancements: worked
examples, display
time, format of
examples, amount of
information, sequence,
embedded refreshment &
remediation

Design method of
management per
selected level of
intelligence:
flowchart,
algorithmic, heuristic

Select display
characteristics (e.g.,
graphics, text, color)
Design screen layout

Design-Development

Specify human factors

Review/select existing materials

Define situational variables

Design-Development-Implement

Define conditions of learner
assessment/evaluation

Specify learner evaluation system

Authoring Activities

Design: menus,
function key prompts,
special helps
glossaries Identify
hardware
configurations

Select portions of
existing materials
appropriate for
inclusion

Identify existing
materials, compare
them with
needs/problem
Identify source
manuals, subject
matter experts, and
resource people

Determine the method(s)
for assessing and
evaluating learner
knowledge acquisition
(e.g., methods of
diagnosis, error
detection, error
analysis)

Determine on-task
learning assessment and
level of diagnosis
(e.g. preventive,
overlay, reactive,
advisement, coaching)
determine use to be
made of pretests,
progress checks, and
posttests Determine
how assessments are to
be administered (i.e.,
by computer or by
paper)

Development

Prepare content narratives

Prepare learning activity design

Develop learning activities

Development-Implement

Editing of learning program

Formative evaluation

Documentation

Authoring Activities

Acquire and document subject matter content (i.e., knowledge base and schematic structure)

Review learning activity designs and associated content for adherence to design and for accuracy and completeness

Employ strengths of medium Implement instructional strategies

Establish format and composition requirements Review all materials for grammar, style and consistency

Conduct one-on-one tryout of prototype materials Revise on the basis of one-on-one result Conduct simulation tryout Refine on the basis of simulation test Edit and produce Perform technical and mechanical review

Design Implement-Maintenance

Develop assessment instrument

Reviews

Implement

Implement-Maintenance

Summative Evaluation

Authoring Activities

Develop items appropriate for each objective and learning activity Develop items consistent with designed assessment system

Subject matter experts review material for accuracy and completeness Designers review material to determine whether it meets requirements established in analysis and development phases

Reproduce materials Establish/modify support services Distribute materials Deliver instruction Collect data on learner performance and learner attitude

Analyze data Distribute report and recommendations Determine whether to make major revision (go to Analysis) or minor maintenance (go to Maintenance)

Maintenance

Authoring Activities

Perform maintenance on
learning activities and
test items