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HUMAN RESOURCES

DESIGNING AND DEVELOPING AN ADVANCED INSTRUCTIONAL DESIGN ADVISOR

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July 1990

Final Technical Paper for Period July 1988 - June 1990

LABORATORY

AIR FORCE SYSTEMS COMMAND
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NOTICE

This paper has been reviewed and is approved for publication.

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REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	July 1990	Final Paper - July 1988 - June 1990

4. TITLE AND SUBTITLE
Designing and Developing an Advanced Instructional Design Advisor

5. FUNDING NUMBERS
PE - 62205F
PR - 1121
TA - 10
WU - 43

6. AUTHOR(S)
J. Michael Spector

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Training Systems Division
Air Force Human Resources Laboratory
Brooks Air Force Base, Texas 78235-5601

8. PERFORMING ORGANIZATION REPORT NUMBER
AFHRL-TP-90-52

9. SPONSORING/MONITORING AGENCY NAMES(S) AND ADDRESS(ES)

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

As computer hardware and software have become more sophisticated, designing and developing effective courseware have become an increasingly complex problem. Special expertise with the various computer technologies is required to use most modern commercial computer-based authoring systems. The Advanced Instructional Design Advisor (AIDA) is being designed as a collection of small expert systems to make advanced interactive technologies accessible to subject-matter experts with relatively little background in instructional or computing sciences. The goal of AIDA is to make courseware design and development more efficacious in typical Air Force training development settings.

14. SUBJECT TERMS
artificial intelligence
computer-based instruction
instructional design
ISD
training development

15. NUMBER OF PAGES
56

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

AFHRL Technical Paper 90-52 July 1990

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This publication is primarily a working paper. It is published solely to document work performed.

SUMMARY

This is a general description of an automated and intelligent tool to assist courseware authors in instructional design and development. The problem addressed by this research is the difficulty and expense of designing and developing effective courseware given the complexities of advanced hardware and software technologies, the variety of instructional settings, and the relative inexperience of Air Force training specialists in instructional design. Many automated tools to support the instructional process are being developed. However, no existing system attempts to provide general guidance for effective courseware design and development. The Advanced Instructional Design Advisor (AIDA) is currently being designed and developed by AFHRL/IDC to explore the feasibility of providing automated and intelligent assistance to Air Force training specialists involved in courseware development. In order to design an effective set of tools, several critical issues need to be resolved, including the identification of useful instructional models and taxonomies of knowledge, a determination of the role for artificial intelligence in instructional design, and an analysis of instructional design requirements. This research effort represents a first attempt to address these critical design issues for AIDA.

PREFACE

In the summer of 1988, the Air Training Command issued a Manpower, Personnel, and Training Need (MPTN 89-14) citing a lack of effective CBI (computer-based instruction) deployment and proposing the development of specifications and guidelines for effective authoring and presentation complete with instructional strategies. The Advanced Instructional Design Advisor (AIDA) is an exploratory R&D effort by AFHRL/IDC in response to this MPTN. The current AIDA design effort is being done by Mei Associates, Inc., Lexington, MA (Contract Number F33615-88-C-0003).

The preliminary conceptual work on AIDA was done as part of my Air Force Summer Faculty Research Program grant at AFHRL/IDC in 1988 (Contract Number F49620-87-R-0004) and Research Initiation Program grant at AFHRL/IDC in 1989 (Contract Number F49620-88-C-0053). This report is primarily a synthesis of the findings of those two research efforts.

I would like to thank the United States Air Force Systems Command, the Air Force Office of Scientific Research, and Jacksonville State University for sponsorship of this research. Universal Energy Systems was very helpful in providing administrative support. I am grateful to the Air Force Human Resources Laboratory for providing a stimulating environment for my research.

The work that has been accomplished on the Advanced

Instructional Design Advisor is the result of an unusually productive working relationship that has developed between the academic and military consultants working with Mei Associates, Inc. on this project. I value highly the many and significant contributions of Drs. John Ellis, Alinda Friedman, Robert Gagne, Henry Halff, Albert Hickey, Eileen Kintsch, Mary Marlino, David Merrill, Harry O'Neil, Martha Polson, Charles Reigeluth, Robert Seidel, Robert Tennyson, Lt. Cols. Hector Acosta, Jerry Barucky, Mike Bush, Larry Clemons, Mike Dickinson, Dan Meigs, Richard Ranker, Maj. Bob Mongillo, Capts. Ed Arnold, Jim Coward, Woollard Rosamond, and Mr. Brian Dallman.

I especially appreciate the thoughtful guidance of Dr. Scott Newcomb, AFHRL/IDC Branch Chief. His ideas and suggestions have been most beneficial. In addition, I appreciate the help and support of the other personnel in the Training Technology Branch (AFHRL/IDC), including Major Bill Wimpee, Dr. Linda Curran, Dr. Dan Muraida, Mr. Dick Vigue (retired), Mrs. Barbara Eaton (transferred), Capt. Bill Dimitroff, Mr. Bill Hawks, Mr. Dennis Gettman, and Ms. Catherine Connolly. Mrs. Sherri Barnes provided administrative assistance well above and beyond the call of duty. Other AFHRL scientists offered many useful ideas, especially Lt. Col. Hugh Burns (retired) and Drs. Barbara Sorensen, Wes Regian and Kurt Steuck. I also appreciate the encouragement and support offered by Dr. Henk Ruck and Col. Rodger Ballentine.

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I. INTRODUCTION

Phases of Instruction

The instructional process involves three major phases: 1) front-end analysis (FEA), 2) design, development, and delivery (DDD), and 3) rear-end analysis (REA). Instructional Systems Design (ISD) has been used by the Air Force to guide progress in all three phases, although its usefulness is somewhat limited since it provides insufficient specific and detailed guidance with regard to courseware design, development, and delivery. ISD does provide a general guideline of steps to follow in designing and developing instruction, and this general guideline will most probably be retained in some form in whatever advanced instructional design systems are developed.

Phase 1, FEA, includes an analysis of instructional requirements and the design requirements for the instructional solutions, including requirements for various courses. Phase 2, DDD, is where the primary course-level and lesson-level planning, development, and implementation occur. The work done in DDD is intended to comply with the instructional requirements of FEA. Phase 3, REA, is basically an analysis of how well the results of DDD met the requirements of FEA. The boundaries between these phases are not always sharply drawn, and the phases do not always occur in a linear or chronological order. Sequences are usually cyclic and somewhat irregular.

CBI Problems

These three phases roughly correspond to the five steps in the classic waterfall life-cycle model of software development: analysis, design, implementation, test, and maintenance (Fairley, 1985). As is the case with many software development efforts, the first and third phases (FEA and REA) receive minimal attention in the instructional design process. It is an all too common problem to become absorbed with the details of DDD and to short-circuit both FEA and REA. A rational and balanced approach distributes the effort among all three phases. One of the long range goals of AIDA is to provide a full range of automated and intelligent tools to assist in all major phases of ISD. The near term AIDA effort is focused on DDD with regard to computer-based instruction (CBI).

As advances in both hardware and software technologies have occurred, courseware designers have naturally wanted to incorporate a wider range of materials, including graphics, video, and sound, in a much more complex computer environment. As a consequence, many persons with many different talents and skills are involved in the ISD process, especially in the DDD phase. For example, if we imagine an instructional design effort for a CBI system, we immediately see a need for subject matter experts (SMEs), instructional designers, production specialists (e.g., video specialists), and system specialists (i.e., those knowledgeable about the particular computer hardware and software systems being used).

As the number of specialists increases, it is reasonable to expect course development time, costs, and quality to increase. As the complexity of the development and delivery systems increases, we again have similar expectations about development time, costs, and quality.

In the typical Air Force instructional setting, these specialists are rarely available. The problem motivating AIDA is to make the kind of expertise such specialists bring to courseware design and development available and accessible to SMEs in an on-line computer environment. A major challenge in designing AIDA is to design a system that reduces course development time and costs and yet contributes to course quality and effectiveness (see Appendix).

Systematic Solutions

The argument presented here is that adopting a systematic approach to integrating existing theories of instruction, learning, and knowledge in an easily accessible automated environment will provide the means to determine which particular instructional prescriptions are appropriate in a variety of automated settings. As AIDA related research proceeds, these validated instructional prescriptions will form the central component of an automated instructional design advisor.

II. OBJECTIVES OF THE RESEARCH

Purpose & Questions

The primary purpose of this research effort was to determine how advances in the cognitive, instructional, and computer sciences could be applied to the design of an advanced instructional design system. In order to achieve this goal, the following related questions were addressed:

1) Which theories of knowledge might be useful in the instructional design process?

2) Which learning theories and taxonomies might be useful?

3) Which instructional design theories and models might be useful?

4) What is the potential role of AI in instructional design?

5) How is ISD useful in the process of instructional design and how can its use be automated and improved?

6) Which strategies should be followed in order to design and develop advanced authoring aids?

7) What kinds of advanced authoring aids already exist and how effective are they?

In formulating answers to these questions it became clear that a standard design philosophy to guide the development of all tools built to support the instructional process was desirable. It was also clear that an expert system to support instructional design was possible.

Sections VIII through X of this paper present initial answers to these seven questions. Question #5 about the usefulness of the existing ISD procedures received minimal attention. The assumption here is that R&D efforts should not be constrained by existing ISD procedures. More strongly, it would be a mistake to take existing ISD procedures for classroom-based instruction and automate them for CBT settings without first establishing their appropriateness for CBT. In order to establish what procedures are appropriate for designing and developing CBT, one should perform a cognitive analysis of tasks involved in designing and developing CBT. Such an effort was clearly beyond the scope of this research.

Specific Tasks

A systematic approach to answering these seven question resulted in the following specific tasks:

1) Evaluation of SOCRATES, a system developed and used at the Air University's Air Command & Staff College (questions 4 and 5).

2) A description of useful instructional models (questions 1 and 5).

3) A description of an instructional model selection

algorithm to match learning objectives, knowledge types, instructional settings, and instructional strategies (questions 2 and 3).

4) A modular description of AIDA (questions 5 and 6).

5) Participation in the formal review of the design requirements for AIDA (question 6).

6) Evaluation of other research and development efforts in this area (questions 4, 5, and 7).

7) An analysis of the role for artificial intelligence in AIDA (question 4). .lm 3

Summary of Results

SOCRATES and several other instructional design advising systems were evaluated. Existing systems are inadequate for a variety of reasons, including failure to account for a variety of instructional settings and relatively inexperienced instructional designers.

Useful instructional models do exist, including Gagne's Nine Events of Instruction, Merrill's Component Display Theory (and more recent Second Generation Instructional Design Theory), and Reigeluth's Elaboration Theory. However, these theories have yet to be incorporated into a relatively general purpose automated instructional design system (Merrill's ID Expert probably comes the closest).

No existing instructional design advising system was found that provided genuinely adaptive instructional models. ITSs do incorporate adaptive instructional techniques, but they do not typically adopt a completely different instructional model as instructional circumstances might dictate. For example, an expository instructional model for teaching a procedure might propose the following:

1. Start with an attention grabber.
2. Present a motivational scenario.
3. Provide a reminder that this procedure is similar to a familiar procedure.
4. State the steps comprising the procedure.
5. Provide several examples of following the procedure.
6. Provide practice and assessment.

If it is determined at step 6 that the instruction has not been effective, then several alternatives exist. One alternative is to retreat to step 4 (or an earlier step) and repeat a somewhat abbreviated sequence. This is the common tactic. Another alternative, however, is to adopt an entirely different instructional model. It is not inconceivable that the failure is due to a breakdown at step 3, the analogy step. To attack such a deficiency, an intelligent system might advise (or adopt or provide) an inquisitory model of instruction that proposes these steps:

1. State the purpose of the procedure.
2. State the steps of the procedure.

3. Provide several examples of the procedure.
4. Request a similar procedure.
5. Request similarities and differences.
6. Repeat steps 3 and 4 several times.
7. Provide additional examples of the procedure.
8. Request hypothesis for result of omitting a step.
9. Request explanation and discussion.
10. Repeat steps 8 & 9 several times.
11. Provide practice and assessment.

Human instructors often adapt their instruction when circumstances indicate a different model or tactic is appropriate. An intelligent CBI instructional advisor should have a similar capability.

There clearly is a role for artificial intelligence in the instructional design and development process. ITSs have already incorporated expert systems to provide instruction based on matching a model of an expert's knowledge with that of a student's. The challenge for AIDA is to provide an expert planning model for designing and developing CBI. An additional challenge for AIDA and for ITSs is to provide adaptive instructional models in the instructional delivery component.

III. PROBLEM AREAS

The general problem with DDD is that advanced hardware and software technologies, including simulations using interactive video disk (IVD) or digital video interactive (DVI) technology, natural language pre-processors, and intelligent tutoring systems (ITSs), have found roosts in various instructional settings. However, our knowledge of how best to use such tools is limited (Montague, Wulfeck, & Ellis, 1983). These technologies generally lack standards, are relatively expensive, require expertise to use effectively, and are not always placed in appropriate settings. The basic problem, however, is that we do not know how best to design courses so as to optimize effectiveness, given that broad subject matter domains, a variety of instructional settings, diverse student populations, and new technologies are involved (Halff, 1988).

A review of the literature reveals no general consensus with regard to a theory of instructional design (Gagne, 1987). Some studies reveal that it often matters not whether certain portions of a course are omitted or whether entirely different approaches are used to teach the material (Montague, 1988).

In order to achieve the research objectives and to support the Laboratory's efforts to design an advanced instructional design toolset, several different problems were evaluated. In determining the current state of instructional design science, two problem areas were explored: 1) Can theories of knowledge, learning, and instructional design be meaningfully integrated?, and 2) What theories are existing instructional design systems incorporating? (These two questions represent questions 1, 2, 3, 7 and tasks 1, 2, 3, and 4 in Section II).

In order to determine the role for artificial intelligence in AIDA, again two problem areas were explored: 1) Is there a role for expert systems in the ISD process?, and 2) Is there a role for neural networks in the ISD process? (These two questions represent questions 4 and 5 and tasks 6 and 7 in Section II).

In order to provide support for the Laboratory's AIDA effort under Contract Number F33615-88-C-0003 with Mei Associates, Inc., two additional problems were explored: 1) What kind of consultants should be involved in the design effort?, and 2) What specific tasks should be assigned these consultants? (These two questions represent question 6 and task 5 in Section II).

IV. PROPOSED SOLUTION

The proposed solution to courseware design and development problems is to develop a computer-based toolset to assist in the process. The specific purpose of this set of tools is to reduce course development time and costs while assisting in the production of consistently effective courses. The cost savings will come in the form of reduced needs for expensive and scarce design and systems expertise as well as in time saved in course development. This means that such a system must be inexpensive, easy to learn, and obvious to use.

In attempting to design a system to improve the course design process, three important questions will eventually need to be resolved: 1) What are the most promising theories of instruction? 2) how can their prescriptions be followed and tested? and 3) What are the limitations of implementations of such systems? Sections VIII through X only sketch an answer to these additional questions.

A review of the literature and visits to military instructional research and development centers reveal that there are no existing systems that claim to solve this fundamental problem in a general way. The Air University at Maxwell AFB has developed a tool, SOCRATES (Doucet and Ranker, 1988), that does provide lesson assistance according to Gagne's nine events of instruction and Merrill's Component Display Theory (Reigeluth, 1983).

Merrill, with partial funding from the Army Research Institute (ARI) designed ID Expert Versions 1.0 & 2.0 (Merrill, 1986) which provide somewhat similar guidance in the lesson construction process.

Such tools are significant steps forward. Their limitations are that they provide restricted guidance for highly constrained settings. The few existing instructional design aids that provide design guidance typically focus on subject matter involving declarative knowledge and are not suitable for maintenance training tasks. AIDA is meant to be a more general solution at the course level, and it is meant to fit within the larger scheme of the instructional process.

V. SOLUTION CONTEXT

Tools for FEA

Before describing AIDA in more detail, it is useful to consider its context in the process of instructional design. It is reasonable to expect a set of advanced tools to be developed to automate and assist throughout the instructional process. To complement the ISD process during FEA, several programs might be useful. One might be a Training Requirements Analysis Planner that would take a roughly stated training requirement and via a query/response process develop that statement into a set of requirements and goals that are in an appropriate format to guide the courseware design process. Another automated aid might be a system to query a course database to find out if similar courses exist, where they are taught, etc. Yet another could be used to guide the media selection process. The FEA programs could also automate required ISD documentation.

Tools for DDD

In the DDD phase a variety of tools are possible. A program might be developed to take lesson objectives, content, and definitions as input and generate test questions, much as CBESS does for restricted domains (Wetzel & Wulfeck, 1987). Entire systems can be built to allow authors to select and sequence lesson materials; ISS is an excellent example of an Air Force owned authoring system (Vigue, 1988). Merlin is a second example of an Air Force owned authoring environment. Neither of these systems provides instructional design guidance. Both are highly sophisticated and, like their commercial counterparts, are difficult to learn.

Other tools that would be useful are IVD and graphics editors and databases containing sample course and lesson templates and examples. As indicated earlier, what is especially needed in the DDD phase is a tool to assist in course design by matching instructional options, knowledge types, and settings (Madni, 1986).

Tools for REA

It is also possible to imagine a range of tools associated with REA, including guides for establishing and conducting crucial controlled tests and access to databases containing relevant course data. A particularly difficult task in this area is testing the effectiveness of a course design process, as opposed to the effectiveness of a particular course.

An AIDA Toolset

In the long range, AIDA is concerned with providing a standard environment (graphical user interface, design philosophy, etc.) for a fully integrated set of tools to support all phases of the instructional systems development process. In the near term, AIDA should focus on design, development, and delivery of maintenance training in computer-based instructional settings.

VI. FUNDAMENTAL CONCERNS

Kinds of Tools

Looking at the kinds of advanced technologies which might be developed to assist throughout the instructional process reveals two distinctions:

1) There are two different kinds of tools that can be developed -- those which automate an established process (e.g., documentation and test generators) AND those which are intended to make the process more effective (e.g., course and lesson templates, ITSs, and lesson and course design advisors)

2) The tools that have been described can be used in two ways -- as stand-alone, special-purpose tools (e.g., practice problem generation) OR as integrated tools sharing information (e.g., a course database).

Standard Design Philosophy

The guiding vision of AIDA is to adopt a standard design philosophy for all related tools so that as tools and mini-advisors are developed they can be gracefully incorporated into a system of tools for the entire instructional process. Part of the standard design philosophy should be this fundamental modular concept. Tools should be developed so that they can operate as stand-alone modules or can, by way of standard interfaces, be incorporated into larger collections of compatible modules. A standard design philosophy is needed to guide specific items, such as menu design, as well as larger concerns, such as the structure of knowledge bases. Standards for networking and graphics are also needed.

AI-Based Tools

Some tools developed to make course design more effective fall into the area of AI, such as ITSs (Wenger, 1987), while some fall more clearly into the traditional disciplines of computer science, such as database design and implementation. AIDA has some aspects of both kinds of systems. A serious question is the extent that course design lends itself to AI applications (Winograd, 1986). Can an expert system for course design be developed that performs as effectively as good human designers?

The initial assumption is that AI has a role to play in course design, as well as its already recognized role in ITSs (Polson & Richardson, 1988). The form of such systems will be sets of production rules and inference engines to take the user from one state (e.g., specific list of course objectives and knowledge of the expected course environment) to another state (e.g., set of lesson templates outlining the course content and sequencing).

Theories of Knowledge

The AI questions suggest other concerns: 1) Are there existing theories of instruction design that could be incorporated as models in an expert system? 2) Do guidelines exist to suggest which models to apply in particular circumstances? and 3) What relationships exist between theories of knowledge, learning, and instruction?

The view here is that relationships between theories of knowledge, learning, and instruction should be expected, with theories of knowledge providing links between theories of instruction and learning (Self, 1988). The theory of knowledge assumed below is a modification to the justified true belief model discussed in Griffiths (1967) and adopted by Kitcher (1983). The pragmatic *modification* is this: Knowledge consists of well-justified and well-connected beliefs (JCB). What counts as "well" in either case depends on the particular circumstances and needs at hand.

In addition, JCB theory acknowledges the usefulness of the distinctions between declarative (knowing that), procedural (knowing how), and causal knowledge (knowing why). Each knowledge type has possible subdivisions (e.g., the distinction between physical process and mental process within procedural knowledge). Human knowledge is like a web of well-justified and well-connected beliefs (Quine & Ullian, 1978). There are too many threads to explore individually in order to precisely model the human belief system. However, useful models can be built by emphasizing the incorporation and integration of multiple knowledge types, according to the most appropriate learning and instruction theories.

What will be carried forward are two ideas: 1) In order to establish understanding, it will be important to provide a framework or model, provide explanations within that framework, and connect that framework to other more familiar frameworks and models, and 2) Multiple levels of understanding are possible and depth of understanding might be measured in terms of internal justifications and connections as well as external justifications and connections (e.g., meaningful analogies and metaphors).

Instructional Theories

There are various instructional theories which contain models prescribing how courses should be designed, including the Gagne/Briggs models of instruction, Landa's algo-heuristic theory of instruction, Collins-Stevens' cognitive theory of instruction, Merrill's Component Display Theory, Reigeluth's Elaboration Theory, functional decomposition and functional context theories, and scenario-based models (Reigeluth, 1983).

What are most noticeably lacking are prescriptions to follow to determine when a particular model would be most useful and exactly what is entailed in a particular application. Merrill has provided a few high level prescriptions for an authoring system, but they are too general to be directly helpful

(Merrill, 1987). Reigeluth claims to solve this problem for three knowledge types (conceptual, procedural, and theoretical), but his conclusions are untested and do not provide clear directions to select an organizing strategy (Reigeluth, 1983).

The Integrated AIDA Approach

The strategy proposed for AIDA is to admit that much useful work has been done in theory of instructional design, select the best models and guides for their use, incorporate those models and guidelines into course design mini-advisors, and adopt a selection strategy that recognizes that a single course will likely involve multiple types of knowledge and mastery levels. What is needed is an organizing strategy that works at the level of a group of lessons, a course module. The size of the subset may range from a single lesson to an entire course, but the typical size is expected to include several (3 to 7) lessons. Selecting an organizing strategy for lesson materials based on an appropriate instructional model for a course module has the obvious advantage of allowing the design of AIDA to be built around the best work already available.

VII. INVESTIGATIVE ACTIVITIES

With regard to the two problems in the area of determining the state of instructional design science, there were four research activities: 1) a review of current and classical attempts to integrate theories of knowledge, learning, and instruction, 2) participation in the 1989 ITS Conference hosted jointly in San Antonio by AFHRL/IDI and SouthWest Research Institute, 3) participation in the ITS Workshop held as part of the Software Engineering Institute's 1989 Summer Conference at Carnegie-Mellon University, and 4) participation in the Utah State University Annual Summer Instructional Technology Institute on "Using Artificial Intelligence in Education: Computer Based Tools for Instructional Design."

With regard to the second set of problems in the area of determining the role of artificial intelligence in AIDA, there were two research activities: 1) a review of current literature in the area of artificial intelligence and instructional design, and 2) a presentation of "The Theoretical Limitations of Neurocomputing" at the 1989 Jacksonville State University Neural Networks Lecture Series.

With regard to the third set of problems in support of the Laboratory's AIDA Task Order Contract Number F33615-88-C-0003, there were three investigative activities: 1) pre-planning and coordination with AFHRL/IDC in drafting documents pertinent to the meetings, 2) attendance and participation in the meetings, and 3) presenting an analysis of the meetings to AFHRL/IDC.

VIII. FINDINGS

The first set of research activities were an attempt to determine the state of instructional design science. Basically the activities involved a review of the relevant literature and participation in a number of workshops and seminars about state-of-the-art instructional design systems.

The Classical View

In reviewing the literature an attempt was made to identify explicit attempts to integrate theories of knowledge, learning, and instruction. The only clearly integrated and synthesized theory was found in the classical literature of Plato's dialogues, especially the Meno and the Theatetus (Jowett, 1871).

Plato's theory is that learning is a process of remembering what the soul has learned in previous incarnations. Instruction then becomes a two step process. First, cause the learner to become aware that he has forgotten something important, such as the meaning of virtue. Then, by a series of analogies and reminders, elicit from the learner what he has forgotten. One can see a certain similarity between these steps as practiced by Socrates and Robert Gagne's Nine Events of Instruction, which include gaining the learner's attention, informing him of the objective, stimulating recall, etc. (Gagne, 1985).

Plato's theory of knowledge involves two key aspects: 1) knowledge involves certainty, and 2) behavior is a measure of knowledge. Making the correct claims about virtue is not sufficient to establish that one knows what virtue is. One must also behave in such a way that it is obvious that one understands the meaning of virtue, and, of course, Socrates had very high standards. What is most interesting is to see the behavioral component in this early view.

A Modern Holistic Account

Most modern theorists will reject certain aspects of this integrated theory (e.g., immortal souls or infinite reincarnations). However, the integrated view is important. In the course of elaborating advanced learning theories, we will need to take into account a complete account of a person. It will not be sufficient to examine just the brain or just behavior or just verbal responses. One modern version of such an attempt to provide a holistic and integrated account of learning can be found in Michael Arbib's In Search of the Person: Philosophical Explorations in Cognitive Science (Arbib, 1985).

Limits of Current Systems

In examining current instructional design systems and the development of CBI, several noteworthy items were discovered. First, the history of CBI reveals a bias towards the DDD phase of instructional design. Little emphasis has been given to FEA and REA. Within the DDD phase, the historical trend has been to first emphasize development and delivery and, almost as an afterthought, to emphasize design. Nearly all assistance in courseware development is now in the form of unintelligent but highly sophisticated authoring tools that require specialized knowledge to use and assume a mastery of the principles of instructional design.

Moreover, advances in technology have made possible the incorporation of sophisticated graphics, video, and sound. These added complexities have aggravated the ease-of-use problems with CBI development systems. The design phase has yet to receive adequate attention in terms of automated tools and techniques (Montague et al., 1983). There are mouse-driven graphics editors and the like, but there are very few aids designed specifically to advise authors how best to organize and deliver course materials in a computer-based environment.

The Need for AIDA

Roughly stated, what needs to occur with regard to courseware authoring systems is to provide additional tools to support the design phase of DDD as well as development, delivery, and the other two phases (FEA and REA), and to integrate all these tools in an easy to use, intuitive system (see Appendix).

Integrating Theories

In response to the questions involving developing an integrated instructional theory (Can theories of learning, knowledge, and instruction be integrated?, and What theories are being used?), it is possible to provide an integrated account of learning, instruction and knowledge (Plato has done so), but modern theorists typically do not make explicit the connections between and among knowing, learning, and instructing. Examples of current instructional theories include Gagne's Nine Events of Instruction, Merrill's Component Display Theory, and Reigeluth's Elaboration Theory.

The Role of AI

The second set of research activities involved an exploration of the role for artificial intelligence in instructional design. This exploration followed two paths: 1) neural networks, and 2) expert systems, including intelligent tutors. These are the two major areas of artificial intelligence applications, so this was a natural course to pursue.

Neural Networks

While there is a great deal of current activity in the area of neural networks, there does not appear to be any direct or immediate application in the area of instructional design. Neural nets are basically learning automata, inspired by the workings of the human brain. Areas of application include pattern recognition, speech recognition, and robotics (Soucek, 1988).

As automated learning environments become more conversational with improving speech recognition and generation technologies, it will be natural to reconsider the role for neural networks, especially in the area of speech recognition. Conversational systems will introduce an important new level of interactivity into CBI. As a consequence, monitoring progress in neural network speech recognition technology should be a priority project at the Laboratory.

Expert Systems

The story with regard to expert systems is different, however. Expert systems have become commercially successful within the last ten years in a variety of domains. It is possible to divide expert systems into two categories: 1) Diagnostic systems that proceed from symptoms backwards toward a relatively small set of causes, and 2) Planning systems that proceed forward from a given set of restrictions to a projected set of outcomes. In both types of systems there is a similar overall architecture involving a set of rules, a set of facts, and an inference mechanism (Luger, 1989).

Early expert systems were written in LISP or PROLOG or another high level computer language. The challenge for computer science was to design effective inference mechanisms. As algorithms for the match and apply phase of the inference engines became more complex, higher level tools were developed. For example, the RETE pattern matching algorithm developed by Charles Forgy at Carnegie Mellon University to match facts with the IF-components of rules was incorporated in the OPS series of production system development tools (Giarratano, 1989).

There now exist a number of expert system shell development languages which hide the complexities of the inference mechanisms from the user. The idea behind these tools is to make the technology of expert systems available to domain experts and require minimal knowledge of artificial intelligence and programming. Examples of such systems include ART, EXSYS, GURU, KEE, and Personal Consultant (Firebaugh, 1988).

Expert Systems in Courseware Development

What should occur with courseware authoring systems is exactly what has been happening with regard to expert system development tools. That is to say, easy to use tools for domain experts need to be developed.

In addition, incorporating expert systems into the instructional design process appears both possible and worthwhile, especially in a typical military setting where the instructional designer has had little formal training in the instructional design process. Diagnostic expert systems have been successfully incorporated in the form of intelligent tutors, which analyze student responses and adjust courseware delivery in accordance with a diagnosis of a student's (mis)understanding based on comparison with a model of an expert's understanding (see Section II). Intelligent tutoring systems have been shown to be effective in specific and restricted domains, but they are expensive to develop and to implement (Wenger, 1987).

Intelligent Instructional Design Guidance

Another challenge is to develop expert system planners to aid courseware designers to develop consistently effective course materials in a cost-effective and systematic manner for a variety of subject matter domains and knowledge types (e.g., declarative, procedural, and causal). There are a few intelligent systems to aid course authors design course materials for declarative or factual knowledge types.

For example, the Air University's Air Command and Staff College at Maxwell AFB has developed a system called SOCRATES, which is intended to assist subject matter experts in organizing course material into effective lesson materials. SOCRATES is based on Robert Gagne's Nine Events of Instruction and David Merrill's Component Display Theory (Doucet, 1988). As mentioned earlier, ARI partially funded a system developed by David Merrill at Utah State University called ID Expert. ID Expert is an expert consultation system for the design and development of instruction.

Kent Gustafson at the University of Georgia has developed a system for Apple Training Systems called IDioM. IDioM is intended to provide support for the entire instructional design process. IDioM is built on HyperCard and is probably the friendliest and easiest to use system of those mentioned. It is also one of the very few which acknowledges the FEA phase of instructional design. IDioM's intelligence is primarily restricted to the selection of appropriate templates for instruction based on input parameters, but this is one useful form of machine intelligence, and it does automate one part of the ISD process. IDioM's user interface has been upgraded and the product has been renamed ID Bookshelf.

There are a few other systems under development, such as the Alberta Research Council's Expert CML, ARI's Automated Systems Approach to Training (ASAT), Ford Aerospace Corp.'s The Instructional Prescriptions Systems (TIPS), the Navy's Authoring Instructional Materials (AIM), and Xerox-PARC's IDE. The effectiveness of all of these systems has yet to be fully evaluated. Furthermore, no system exists as yet to advise course authors how best to design, develop, and deliver materials that involve multiple knowledge types for a variety of subject matter domains and instructional settings. Part of the challenge for AIDA is to accomplish this for computer-based settings and to provide a full range of automated tools to support all major phases of the ISD process in an easy to use, flexible, and intuitive system.

The answers to the two questions about the role for artificial intelligence are now obvious: 1) There is a role for expert planning systems in the instructional design process, and possibly a role for an intelligent tutor to teach instructional design, and 2) There is no immediate role for neural networks in the instructional design process, although there may be a role in the area of speech recognition in the not-so-distant future.

A Crucial Issue

One of the most fundamental issues yet to be resolved is how to represent (if it possible) the knowledge of experts, specifically instructional design experts (Winograd, 1986). Because expert systems are intended to emulate human experts in the sense of producing results consistently similar to those produced by human experts, it will be necessary to identify human experts in the area of instructional design and to measure the effectiveness of automated design tools against the effectiveness of those experts.

IX. AIDA DESIGN REQUIREMENTS

The following requirements indicate the basic design concerns for AIDA, given the problem context, the problem areas, and the fundamental concerns just discussed:

1. Proceed according to a standard design philosophy that maintains consistency of materials and presentations. The issues with regard to standard design philosophy include but are not restricted to: standard selection processes, dynamic default settings, multiple and dynamic levels of assistance, the standard use of mini-advisors with relatively small

special-purpose rule sets, standard ISD documentation and materials for students, standard design for editors, a standard graphical user interface (GUI), and standard interfaces to other modules and commercial systems. Because the motivation for a standard design philosophy is the integration of tools, the design of standard databases with information about existing schools, courses, delivery systems, and students is necessary.

2. Proceed within the framework of a theory of knowledge. The suggested theory here is JCB because it is a practical modification to an established epistemological view. The modifications are intended to provide some connection to both learning and instruction theories. The emphasis on WELL-justified and WELL-connected beliefs provides a basis for guiding understanding as well as a basis for evaluating understanding. The idea of a web of beliefs and a variety of knowledge types lends itself to both instructional and learning interpretations.

3. Proceed within the framework of a modularized theory of instruction. The theory adopted initially is that Reigeluth's Elaboration Theory, Merrill's Component Display Theory, the Gagne/Briggs models of instruction, and other theories offer meaningful, useful, and potentially effective organizing strategies for course materials. What is most needed is an algorithm to determine when to apply which model. The reason the selection algorithm has not been established is that the

assumption was that the strategy would apply course-wide; this, at least, is Reigeluth's assumption. It is exactly the assumption of a single course-wide organizing strategy that this design rejects. The proposal here is that an appropriate and effective selection can be made for a course module.

4. Proceed with a design using these functional modules: a) "macro" module to assist in refining course goals into modules and objectives, b) "mini" module to assist in the selection of appropriate strategies for selecting, organizing, and sequencing course module materials , and c) "micro" module to assist in the selection and sequencing of materials within a lesson. Each module would eventually have access to databases containing course information, templates, examples, etc. Each module would also have access to a set of mini-editors to assist in the creation, alteration, and incorporation of lesson materials into a course. AIDA should be designed so that it could support a wide range of instructional settings, including the classroom lecture setting, a computerized and networked lab setting with full support for CMI, and specialized settings with ITSs and simulations. In short, the AIDA system would consist of a set of modules which all supported multiple modes of operation, multiple and dynamic levels of assistance, user-transparent interfaces, and other features prescribed by the standard design philosophy.

Depicted below is a conceptual model of AIDA:

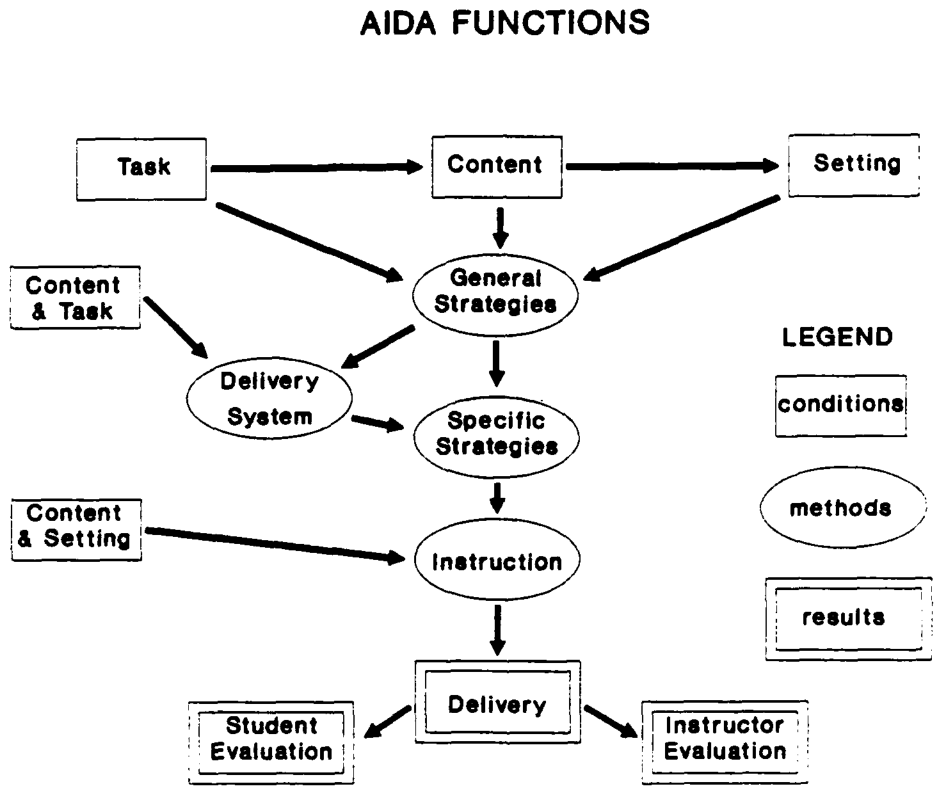

Figure 1. Functional Model of AIDA

AIDA would make available a variety of operating modes. For example, at the highest level there might be different views of the system for training managers, instructional designers and developers, and students. For the developer, there would be modes for entering material (text, graphics, etc.) into lesson templates, for storyboarding and linking material, and for testing the delivery of the lessons created.

Depicted below is a conception of an AIDA menu that would be consistent with the previous recommendations:

AIDA - DEVELOPER'S MAIN MENU

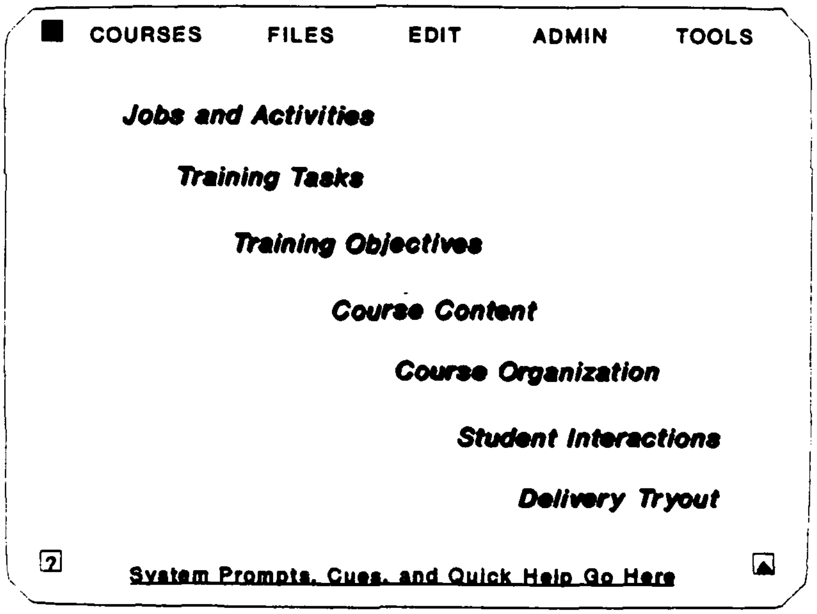

Figure 2. An AIDA Menu

X. RECOMMENDATIONS

The primary conclusion of this research effort is that it is worth pursuing the design of AIDA. Significant issues need to be resolved, including the desirability, feasibility, and costs of an integrated system of modules sharing access to common databases, common selection processes, files, mini-editors and mini-advisors. If one begins with the possibility of such a system, then one is led to the need for a standard design philosophy to guide related efforts.

AFHRL/IDC should consider the following specific actions:

1. Assign a team with expertise in theory of knowledge, cognitive and behavioral theories of learning, AI, integrated computer systems, and curriculum and instructional design with the task of developing the specifications for a standard design philosophy for all tools developed to automate and assist the instructional process.

2. Assign a team with similar expertise with the task of refining the design requirements for AIDA. The design requirements need to be refined to reflect such things as the selection algorithm to be used to organize material at the course module level, the specific structure and modules required for AIDA, a minimal subset of modules to be implemented in a prototype, and initial rule sets to be used in the mini-advisors.

3. Have those documents (standard design philosophy and AIDA design requirements) critically reviewed by a team of specialists from leading academic research centers and from key military training centers.

4. Have the reviewers meet in a forum and share, clarify, and refine their critiques of the two documents. Detailed reviews of SOCRATES and similar systems should be provided so as to gain the most recent and pertinent lessons learned.

5. Produce the final standard design philosophy specifications and design requirements for AIDA.

6. Initiate work on related projects using the standard design philosophy as a guiding requirements standard.

7. Design and develop a prototype AIDA system with a minimal subset of functions and models, and test it in controlled settings.

8. Evaluate progress on AIDA and related projects.

It should be noted that the Laboratory has undertaken all of the above tasks with the exception of those involving the development of a standard design philosophy.

The Laboratory should definitely continue with the design and development of a prototype AIDA system. It is now time to shift the emphasis back to the less theoretical and more practical design and development issues. The need for a guiding and coherent theory is obvious, but the design and development of AIDA need not await the validation of such a theory. Indeed, AIDA is intended partly as a tool to use in refining and integrating theories of knowledge, learning, and instruction.

The Laboratory should not abandon attempts to make AIDA an intelligent system. There appears to be no immediate role for neural networks in AIDA. However, there are potential roles for a number of expert system planners throughout the ISD process. Of special concern is the potential role for expert system technology to facilitate the DDD phase of courseware development.

With regard to prototyping, serious consideration should be given to developing the prototype using an object-oriented design/hyper-media development system such as HyperCard on the Apple MacIntosh, NextStep on the NeXT computer system, or Hewlett-Packard's NewWave with Windows 3.0 on an 80286/80386 system. The prototype system need not use the same hardware or software as the final target system. The critical choices for a prototype development system are cost and ease of development effort. The point of the prototype is to illustrate the functionality of the proposed system in an effort to prove the concept is workable. It should be noted that adoption of this prototyping recommendation involves abandoning the Instructional Support System (ISS) as a test-bed delivery system for the prototype.

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APPENDIX

NEEDS ASSESSMENT REPORT

Visit to Lowry AFB Technical Training Center (3400 TCHTW)

2 - 6 Oct 1989

Drs. Dan Muraida & Mike Spector (AFHRL/IDC)

I. Purpose

The purpose of the visit was to conduct a preliminary needs assessment for the Advanced Instructional Design Advisor (AIDA). The motivating objective was to involve experienced Air Force instructional designers, developers, training managers, instructors, and other relevant personnel in the early design work on AIDA to insure that AFHRL/IDC research and development efforts are directed toward practical and useful goals.

II. Agenda

2 Oct 89

1500 - 1700 3400 TCHTW/TTO (Wing Tech Tng)

3 Oct 89

0900 - 1100 3450 TCHTG/TTMYF (Tng Dev Branch)
3450 TCHTG/TTMYF (Instructors)

1300 - 1500 3400 TCHTW (Training Managers)

4 Oct 89

0900 - 1100 3450 TCHTG/TTMYA (ATLAS F-16)

1300 - 1500 3460 TCHTG/TTMTN (BMIS)

5 Oct 89

0900 - 1100 3430 TCHTG/TTMA (Space Systems)

1300 - 1500 3400 TCHTW/TTF (CBT Tng & Fac Dev)

6 Oct 89

0900 - 1100 3440 TCHTG/TTMXS-Z (MS&D Exp Tng)

III. Format

The trip was coordinated through Lt. Col. Hector Acosta (ATC HQ/XPC). All meetings were arranged by Brian Dallman (3400 TCHTW/TTOZ). AFHRL/IDC representatives were Drs. Dan Muraida and Mike Spector. Capt. Jim Coward (ATC HQ/XPCRI) represented ATC headquarters.

Brian Dallman arranged meetings with small groups of key personnel involved in all phases of instructional design, development, and support. Groups varied in size from 4 to 14. Discussion was guided by a needs assessment guide. A survey was not formally administered because it was felt that more meaningful information and insights could be gathered through informal discussions facilitated by Brian Dallman.

IV. Summaries

A. 2 oct 89 1500 - 1700 3400 TCHTW/TTO (Wing Tech Tng)

Participants at this meeting were Brian Dallman, the Training Wing's Technical Applications Officer, Fred Norman, Chief of the Training Wing Operations Division Plans Branch, Capt. Coward, Dan Muraida, and Mike Spector. Main topics of discussion included the general process of designing, developing, and delivering courses in the training wing, the pertinent ATC regulations and documentation, the organization of the training wing, the interrelationships of the various groups and branches, and the relevant decision making processes.

Documentation pertinent to course development includes 1) training plans, which contain specialty training standards (STSs), and course charts indicating the general sequence of instruction, and 2) plans of instruction (POIs), which contain measurements, curriculum descriptions, study guides, and lesson plans. The Plans Branch puts controls in place and oversees compliance with ATC regulations through various training managers. The training managers interact with the various Training Development Branches (TDBs) in the Training Groups. The TDBs are responsible for the development and management of specific training materials and instruction. Training specialists and instructors assigned to various projects are responsible for designing, developing, delivering, and modifying course materials. Organization of the training wing is in accordance with AFR 23-40.

The decision to train is typically made on the basis of occupational survey reports (OSRs) and then passed to the training wing, sometimes with constraints (time in school, budgets, whether or not to export the training, etc.). The Training Groups are responsible for developing course resource estimates.

The decision to use self-paced instruction (programmed texts or computer-based training) is typically made in developing the training plan after the course resource estimate is developed. The training plan is developed following the guide of the STS's task knowledge, skill, and performance levels. Plans of instruction are then developed to elaborate training plans. Lesson plans are then implemented and the course taught. Evaluations typically occur in the field about 6 months after graduation from the school.

Most of the training is developed to be delivered in a group-paced, stand-up setting with small classes (8 students). A few interactive, self-paced courses are being developed. Typical hours of development per course hour for self-paced instruction are 600 to 700.

B. 3 Oct 89 0900 - 1100 3450 TCHTG/TTMYF (Tng Dev Branch)
3450 TCHTG/TTMYF (Instructors)

Participants in this meeting included Brian Dallman, Capt. Coward, Dr. Muraida, Dr. Spector, 3 training specialists from a TDB, and 3 instructors. These training specialists represented the Avionics Training Division which had recently put 10 new courses in place.

Two of the TDB personnel had come straight from an overseas flight-line assignment to the TDB with no prior specific schooling or course authoring experience. One instructor admitted that he was not a qualified subject matter expert (SME) due to equipment upgrades. TDB personnel indicated that strict adherence to ATC Instructional Systems Design (ISD) procedures caused some problems and misunderstanding. Specifically, the ISD sequence from objectives to tests to materials was not generally accepted or understood. Instructors reported that standards were lax (e.g., 80% on an open book exam) and the wash-out rate was non-existent. Training quality reports from the field were not timely, were not detailed, and lacked constructive criticism, according to TDB personnel.

Both TDB personnel and instructors reported that instructional design decisions were made above the training group level (training managers at the wing, at ATC headquarters, or at the using commands). TDB personnel indicated that lesson sequencing was done almost totally in accordance with the sequence reflected in the STS.

C. 3 Oct 89 1300 - 1500 3400 TCHTW (Training Managers)

Participants in this meeting included Brian Dallman, Capt. Coward, Dr. Muraida, Dr. Spector, and 6 training managers

(TMs), all but one of whom were civilians, whereas most of the training specialists in the training groups were NCOs. The primary focus of this meeting was decision-making processes affecting course design and development.

The training managers reported that the TDBs do not develop instruction. Instruction is developed by SMEs who are not instructional designers. TMs may have instructional design expertise but do not dictate instructional design. This group of TMs reported that important instructional design and development decisions were made at systems acquisition time or by System Program Offices (SPOs), especially for equipment-based courses. TMs did not interact directly with the SMEs; rather they interacted with the TDBs. TMs described ISD documentation requirements as a hassle and indicated that they had little authority to make instructional design or development decisions.

D. 4 Oct 89 0900 - 1100 3450 TCHTG/TTMYA (ATLAS/F-16)

Participants in this meeting included Brian Dallman, Capt. Coward, Dr. Muraida, Dr. Spector, and 6 training specialists assigned to the ATLAS/F-16 & F-111 IVD projects. The focus of this discussion was on instructional design and lesson development in an IVD setting.

The 3306 TES set the training requirements, including decisions about training resources. These decisions were passed along to TMs who passed them to the TDBs. TDB personnel reported being left out of the decision-making process. Some SMEs did not agree with the STS requirements as there were minimal requirements for hands-on knowledge; based on their own field experience they believed that hands-on knowledge was highly desirable. Course sequencing typically followed the outline of the STS.

Instructional designers reported a long learning curve to master QUEST and other aspects of IVD authoring. They used an AIS IVD model developed by AFHRL; they reported that having additional IVD lesson models would have been helpful. There was concern that the expertise of these military training specialists would be lost when they transferred to another assignment.

Designers indicated that a guide on the use of IVD published at Hill AFB and ATC Manual 50-4 on CAI were useful. Many design decisions, however, were made by trial and error. The first 3 or 4 course offerings were used for internal validation.

Essential requirements for the authoring system in this environment were reported to be flexibility and complexity in order to accommodate the varying lesson requirements. In addition, due to frequent modifications to the aircraft, course materials were in a constant state of revision, making ease-of-modification an important characteristic of an authoring system.

The group reported that the faculty development 1 month course on the QUEST language was inadequate because it did not incorporate any materials on the use of IVD. Dr. Ruth Gordon's 1 week course on CAI for training managers was judged outstanding, as was the AIS training offered off base.

Designers reported a general lack of materials to guide CBT development and that existing ISD materials were not relevant to CBT. They also reported that time constraints to get courses on-line caused violations in regular, established review procedures. Several time-consuming tasks were identified, including reviews of training plans and course charts, required documentation (especially ATC Form 10), and formatting disks and grading tests.

E. 4 Oct 89 1300 - 1500 3460 TCHTG/TTMTN (BMIS)

Participants in this meeting included Brian Dallman, Capt. Coward, Dr. Muraida, Dr. Spector, and 4 training specialists assigned to the BMIS project. The focus of this discussion was the process of instructional development in a CBT environment.

This group indicated that the decision to use CBT had been made by outsiders. They were handed the requirement of developing exportable courses to be maintained at Lowry AFB. They indicated that the only specialized military training received relevant to their jobs were the faculty development courses on QUEST (1 month) and CAI (1 week) and these courses were superficial. They all indicated a willingness and eagerness to take additional courses and learn more.

A great deal of time was spent in flowcharting lessons. One training specialist reported that 300 hours were spent in developing a flowchart for a 45 minute lesson (this includes the review process). Typical development hours per hour of instruction were in the 500 to 600 range. Most designers were self-taught and learned by reading, seeing good examples, and trial and error.

Several personnel indicated that decision aids for media selection would have been useful. Rigid interpretation of ISD documentation was reported as a problem area. Teamwork was identified as an essential ingredient of successful CBT development, with the team composed of an SME, an instructional design specialist, and a programmer. This group felt fortunate to have collected this expertise and worried what would happen when military personnel transferred out.

F. 5 Oct 89 0900 - 1100 3430 TCHTG/TTMA (Space Systems)

Participants in this meeting included Brian Dallman, Capt. Coward, Dr. Muraida, Dr. Spector, and 8 training specialists in the CBT Development Branch. This group included several officers, NCOs, and civilian personnel. They were operating in a new building with new computer laboratories. They had recently put 3 new courses in place. The discussion focused on their experiences with CBT and IVD.

An immediate concern about sustaining financial support for this very well-equipped facility was expressed. Although this facility was well-equipped, there was no local capability for IVD editing or simulation editing. In addition, a local area network (LAN) for computer-managed instruction (CMI) and graphics development software were cited as other resources in immediate demand.

There was a great deal of programming experience in this group, they cited the need for additional training in the area of instructional design. They had learned CBT design techniques by trial and error and by examining the few available models. In designing instruction, they were guided by 3 general goals: 1) involve the learner, 2) make the system responsive to the learner, and 3) make the material interest-sustaining. There was no specific guides for the elaboration of any of these goals.

When asked about useful tools in designing and developing instruction, this group cited the usefulness of IVD editors, simulation editors, graphics editors, and tools to automate the ISD documentation requirements. A rapid lesson prototyper would be extremely useful. They believed guides, manuals, and models for CBT were quickly outdated, based on past experience.

Story-boarding was cited as an especially time consuming task. Lack of a central repository of information and expertise was cited as an additional problem area. The importance of maintaining an important and meaningful role for the instructor in a CBT setting was emphasized, although no specific or systematic ways of doing this were cited.

This group believed uninformed outsiders were establishing requirements for instructional design and imposing impossible time constraints. They cited the lack of standardization of such lesson-level things as screen design as another problem area.

G. 5 Oct 89 1300 - 1500 3400 TCHTW/TTF (CBT Tng & Fac Dev)

Participants in this meeting included Brian Dallman, Capt.

Coward, Dr. Muraida, Dr. Spector, and four representatives from the faculty development division (1 officer, 1 civilian, and 2 NCOs). The focus of this meeting was the support given by faculty development to the various training groups.

Faculty development personnel indicated that there was minimal support for training in the area of CBT because there needed to be a documented 30% usage level before regular and standard support could be provided. Current courses aimed at in-coming SMEs who end up doing most of the instructional design emphasized the required ATC ISD documentation. This group believed it was an invalid assumption and a mistake to think that any of the faculty development courses would turn an SME into an instructional designer. They believed that TDB personnel should be responsible for most of the instructional design and let the SMEs focus on actual instruction and maintaining their subject matter expertise.

The faculty development group said that they, too, needed more training in the area of instructional design. A central repository of bad examples of instructional design, as well as a collection of good examples, was cited as a desirable tool. They believed that the training groups needed more guidance in the area of instructional design and suggested established design teams and consolidating existing expertise and lessons learned in some manner (expert support team or an expert system).

H. 6 Oct 89 0900 - 1100 3440 TCHTG/TTMXS-Z (MS&D Exp Tng)

Participants in this meeting included Brian Dallman, Capt. Coward, Dr. Muraida, Dr. Spector, and 14 members of the 3440th Training Group who were involved in developing exportable CBT training. The focus of discussion in this meeting was their experiences in adapting ISD to the exportable CBT arena.

This group of training specialists had worked closely with the using command to establish several specific principles of instructional design appropriate to their situation. For example, they required a student interaction every 3 to 5 frames. In determining appropriate feedback, they asked 3 questions, categorized as easy, medium, and hard, and then branched based on responses. They attempted to place all fundamentals and basics in the first block of instruction. The group was happy to have this kind of specific guidance and did not question its universal application in their setting.

The ISD model that had been adapted to their setting involved these steps: 1) task breakdown into elements, 2) tiger team review of the task breakdown, 3) identifying instructional outcomes for each task and appropriate methodologies (e.g., remediation, continuance, etc.), 4) developing tutorial materials with interactions every 3 to 5 frames, 5) practice with the particular task components, and 6) mastery testing of the whole task.

The group expressed dissatisfaction with fitting the whole-task mastery model into rigidly interpreted ATC school-house models of satisfactory performance (e.g., 70% might be a pass in a typical stand-up setting). In general, the group believed that many of the requirements being imposed by wing training personnel were not appropriate in their setting. They also believed that they had not received the appropriate training for their task and had been thrown into an unfamiliar and demanding setting.

In spite of these perceived obstacles, this group expressed a can-do attitude and a principled, systematic approach to CBT design. They developed elaborate task hierarchies and reviewed these hierarchies in a group setting. In developing the hierarchies they were guided by this question: If you were a job site supervisor, what would you like this person to know at the end of this training? They made minimal assumptions about student knowledge. They grouped material into 40 minute lessons.

The most time-consuming task was the review process for lesson materials. Reviewers were viewed as inconsistent and the linear review process caused unnecessary delays. Consistent standards for lesson materials had not been carefully elaborated. Story-boarding and flowcharting was done by hand and was also time-consuming. Automated ISD documentation was definitely desired, especially in a manner that put the ISD process in the background and allowed the training specialists to focus on the design and development of lesson materials.

In addition, they believed that they were operating with a standard of 270 hours of development per hour of instruction imposed by the training wing. Wing personnel present indicated that this had been an unfortunate misunderstanding. Everyone believed that 270:1 was a totally unrealistic ratio, especially for novices working in an exportable CBT setting.

With regard to resources, this group would have liked exemplar lesson models at the beginning of the project, but they saw no value in such models now. They were not using the Hill AFB style guide because they believed that it was not meaningful. They cited the need for a centralized repository of knowledge and tools.

V. Conclusions

The following list reflects needs, issues, and problem areas that we believe are relevant in the development of AIDA

1. There is a general lack of knowledge about educational

principles and implications for instructional design at all levels. Several individuals had developed instructional design expertise and were sensitive to such things as working memory overload and varying requirements for simulation fidelity, but many of these experts would soon be transferring back to field organizations. There is a need for a centralized source of instructional design expertise (principles, standards, tools, examples, etc.) which is accessible to instructors, designers, developers, and managers.

2. There is an immediate demand and need for tools to automate the ISD documentation process and develop other course materials. Such tools, should they be developed, should allow users to focus on developing and revising course materials, making ISD documentation a background/hidden support system.

3. There is very little understanding of alternative instructional models. Instructor-based training is fairly well understood, although the instructor's role as a model for a professional military technician is not well-documented in the ISD process for instructor-based training. There is a definite and obvious need for well-articulated guidelines for the instructor's role in a CBT setting.

4. Decisions which affect instructional design are made at a variety of levels, including acquisition groups, using groups, ATC headquarters, TMs, TDBs, and the training specialists who design, develop, deliver, and maintain the instruction. Some decisions made by one group may seem uninformed and capricious to another group. Consistently effective decision-making in the instructional design process is needed. Instructional design/decision aids which offer informed alternatives and can produce justifications would be useful in working towards a consistently effective decision-making process.

5. Many of those involved at all levels in instructional design and development felt those involved at higher levels did not fully support or understand their specific tasks. Decision aids should be aimed at both informed and uninformed audiences and should provide justifications and alternatives.