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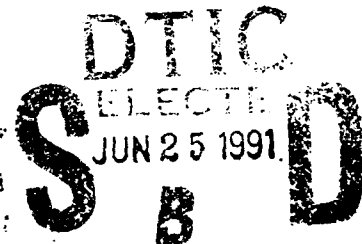


**ARMSTRONG
LABORATORY**

**SPECIFICATIONS FOR AN ADVANCED
INSTRUCTIONAL DESIGN ADVISOR (AIDA)
FOR COMPUTER-BASED TRAINING**

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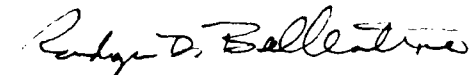
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13. ABSTRACT (Maximum 200 words) The Advanced Instructional Design Advisor (AIDA) is an AFHRL project aimed at providing developers of computer-based instruction with automated and intelligent tools to assist in the design, development, and delivery of courseware. This paper summarizes the design of AIDA and indicates an appropriate method for implementing and testing an initial AIDA prototype.				
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PREFACE

This is the final report for Task Order No. 6 of Contract No. F33615-88-C-0003. The report is the joint effort of the Air Force Human Resources Laboratory (AFHRL), the sponsor of the research, and the contractor, Mei Associates, Inc.

Section 1, describing the history of the AIDA concept within AFHRL and the Laboratory's long range plan for AIDA, was written by AFHRL.

Sections 2 and 3, describing the purpose, detailed requirements, approach, and plan for Task 6, were prepared by Mei Associates.

Section 4, containing summaries of the concept papers, synopses of the concept design and review meetings, and Section 5, defining the problems to be addressed in follow-on tasks, were prepared by AFHRL.

Section 6 presents the preliminary system specifications that are the product of the task effort. The section is divided in two parts. The first describes the functional architecture and was written by AFHRL. The second part lists a sample of some 100 system functions and characteristics defined in the task. It was compiled by Mei Associates.

Finally, Section 7 outlines the research questions which were identified, for both near term and long term resolution by AFHRL. This section was prepared by AFHRL.

Mei Associates compiled the appendices and edited the complete manuscript.

Dr. Dan Muraida was the contract monitor for AFHRL. Dr. Mike Spector conceptualized the AIDA project under the direction of Dr. Scott Newcomb, Branch Chief for the Training Technology Branch of the Training Systems Division of AFHRL (AFHRL/IDC). Dr. Albert E. Hickey was project manager for the contractor, Mei Associates.

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SECTION 1. BACKGROUND

The purpose of this section is to provide background information. The discussion is divided into four parts: 1) a short history of the AIDA concept, 2) AFHRL/IDC's long range plan for AIDA, 3) the long range schedule, and 4) the benefits of the long range AIDA program.

1.1 HISTORY OF THE AIDA CONCEPT

The Advanced Instructional Design Advisor (AIDA) was first described in Preliminary Design Considerations for an Advanced Instructional Design Advisor, Dr. Michael Spector's final report for his 1988 Summer Faculty Research Program grant at the Air Force Human Resources Laboratory (AFHRL). That research was conducted under the supervision of Dr. Scott Newcomb, Branch Chief for the Training Technology Branch of the Training Systems Division (AFHRL/IDC).

Newcomb assigned Spector the task of conceptualizing a next-generation courseware authoring system for the Air Force. Spector conducted an extensive literature search, reviewed several authoring systems used by the DoD including the Air Force's ISS and SOCRATES and the Navy's AIM and CBESS systems, and had many engaging discussions with Newcomb and other researchers about what the future held in store for courseware authoring.

The central problem in courseware authoring was identified as the difficulty and expense of designing effective instructional materials given the complexities of advanced hardware and software technologies and the variety of instructional settings. Existing systems did not address the issue of effective instructional design at the course level.

Spector proposed a computer-based tool to assist in the instructional design process. The tool would reduce course development time while assisting in the production of consistently effective instructional materials. AIDA would incorporate prescriptive advice about course authoring based on established theories of knowledge, learning, and instruction.

AIDA would contain a variety of tools. Some would automate established processes. Others would assist or advise authors about designing effective instructional materials. The tools might be used as stand-alone, special purpose tools, or as integrated tools using a shared database of course and content information.

Since a variety of tools were envisioned, it was recommended that a modular approach be adopted and that a standard design philosophy be specified in order to provide for the graceful

growth of the system. In order to incorporate the best instructional knowledge available, Spector recommended using a team of experts in the fields of epistemology, cognitive psychology, artificial intelligence, computer systems, and curriculum and instructional design. The team of experts would develop specifications for a standard design philosophy and a requirements specification for AIDA. A prototype AIDA based on a minimal functional subset would then be built and evaluated.

AFHRL/IDC decided to continue the exploratory development of AIDA under Work Unit 1121-10-43, Computer-Based Training (CBT) Software Development and Technical Support. The AIDA project is primarily a response to the Air Training Command (ATC) MPTN 89-14T, Research and Development of Computer-Based Instruction (CBI).

In a follow-on 1989 Research Initiation Program grant, Spector submitted a report entitled Refinement Considerations for an Advanced Instructional Design Advisor. In that document, the instructional design process was divided into three phases: 1) front end analysis (FEA), 2) design, development, and delivery (DDD), and 3) rear-end analysis (REA). One finding was that the design phase of DDD, as well as FEA and REA, had received inadequate support in the form of research and development.

Spector also evaluated the potential role for artificial intelligence (AI) in the instructional design process. AI applications were divided into two large groups: artificial neural networks and expert systems. While neural networks hold great promise in the general area of pattern recognition, there does not appear to be an immediate application in the area of instructional design. As automated learning environments become more interactive and conversational, perhaps neural networks will have a significant role to play in the area of speech processing.

There does appear to be a significant role for expert systems in instructional design. Diagnostic expert systems have already been successfully incorporated into intelligent tutoring systems. Expert planning systems were envisioned to aid courseware designers in the development of consistently effective course materials for a variety of subject matter domains and knowledge types.

Task 6 is the first in a series of tasks (see section 1.2 below) to refine, elaborate, and evaluate the AIDA concept. This report reflects progress on AIDA through May 1990. The AFHRL/IDC AIDA Project Manager is Dr. Dan Muraida. The contractor for Task 6 is Mei Associates, Inc. of Lexington, Massachusetts. Mei Associates' Principal Investigator is Dr. Albert Hickey. Spector has continued working with AFHRL on the AIDA project under a University Resident Research Program grant.

1.2 THE LONG RANGE PLAN FOR AIDA

This section represents AFHRL/IDC's current overarching plan for the AIDA project.

The purpose of the Advanced Instructional Design Advisor (AIDA) program is to provide reliable, effective, and efficient instructional design guidelines for Air Force course designers. The approach to this goal contains four thrusts. Each is described below.

1.2.1 Status and Structure of Instructional Design Knowledge

The first thrust is an effort to assess what is currently known about instruction and instructional design. This assessment focuses on the major validated findings of instructional design research. The purpose is to derive critical instructional design information and initial estimates of the necessary detail for instructional design guidelines. In addition, this effort will identify areas of contradictory research findings and produce recommendations for an instructional design research and development agenda. This work was conducted under a task order contract (Task 6).

1.2.2 Instructional Design Guidelines: Functional Requirements

The second thrust attempts to identify optimal methods of organizing and presenting validated instructional design information in the form of guidelines. Part of this effort builds on prior work which will have identified relationships among different areas of instructional design knowledge.

The focus is on functional requirements for an organized collection of guidelines which accurately represent the complexities of instructional design without exposing the user to those complexities. The functional requirements will be based on a model of instructional design which embraces the processes of design, development and delivery. A subsequent task will elaborate the functional requirements and develop a set of design specifications for an automated system of guidelines. This work was conducted under two task order contracts (Tasks 6 and 13).

The computer architecture and human factors issues involved in producing automated guidelines will be studied in a Small Business Innovative Research (SBIR) effort.

1.2.3 Empirical Studies of Instructional Guidelines Delivery and Supporting Instructional Strategies

In the third thrust, empirical research will be planned in parallel with the development of elaborated functional requirements and specifications. The elaborated functional requirements and specifications will encompass a complete automated guideline system, although they will be used to build an experimental testbed system which implements only certain basic functions of an automated guideline system.

All empirical research done prior to the development of the experimental testbed system will be conducted under the auspices of an in-house work unit. All development work devoted to building the testbed will be conducted under a Broad Agency Announcement (BAA) contracting vehicle. Empirical research using the testbed system to conduct studies on guideline characteristics or instructional strategies will be conducted under the auspices of the BAA.

a. Prior to Completion of the Experimental Testbed:

Guidelines research will focus on identifying critical variables in the automated instructional design process. Existing prototypes which automate a limited number of basic instructional design processes will be used for this purpose. The data and the conclusions of this stage of the guidelines research will provide useful information for design of the experimental testbed system and the subsequent research which it will support.

Research in the effectiveness of instructional strategies with computer-based interactive technologies will also employ existing instructional authoring tools. The first set of instructional strategy studies will address the lack of instructional principles for the use of audio reinforcement in a CBT setting. A second set of studies will examine Merrill's transaction theory and the usefulness of transaction shells in CBT. The results of the work accomplished prior to the completion of the experimental testbed system will add to the knowledge base of instructional design principles required for a system of instructional guidelines.

b. After Completion of the Experimental Testbed:

At this point most of the guidelines research will be conducted using the testbed's capability to present different types of instructional design guidance and different methods of interacting with the user. Likewise, most of the instructional strategy research will use the capability of the testbed system to implement basic instructional functions (e.g., establishing linkages between instructional objectives and plausible instructional strategies).

The research and development conducted during this phase of the AIDA project will provide new information about the optimal nature and delivery characteristics of instructional design guidance for the non-expert instructional designer. Secondly, this research phase will begin to produce conclusions about the extent to which instructional strategies (new or old) can be extrapolated to a computer-based interactive setting.

1.2.4 Empirical Test of an Instructional Design Guidance Methodology

The fourth thrust of the AIDA research program will consist of the design, development, and testing of the complete experimental model. This will include tests of all functions of the automated guideline system, continued experimentation on optimal guideline characteristics, and continued research on instructional strategies in the automated delivery of instruction. This work will be conducted under a fully specified contract.

1.3 THE LONG RANGE SCHEDULE

1.3.1 Milestones

Complete work in first thrust area with the following products:

Review of current instructional design theory;
A cognitive model of the instructional design process;
Functional requirements for instructional design guidelines;
A research and development agenda for instructional design;
Recommendations for instructional design research.

.....3rd QTR90

Business Strategy: Task Order Contract

Contract award for functional and design specifications for a subsystem of instructional design guidelines ...3rd QTR90

Business Strategy: Task Order Contract

Completion of instructional design guidelines1st QTR91

Contract award for (1) design, development and testing an experimental model of an automated guideline system and (2) initial instructional strategies and guidelines research1st QTR91

Business Strategy: Broad Agency Announcement

Completion of experimental model tests and associated instructional strategies and guidelines studies...1st QTR94

Contract award for (1) Construction and test of the complete experimental model of automated guideline system and (2) continuation of instructional strategies and guidelines research1st QTR94

Completion of experimental model tests and instructional guidelines and strategies research.1st QTR98

1.3.2 List of Relevant Work Units

Thrust:

- 1st: 1121-10-43, Task 6
- 2nd 1121-10-43, Task 6 and 13; 1121-10-70 (SBIR)
- 3rd 1121-10-66, In-House Work Unit; 1121-10-71 Direct BAA
- 4th 1121-10-67, Fully Specified Contract.

1.4 BENEFITS OF THE LONG RANGE AIDA PROGRAM

1.4.1 Payoff

The expected contributions of AIDA to Air Force training are:

- o reduced training costs
- o increased utility of CBT technologies
- o increased instructor productivity
- o reduced student time under instruction
- o increased student comprehension and learning transfer
- o establishment of instruction standards
- o improved quality assurance.

1.4.2 Opportunity

Subject Matter Experts (SMEs) with little or no experience in instructional design or ISD will be able to use a theoretically oriented and empirically validated collection of instructional design tools to determine optimal instructional designs. As a result, novice instructional designers will be able to produce efficient and effective instruction in a variety of delivery modes.

SECTION 2. INTRODUCTION TO TASK 6

2.1 PURPOSE OF TASK 6

The objective of Task 6, called AIDA Phase I, was to design, develop, and document the concept and functional specifications for AIDA as the basis for subsequent work units (see Sec. 1.2.1).

2.2 BACKGROUND

Basic behavioral science issues had to be resolved before designing AIDA. For example: (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 artificial intelligence in instructional design? There were other issues to be resolved. For example: (1) Which strategies should be followed in order to design and develop advanced authoring aids? (2) What kinds of advanced authoring aids already exist and how effective are they? (3) How might ISD be incorporated into AIDA? These were the questions to be answered in Task 6.

SECTION 3. METHODOLOGY FOR TASK 6

To accomplish Task 6, Mei Associates retained as consultants seven of the most creative people in the fields of psychology and instructional design, both theory and practice, and brought them together in an interactive procedure which resulted in the integration of the best concepts for AIDA.

3.1 THE CONSULTANTS

Seven consultants were chosen from among academic researchers with a reputation and demonstrated research in fields related to instruction design. They are:

- | | |
|---------------------------|-----------------------------------|
| 1. Dr. Robert M. Gagne | Florida State University |
| 2. Dr. Henry M. Halff | Halff Resources, Inc. |
| 3. Dr. M. Dav' Merrill | Utah State University |
| 4. Dr. Martha C. Polson | University of Colorado |
| 5. Dr. Robert D. Tenryson | University of Minnesota |
| 6. Dr. Harold F. O'Neil | University of Southern California |
| 7. Dr. Charles Reigeluth | Indiana University |

The first five consultants on the list were designated "design consultants." The last two were appointed "review consultants" to review and critique the concept documents prepared by the design consultants.

Abbreviated vitae of the seven consultants are presented in Appendix E.

3.2 THE MILITARY ADVISORS

At the same time, the Air Force Human Resources Laboratory (AFHRL) invited specialists from the three services to join a board of Military Advisors. The military advisors are:

- | | |
|-------------------------|---------------------|
| 1. Dr. Dee Andrews | AFHRL/OTT |
| 2. LCOL Jerry Barucky | USAFRS/RSCD |
| 3. LCOL Mike Bush | USAF/DFP |
| 4. LCOL Larry Clemons | ATC/XPCRI |
| 5. CAPT James Coward | HQ ATC/XPCRI |
| 6. Mr. Brian Dallman | 3400 TCHTW/TTOZLCL |
| 7. LCOL Mike Dickinson | HQ HSD/YA |
| 8. Dr. John A. Ellis | NPRDC |
| 9. Mr. John LaBarbera | HQ USAF/DPPT |
| 10. Dr. Mary Marlino | USAF/DFP |
| 11. Dan Meigs (Retired) | 3302d TCHTS/CC |
| 12. MAJ Robert Mongillo | ATC/XPCRR |
| 13. Rich Ranker | AWC/DFP |
| 14. MAJ Karen Reid | ATC/TTIP |
| 15. Dr. Robert Seidel | Army Research Inst. |

3.3 PROJECT MANAGEMENT

The Project Manager for the contractor, Mei Associates, was Dr. Albert E. Hickey. The Project Monitors for AFHRL were Drs. Daniel Muraida and Michael Spector.

3.4 THE PROCEDURE

As described in detail in Sections 1 and 2, the objective of Task 6 was to design, develop, and document the concept and functional specifications for AIDA.

The task was divided into two consecutive design cycles, each about four months in duration. Each design cycle was organized around three two-day meetings at AFHRL: a Planning Meeting, a Concept Design Meeting, and a Concept Review Meeting. The schedule is shown in Table 3.1.

Cycle 1:

1.	Kick-off Meeting,	Part 1	Jul 6
		Part 2	Jul 18-19
		Part 3	Aug 8-9
2.	First Concept Design Meeting		Oct 18-19
3.	First Concept Review Meeting		Dec 5

Cycle 2:

4.	Planning Meeting		Dec 6
5.	Second Concept Design Meeting		Feb 20-21
6.	Final Concept Review Meeting		Apr 24-25

TABLE 3.1 PHASE I SCHEDULE

AIDA TIME-LINE

Task Order 006

1989

1990

Aug Sep Oct Nov Dec Jan Feb Mar Apr May

August 17-18 5-6 20-21 25-26 20

(2.1)

(2.3)

(2.6)

(2.8)

(2.11)

Kick-off Initial 5 Integration Present 5 Integration
Meetings task papers 5 new tasks new tasks Consolidation

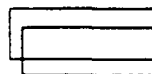
Drafts due
Oct 10



Oct 31



Mar 10



← Cycle 1 →

→ Cycle 2 →

Figure 3.1

AFHRL and Mei Associates collaborated in formulating the agenda for the six meetings. The meeting agenda are reproduced in Appendix A.

In each of the two design cycles, the five design consultants performed tasks assigned during the first meeting in the cycle. In cycle 1, the tasks were tailored to the individual consultants. In cycle 2, all five design consultants received the same tasking letter and were asked to choose the remaining issues they wished to address. The design consultants submitted their task results, in the form of concept papers, to Mei Associates for distribution to the participants prior to each Concept Design Meeting. The papers were presented and discussed at the meeting. Some papers were subsequently revised.

At each of the two Concept Design Meetings, the five design consultants drafted the tasking letter for the two review consultants, Drs. O'Neil and Reigeluth. In cycle 2, two of the military advisors, Mr. Dallman and Dr. Marlino, also accepted review assignments.

The review consultants were asked to allocate five days to their review of the concept paper and the ensuing discussion. Their reviews were disseminated in draft prior to each Concept Review Meeting, where they were presented and discussed.

Copies of the tasking letters to the design and review consultants are reproduced in Appendix B.

The proceedings of all meetings were recorded and transcribed by the contractor. AFHRL prepared and distributed a Progress Report following each meeting. A list of the documents produced during the task is given in Appendix C.

SECTION 4. TASK RESULTS AND CONCLUSIONS

The purpose of this section of the report is to summarize the results of the current task, Task 6. The discussion is divided into five parts: 1) Analyses of the cycle 1 papers, 2) Analyses of the cycle 2 papers, 3) Reviews of the meetings, 4) Areas of consensus and disagreement, and 5) Conclusions about key parameters and issues related to AIDA.

4.1 ANALYSES OF CYCLE 1 PAPERS

This section contains summaries of the papers submitted in cycle 1. Specific task assignments for these papers can be found in Appendix B.

4.1.1 Gagne's Cycle 1 Paper: "Principles of Instructional Theory"

Summary

Gagne's purpose was to cite the basic principles established in instructional science and indicate their importance in determining the nature of instruction. Gagne outlined 12 principles of instructional theory and indicated the relative importance and difficulty of learning each. Discussion indicated general agreement with two notable exceptions: 1) Those indicated as easy to master were not so easy to master, and 2) the presentation (not the order) of generality, instances/non-instances, and practice was the critical element in the principle concerning concepts and rules. Gagne revised his paper to reflect his agreement on these two issues.

Major Assumptions

1. Single objective lesson components can be isolated.
2. Applying instructional principles will optimize learning.
3. Mastery of many instructional principles is relatively easy.
4. There is no general principle covering expository or discovery learning.
5. Learning objectives determine instructional strategies.
6. The nature of the cognitive task determines the learning objective.
7. Learning is internal; instruction is external.

Major Propositions

With regard to student attention:

1. Arouse student interest before initiating any other transactions.

With regard to task clarity:

2. Communicate clearly what the student must learn to do -- demonstrate its usefulness.
3. Communicate the relation between what is to be learned and its usefulness.
4. Make the stimulus aspect of the task readily perceptible.

With regard to stimulating cognitive processing:

5. Stimulate recall of previously learned relevant information.
6. Guide learning through elaborations.
7. Verify initial learning by performance.
8. Provide varied practice with corrective feedback.
9. Arrange occasions that require retrieval.

With regard to learning objectives:

10. Five types of learning objectives have been identified. They are coupled with the following instructional strategies:
 - (i) Verbal - Relate to organized prior knowledge; use spaced review.
 - (ii) Concepts - Provide definitions, examples, non-examples, and practice in identifying new examples.
 - (iii) Procedural - Verify mastery of parts of a task before attempting the whole task.
 - (iv) Motor - Provide practice with reinforcement.
 - (v) Attitudes - Provide demonstration with a human role model.

4.1.2 Halff's Cycle 1 Paper: "Prospects for Automating Instructional Design"

Summary

Halff's purpose was to provide a concept of how AIDA would support the development of two broad instructional paradigms, and to identify the principles of learning and instruction that apply to the design of each of the AIDAs and to its instructional products. Halff argued that cognitive structures have a role to play in instructional design. He maintained that learning mechanisms and instructional design are interdependent; a shortcoming of many current instructional design researchers and implementers is to ignore learning mechanisms.

Halff described two general approaches to the automation of instructional design: advisory and generative. The advisory approach attempts to automate the formulation of instructional designs, making implementation primarily the responsibility of a human developer. The generative approach attempts to use the computer to generate instruction from known instructional paradigms. He then presented two examples of generative approaches and argued that generative approaches to automating instructional design show some promise.

Halff asserted that successful automation of instructional design requires a prudent division of labor between the human and the computer. He saw the large scale production of instructional materials which conform to complex specifications as an appropriate role for the computer in instructional design. Another role would be the use of the computer to track the development of the design, offering suggestions on modifications and additions. He argued that the interpretation of instructional design principles and the decisions on how to fashion them into a viable design should lie within the jurisdiction of the human developer.

Major Assumptions

With regard to instructional theory and learning theory:

1. A theory of instruction is needed to support both automation and justification of the instructional design functions.
2. Learning should be understood in mechanistic terms.
3. A complete theory of learning will describe stimuli, responses, performance mechanisms, and the laws of learning.
4. The individual organism is the unit of analysis in any theory of learning.

With regard to knowledge representation, transmission, and context:

5. Cognitive functions receive contextual support in non-instructional situations.
6. As knowledge evolves so do the mechanisms for its transmission (i.e., instruction).
7. Instruction is an evolutionary process.
8. The non-instructional context is significant.

With regard to instructional design:

9. In any given context the implementation of successful instructional design recommendations is a function of the designer's interpretation and intuitions.
10. Instructional design principles are not separable from content.

With regard to ISD:

11. ISD implies that instructional objectives can be determined without reference to instructional methods and that methods are not subject specific. (Halff does not support this separation.)

Major Propositions

Concerning instruction and instructional design:

1. Effective instructional design is a cooperative enterprise between instructional designers and learners based on mutual observance of cultural conventions for effective learning.
2. Instructional designers are typically not committed to learning mechanisms and theory, but they are sensitive to the situated nature of learning.
3. Human instructional designers should be involved in some way in the development of instruction.
4. Top-down structure analysis for instructional design works when applied appropriately.

With regard to prospects for automation:

5. Computers can be usefully employed to generate alternative, device-specific strategies, sequence problems, project costs, and evaluate them.

6. Automation should assist in the generation of instruction from known designs, and should support existing instructional paradigms for broad subject areas, rather than attempting to implement a universal theory of instruction.

4.1.3 Kintsch's Cycle 1 Paper: "Principles of Instructional Theory from Research on Human Cognition"

Summary

Kintsch's paper, which she prepared under a subcontract to Polson, presented 10 learning principles drawn primarily from cognitive science research (especially Glaser and Bassok, 1989) with emphasis on their implications for instruction. These principles were well received by the other consultants, reflecting general consensus in this area. The principles are as follows:

1. Comprehension in all domains is an active process of meaning construction by which the learner creates an interpretation of the incoming information. Instruction should be centered on the learner's own knowledge construction activities.
2. Learning occurs by extending existing knowledge. In designing instruction, one needs to be aware where students are in acquiring new skills, and what kind of knowledge manipulation is important in a given context.
3. The organization of knowledge in memory determines its accessibility and the depth of understanding that is achieved. Instruction should find multiple ways to tie new information to the learner's prior knowledge.
4. Learning is enhanced when knowledge is learned in a specific context with a specific and stated cognitive goal. New knowledge should be taught in a meaningful context.
5. Comprehension, writing, problem solving and learning are strategic rather than rule-governed processes. Instruction should be designed to make the relevant cognitive strategies explicit.
6. Metacognition is a significant component of knowledge acquisition and use. Cognitive apprenticeship is a promising instructional approach.
7. Knowledge acquisition is supported by learning in a social setting. Cooperative and collaborative learning environments should be fostered, even in CBT settings.

8. The ability to engage in higher-level thinking depends on automaticity at lower levels. Instruction should provide opportunities for extensive practice.
9. Learning is enhanced through immediate qualitative feedback. Instruction should provide feedback geared to the learner's present level of knowledge or skill.
10. The content of instruction should be designed to fit the changing needs of students at different stages of skill acquisition. Tasks should increase in complexity; sequencing should reflect increasing diversity; and tasks requiring global skills should be presented first to encourage the construction of a conceptual model.

There is no unified learning theory to support these 10 principles, but the author believes that it is important to design instruction within a theoretical account of human information processing. The result of applying these principles would be less emphasis on didactics and more emphasis on problem solving in a collaborative setting.

Major Assumptions

1. Attention to mental structures proposed by cognitive scientists when designing instruction can improve learning.
2. There are three distinct types of knowledge: declarative knowledge of a subject domain, procedural knowledge for operating with declarative knowledge, and knowledge about the conditions of knowledge use (executive control/cognitive strategies).
3. Learning is an active process of meaning construction or interpretation.
4. Learning is strategic -- not rule-governed.
5. The organization of knowledge determines its accessibility.
6. Qualitative differences in strategies separate experts from novices.
7. Internal memory structures/representations are transformed in knowledge transformation.

Major Propositions

1. See the 10 principles presented in the summary; some corollaries follow.

2. Design instruction to encourage the learner's independent meaning construction activities.
3. Introduce connectedness with new knowledge to promote retention and transfer.
4. Introduce new knowledge in a meaningful context.
5. Maximize learner involvement.
6. Put the learner in control of the learning process.
7. Teach strategies in service of meaningful goals.

4.1.4 Merrill's First Cycle 1 Paper: "Project AIDA: A Concept Paper"

Summary

Merrill's purpose was to define the concept of AIDA, to indicate the functions it should perform, including knowledge acquisition and strategy analysis, and to identify the principles of knowledge theory, learning theory, and instructional theory that underlie these functions. This paper is divided into three parts: 1) background information on Merrill's ID EXPERT v1.0 and v2.0, 2) a conceptual review of the components of ID EXPERT v3.0, and 3) a discussion of the theoretical foundations of ID EXPERT v3.0.

ID EXPERT v1.0 was funded by the Army Research Institute (ARI) and implemented using the expert system shell S.1 on a VAX computer. ID EXPERT v2.0, partially funded by ARI, was implemented using NEXPERT and HYPERCARD on Macintosh SE computers. ID EXPERT v3.0 is being developed based on the premise that previous systems and instructional design theories (ID-1) lack prescriptions appropriate to advanced interactive technologies.

ID EXPERT v3.0 consists of 4 main subsystems: 1) a Knowledge Acquisition and Analysis System, 2) a Strategy Analysis System, 3) a set of transaction subsystems, and 4) an Intelligent Advisor-based Instructional Delivery System. Many of these subsystems are constructed of mini-experts which provide highly specialized expertise. The middle part of the paper describes this modular conception in detail.

The last part of the paper is devoted to the theoretical foundations for ID EXPERT v3.0. A second generation instructional design theory (ID-2) is proposed, based on nine limitations of ID-1. The limitations include such things as the emphasis on small components, failure to recognize integrated wholes, limited prescriptions for course organization, and the

general insensitivity to new interactive technologies. ID-2 should be capable of analyzing, representing, and guiding instruction to teach integrated sets of knowledge and skills; it should be capable of producing prescriptions for the selection of instructional strategies and the selection and sequencing of instructional transactions; it should be an open system, able to incorporate new knowledge; and it should integrate the phases of instructional development.

Major Assumptions

1. Learning results in the organizing of memory into structures called mental models.
2. There are different learning outcomes and different conditions required to promote these outcomes.
3. The details of cognitive structures are not well understood.

Major Propositions

1. ID-1 had a behavioral orientation; a cognitive orientation is needed.
2. Organization during learning aids in later retrieval.
3. Elaborations generated at the time of learning can facilitate retrieval.
4. Different learning outcomes require different types of mental models.
5. The construction of a mental model by a learner is facilitated by instruction that explicitly organizes and elaborates the knowledge during the instruction.
6. Different learning outcomes require different organizations and elaborations.
7. The means of knowledge representation should be determined by the use to which the knowledge will be put.
8. The identification of instructional goals is critical to instructional design.
9. Instructional strategy specifies a pedagogy for selecting, sequencing, customizing, and integrating instructional units. There are levels of instructional strategy. Micro-strategy is embedded into a transactional unit and controls the presentation of that transaction. The next level strategy determines how transactions are assembled into frame sets. A higher level determines how frame sets are

integrated into elaborated frames corresponding to a particular instructional goal. The highest level integrates the goals for a course.

10. There are three fundamental frame types: entity, activity, and process.
11. There are three types of elaborations: component, abstraction, and association.

4.1.5 Merrill's Second Cycle 1 Paper: "Project AIDA: A Theory Paper"

Summary

Merrill's second paper was generously provided to facilitate understanding of the principles and theory underlying the first paper. The paper began with a definition of theory and a distinction between descriptive and prescriptive theories. Theories involve objects and relationships. Descriptive theories are concerned with identifying and describing the relevant objects. Prescriptive theories are more concerned with the relationships among objects.

The next section of the paper reviewed ID-1 and ID-2. ID-1 is concerned with the wrong objects; ID-1 objects are too small and fragmented. ID-2 should focus on more robust objects such as mental models and integrated interactions. A major task confronting ID-2 is to completely describe these more complex instructional objects.

Instructional design theory must resolve two major questions: (1) What to teach (content)? and (2) How to teach (pedagogy)? The remainder of the paper is devoted to assumptions and major propositions relevant to these two concerns.

Major Assumptions

1. Instructional theory should be more concerned with descriptive theories.
2. Memory consists of both declarative and procedural knowledge.
3. Memory is organized into integrated sets of declarative and procedural knowledge called mental models.
4. Different learning outcomes require different conditions.

Major Propositions

1. Organization during learning aids in later retrieval.
2. Elaborations generated at learning time can facilitate retrieval.
3. Instruction should focus on helping learners acquire mental models.
4. Acquiring mental models is facilitated by instruction that explicitly organizes and elaborates knowledge.
5. Significant learning outcomes consist of complex human activities (enterprises) requiring integrated sets of knowledge and skill.
6. Different enterprises require different mental models, the cognitive representation of the knowledge and skill required for an enterprise.
7. Different learning activities are required for promoting the acquisition of different mental models.
8. Instructional interactions should be organized around all the activities needed to promote acquiring a particular mental model.
9. Use integrated interactions focusing on all of the knowledge comprising an elaborated frame network to facilitate acquisition of a mental model.
10. Different types of knowledge frames require different types of transactions.
11. The following six content rules apply:
 - (i) There are limits to short-term memory (7 ± 2).
 - (ii) Learning the attributes of a class is essential to generalization and transfer.
 - (iii) There is no enterprise without an entity.
 - (iv) Teaching a tool requires an application.
 - (v) New mental models are built from previously acquired mental models.
 - (vi) A process underlies every human activity and is that which provides an understanding of that activity; one can execute the activity without knowing the process.

12. The following 12 pedagogy rules apply:

- (i) Transactions should be consistent with the role and function type of knowledge involved; student expectations should be taken into account; different roles require instruction that serves different functions.
- (ii) Learners follow the path of least effort.
- (iii) Maximize the amount of learner control that can be used to a learner's advantage.
- (iv) Transactions should promote active interactions.
- (v) Learners learn what they do.
- (vi) Practice without performance feedback is not productive.
- (vii) There are three primary presentation forms: generality, instance, and practice; transactions should include all three.
- (viii) Early learning should involve extensive attention focusing.
- (ix) Learning improves when information is represented in multiple ways.
- (x) Learning improves when instances and non-instances are carefully matched.
- (xi) Learning improves when divergent instances are presented.
- (xii) Learning improves when simple knowledge and skills are elaborated to form more complex knowledge and skills.

4.1.6 Muraida and Spector: "Lowry Needs Assessment Report"

Summary

Muraida and Spector conducted an in-depth, preliminary needs assessment at the Lowry AFB Technical Training Wing (TTC) 2-6 Oct 1989. Brian Dallman (3400 TCHTW/TTOZ) acted as facilitator and arranged interviews with instructional designers, developers, training managers, and instructors involved in various CBT developments. Capt. Coward (ATC/XPCRI) participated in the interviews and contributed many useful insights.

Major Assumption

1. Air Force practitioners have many useful ideas and lessons learned to contribute to the design of an AIDA.

Major Propositions

1. There is a general lack of knowledge about educational principles and implications for instructional design at all levels.
2. There is a need for a centralized source of instructional design expertise.
3. There is an immediate demand and need for tools to automate ISD documentation and develop course materials. Such tools should allow users to focus on developing and revising materials and make ISD documentation a transparent support system.
4. There is very little understanding of alternative (i.e. non-instructor-based) instructional models.
5. Consistently effective decision-making in the instructional design process is needed. Instructional design/decision aids which offer informed alternatives and which can produce justifications would be useful.
6. Decision aids should be aimed at both informed and uninformed audiences and should provide justifications and alternatives.

4.1.7 Polson's Cycle 1 Paper: "Cognitive Theory as a Basis for Instruction"

Summary

Polson's purpose was to state the major distinguishing characteristics of the contents and processes of cognition, including the kinds of knowledge and the different forms each may take (i.e., summarize the results of cognitive science relevant to AIDA). Cognitive science tends to model human cognition as an information processing system operating on three types of knowledge: declarative, procedural, and contextual.

The key components of human cognition are working memory and long term memory. Learning is a matter of encoding and organizing information so that it can be retrieved and used when appropriate. Representation systems are critical in understanding human knowledge. Knowledge is viewed as follows:
1) associative in nature, 2) organized into functional units, 3)

permeated with default beliefs and potential inconsistencies, and 4) hierarchical in structure.

The paper then reviewed two well developed theories of cognition: 1) Kintsch's construction-integration model of discourse comprehension, and 2) Anderson's ACT* theory of skill acquisition. Kintsch's theory is concerned with how declarative knowledge structures are acquired. Anderson's theory is an attempt to model the acquisition of procedural knowledge. Both argue for computer-based training systems to support their views, although Kintsch's CBT is non-intelligent while Anderson supports the use of intelligent tutoring systems.

The conclusion was that a unified theory of cognition does not exist, although Kintsch and Anderson together present a small step in that direction. Lack of a unified theory should not impede progress, however. As Glaser and Bassok have indicated, progress in an area is often made on the basis of instrumentation that is designed to facilitate experimentation. With regard to AIDA, a significant tool would be the design of instructional interventions that operationalize proposed theories in the form of environments, techniques, materials, and equipment.

Major Assumptions

1. All assumptions for Eileen Kintsch apply.
2. Working memory is limited and requires active processing to maintain information; long term memory is unlimited and does not require active processing to maintain information.
3. In order for a cognitive theory to be useful to instructional design it will have to provide guidance on how to design instruction to foster encoding that facilitates appropriate retrieval and manipulation.
4. People act to maintain their goals through rational action.
5. Information processing is an active process on complex knowledge structures; intelligent action results from such processes.
6. Learning is the use of strategic processing to encode, organize, retrieve, and transform information.
7. A theory of knowledge must be based on knowledge representation; issues of representation play a key role in all theories of cognition and memory.
8. A proposition represents a single idea; propositions represent units of meaningful knowledge.

9. The goal of instruction should be to promote coherent, interrelated, well-structured, easily accessible knowledge units.

Major Propositions

1. All of Kintsch's propositions apply.
2. The first task in instructional design is to analyze the knowledge structures of the expert so that the instruction can be aimed at promoting the correct structures.
3. Types of knowledge do not map directly onto types of representation.
4. Learning is the successive transformation of naive mental models into a series of increasingly complex mental models adequate for solving larger sets of problems.
5. We know more about the differences between novices and experts; we know less about the mechanisms of transition.
6. Useful representations for declarative knowledge include propositions, semantic nets, scripts, schemata, frames, and plans.
7. The most common form of representing procedural knowledge is a production system.
8. Control processes and structures exist which guide the processing of information; this includes metacognitive knowledge.
9. It is too early in the history of cognitive science to have a complete theory of instruction.

4.1.8 Tennyson's Short Cycle 1 Paper: Cognitive Model of Learning

Summary

Tennyson's short paper presents the cognitive model that is used in the longer paper to update ISD. Tennyson's cognitive model of learning stresses that knowledge acquisition comes from internal as well as from external sources; behavioral models allowed only for external sources. Tennyson defines a knowledge base as an associative network of concepts. Knowledge bases vary with regard to amount, organization, and accessibility. It is the organization and accessibility of knowledge that distinguishes experts from novices, not the amount of knowledge.

He identifies three types of knowledge: declarative ("knowing that"), procedural ("knowing how"), and contextual ("knowing when and why"). It is contextual knowledge which determines the organization and accessibility of the other two types of knowledge.

Tennyson goes on to identify three cognitive abilities: differentiation (selection), integration (restructuring), and creation. These cognitive abilities are used by the human retrieval system in the service of three thinking strategies: recall, problem solving, and creativity. This constitutes Tennyson's operational definition of cognitive complexity.

Major Assumptions

1. Instructional theories are theories which prescribe manipulations of instructional variables and conditions hypothesized to improve learning.
2. A learning need or problem is part of a larger environment; context and connectedness are crucial to understanding.

Major Proposition

1. A major consideration for instructional design is how specific knowledge will be stored, retrieved, and used in problem solving.

4.1.9 Tennyson's Long Cycle 1 Paper: Cognitive Science Update of Instructional Systems Design Models

Summary

The long paper is a detailed and thorough update of ISD taking into account the contributions from computer science, management information science, psychology, and instructional technology. ISD refers to a system of procedures to guide the development of learning environments. Instruction involves both the planning of an environment in which learning can occur and the delivery of information in that environment. Early ISD models were based on behavioral learning theory (e.g., small steps of content presentation, overt learner responding, and immediate reinforcement of correct responses) and designed according to principles of general systems theory (e.g., behavioral objectives, pretest, organization, post-test, revision).

Updated ISD (UISD) is broken into five phases: analysis, design, development, implementation, and maintenance. Evaluation is made a key item in each phase. The analysis phase draws heavily on learning theory and emphasizes the connectedness of human

knowledge. Older ISD models fail to adequately integrate knowledge. Knowledge engineering techniques are recommended to extract expert knowledge and structure an appropriate knowledge base for a particular domain. The analysis phase ends with an instructional design decision. Tennyson recommends documenting this decision in the form of a proposal that states the rationale for the instructional decisions and specifies the means for accomplishing the stated goals.

Learning objectives are identified at the beginning of the design phase. Tennyson's proposed categories are: 1) verbal information (facts, concepts, rules, and principles -- declarative knowledge), 2) intellectual skills (using concepts, rules, and principles -- procedural knowledge), 3) contextual skills (organization and accessibility of a knowledge base), 4) cognitive strategies (elaboration of strategies to provide students with more detailed domain-specific contextual knowledge, and development of integration and differentiation), and 5) creative processes (the ability to solve problems derived from the outside and the ability to create new problems).

A critical step in the design phase is the analysis of information organization. Tennyson proposes three forms of elaborated analysis: 1) attribute characteristics (for declarative knowledge), 2) semantic structure (connections to prerequisite knowledge), and 3) schematic structure (connections within and among the schemata of a given domain of knowledge. Instructional strategies should be sensitive to both the information to be learned and the lesson objective. He identifies five categories of instructional prescriptions: 1) expository strategies, 2) practice strategies, 3) problem-oriented strategies, 4) complex-dynamic strategies, and 5) self-directed experiences. The other phases of UISD reflect similar modifications.

Major Assumptions

With regard to instructional design:

1. Instructional design is a system of procedures to guide development of effective learning environments.
2. The behavioral paradigm for organizing knowledge is not adequate for sequencing instruction.

With regard to ISD:

3. Procedures defined in ISD models are, for the most part, supported by instructional theories.
4. Research and theory in cognitive science and instructional technology can provide the means to update the learning theory foundations of the ISD model.

5. The major phases of the ISD and USID process are analysis, design, development, implementation, and maintenance.

Major Propositions

1. Learning problems should be related to the total learning context in terms of links to hierarchically and laterally related domains.
2. It should be possible to trace each instructional activity back through the curricular system to specific needs and goals of the curriculum.
3. Evaluation should be an integral part of all ISD variables.
4. Curricular design variables should be integrated into the development of instruction.
5. There is a need to investigate variables and conditions for testing and evaluating domain-specific higher cognitive processes.
6. AIDA should include the capability to assist designers and developers in identifying appropriate instructional and human resources.

4.1.10 O'Neil's Cycle 1 Critique

Summary

The general thrust of O'Neil's critique was that AIDA was an ambitious and important project with serious funding problems. As a result, not all of the ideas suggested for AIDA would be able to be realistically incorporated. For example, given current budgetary constraints AIDA would not be able to provide support for all of ISD; how much of the earlier and later phases of ISD to support would need to be resolved. In addition, AI is expensive; therefore, a serious issue is how to take advantage of AI in AIDA and contain costs at the same time.

O'Neil suggested that the AFHRL/IDC AIDA Project Team should prioritize capabilities desired in AIDA. In support of this suggestion, he offered an instrument to use in rating 22 possible AIDA system features. This instrument was used at the April AIDA review meeting. Results are summarized in Appendix D.

O'Neil recommended the technique of working backwards from cost constraints to the features to be included. He suggested that it was unreasonable to expect to be able to reduce time and cost of producing courseware and also improve the quality of the

courseware. Again, someone would have to decide which was most important.

The working assumptions behind O'Neil's remarks were the following: 1) CBI and CBT were or could be effective, 2) Authoring is the bottleneck in CBT, 3) Current authoring systems do not focus on instructional design, and 4) Some ISD model was desirable.

With regard to requirements, O'Neil said that an important aspect of AIDA would be the ability to provide justifications for decisions made in designing and developing instruction. In addition to the needs assessment performed at Lowry AFB, some study of existing authoring aids should be conducted. AFHRL/IDC does have another project called Computer-based Selection and Implementation Strategies (CSIS) which will include an analysis of various authoring languages used by the Air Force. In considering the design of AIDA, some consideration should be given to the Air Force of tomorrow.

With regard to implementation, O'Neil strongly emphasized the need to look at existing systems and develop a set of lessons learned. The particular systems that O'Neil recommended for review were the following: 1) AIS II/ISS, 2) PLATO/TUTOR, 3) COURSE OF ACTION, 3) NPRDC's AIM, 4) AFHRL's IKAT, 5) IDIOM, 6) Air University's SOCRATES, 7) IMTS, and 8) numerous commercial systems. Merrill quickly amended the list to include his own ID Expert, Elron Corporation's ACE, the Alberta Research Council's CMI, Xerox PARC's IDE, System G, Ford Aerospace's HUMORS, and several others to be described in the March 90 issue of Educational Technology. O'Neil indicated that one thing such a review would suggest was the important trade-off between ease-of-use and power.

Another task that O'Neil suggested worth pursuing was the development of baseline data concerning costs and time of producing lesson materials with the various systems. His own experience indicates roughly 400 hours and \$10K per hour of individualized instruction with wide variations due to a variety of authoring systems, media technologies, and constraints.

O'Neil identified three approaches to CBT: 1) artistic, 2) analytic, and 3) empirical. The artistic approach is used by media developers who emphasize action and dramatic content. The analytic approach uses accepted instructional theorems to guide the development of specific materials. The empirical approach is the means by which the other two approaches can validate claims that their methods are effective.

O'Neil proposed the following collection of tools which could be incorporated into AIDA: 1) automation of existing paperwork, 2) task analysis, 3) cognitive task analysis, 4) simulation support, 5) templates of varying levels of power and flexibility which are sensitive to types of knowledge and control strategies, and 6)

computer-generated assignments. O'Neil identified the tool most in demand as the automation of existing paperwork. O'Neil also described a typical macro-instructional sequence with much emphasis on test and measurement. He indicated his belief that test and measurement should be made an integral component of AIDA and supported the point with a description of four generations of computerized measurement. He also provided several sample templates to illustrate how templates could be used to guide lesson development.

O'Neil then presented three sets of issues for AIDA: management, technical, and authoring. Management issues included the decision to support individual or team authoring, novice or experienced instructional designers, provide tools or an entire system, provide programming aids or design aids, support a limited or full range of media presentation possibilities, and pursue a fixed price or cost plus contracting mechanism.

Technical issues included categorizing types of learning relevant to instructional design, identifying underlying theories of learning (behavioral and cognitive) and their implications, specifying the influence of cognitive science and its implications for instructional design, and performing formative evaluation with various media.

The major issue with regard to author interaction was to decide which types of interactions to support, given a choice of templates, customized parameters with templates, programmable templates, on-line help, on-line advice, intelligent job aiding, and articulate expertise.

He also presented a list of four different ways that AI could be used in AIDA: 1) Intelligent Computer-Assisted Instruction, 2) Intelligent Job Aid, 3) Intelligent Interface, and 4) Intelligent Help. O'Neil argued that the most promising choice was the third, as this approach allowed an intelligent front-end to templates, which would most likely be included in some form in AIDA.

O'Neil's main point with regard to these issues was that any choice had significant consequences with regard to the power and cost of AIDA.

4.1.11 Reigeluth's Cycle 1 Critique

Summary

Reigeluth's critique focused on this question: What is likely to contribute to a workable AIDA? His paper is divided into suggestions in four areas: 1) approaches to designing AIDA, 2) conceptions of how AIDA should operate, 3) the nature of required knowledge bases, and 4) miscellaneous issues.

With regard to approaches, Reigeluth made a distinction between prescriptive theories of instruction (science of the artificial) and descriptive theories of learning (science of the natural). Inductive methodologies derive prescriptive theories of instruction from practice. Deductive methodologies derive prescriptive theories of instruction from theories of learning.

Reigeluth recommended following an inductive approach, not attempting to deduce instructional prescriptions from learning theories. He indicated that rapid prototyping was an effective way to implement an inductive approach.

Reigeluth also suggested that the initial experimental prototype should be aimed at a simple task not involving generating instruction. Reigeluth suggested that the AIDA design approach should be based on existing recognized and relevant principles of instruction, without trying to develop ID-2 first. He suggested that the initial development effort would guide the development of ID-2. Following the logic of this approach, Reigeluth suggested relying heavily on field testing of the experimental subsystem to evaluate both quality of instruction produced and the ease of use of the system.

With regard to how AIDA should work, Reigeluth argued that it should be an assistant, not just an advisor, in the sense that AIDA should do much of the work of the developer, generating instruction from known designs (templates). AIDA would be used by both an SME and a designer. The instructional designer would review the instruction generated by the computer for optimality. Reigeluth saw a continuing role for an instructional designer to handle content-specific, cultural, and contextual considerations that cannot be automated.

With regard to the nature of the knowledge base, Reigeluth argued that learner variables should not be overemphasized as they only influence what should be taught rather than how material should be taught. Reigeluth argued that front-end analysis should not be tied to a single theory of learning.

Reigeluth argued that the sequence of activities would be to decide which instructional strategies to incorporate in the initial experimental subsystem. These instructional strategies would dictate the structure of particular instructional development models to be incorporated into the system. He made a distinction between types of knowledge and levels of cognitive ability for domain dependent content that he found missing in Tennyson's paper. The same type of knowledge could be learned at a memorization level, at an application level, or at an understanding level. The level of cognitive ability desired influences the methods of instruction likely to optimize attainment of the learning objective.

For memorization tasks, Reigeluth argued that the most useful distinction is between associations, lists, ordered lists, and lists of associations. For application tasks, Reigeluth argued that the important distinctions are between concepts, principles, and procedures. For understanding, the critical distinction is between conceptual and causal understanding. Conceptual understanding requires distinguishing types of relationships, each of which indicates a different instructional strategy. Why these are the important distinctions, who makes them, and how they are made was not indicated. Whether or not other meaningful levels of cognitive ability are useful was not examined.

Reigeluth argued that domain independent content did not have associated with it different levels of cognitive levels. Consequently, it was acceptable to speak of a single category of strategies -- cognitive strategies.

Reigeluth believes that it is important to distinguish contextual and causal knowledge (both domain dependent) from cognitive strategies (domain independent). He indicated that we know more about instructional strategies for causal knowledge, some about teaching cognitive strategies, and little about teaching contextual knowledge.

The last section of the paper contained miscellaneous observations and suggestions. He claimed that the major issue in instructional theory concerns optimality, not validity. The distinction between natural (descriptive) and artificial (prescriptive) may be in dispute, but there is general agreement that AIDA should be aimed at devising instructional strategies which do optimize learning in terms of retention, transfer, time to learn, and depth of understanding.

4.2 ANALYSES OF CYCLE 2 PAPERS

This section contains summaries of the papers submitted in cycle 2.

4.2.1 Friedman's Cycle 2 Paper: "Designing Graphics for Courseware: The Role of Graphics in Knowledge and Skill Acquisition"

Summary

The paper by Alinda Friedman, prepared under a subcontract with Polson, was generally highly regarded and well received. Friedman in effect suggested that building a mini-expert for incorporating graphics effectively into courseware involved sufficiently complex research and development issues to justify a separate project. Her review and analysis of the relevant literatures is definitely worthwhile. One suggested taxonomy of graphics uses the realistic/abstract distinction as the primary dimension, with photographs at one end of the spectrum and tables and charts at the other.

Another way to categorize graphics is according to information content (e.g., shape, color, spatial location, action sequence, etc.). An information parser could then make recommendations regarding the types of representations best suited to each need. A domain parser could conceivably provide recommendations about general conveyance needs to be used by the information parser.

4.2.2 Gagne's Cycle 2 Paper: AIDA Concept of Operation"

Summary

Gagne identified several key assumptions that he had made: 1) the instructional designers using AIDA would be academically capable SMEs with some minimal instructional design experience or exposure, 2) users would be capable of performing a job task analysis or job tasks would already be categorized into learnable capabilities, 3) it is desirable to have instructional designers follow standard procedures that are adaptable to a variety of trainees, environments, and tasks, and 4) it is desirable to develop an advisory system for this purpose.

Gagne's AIDA requires the designer to make intelligent decisions and use common sense. He sees military designers and developers using AIDA to create instruction, guided by its advice. AIDA will not create the instruction on its own, as suggested in Merrill's "moonshot" system.

Gagne's AIDA used Merrill's tentative architecture (Information, Content, Executive, Strategies, and Delivery), and proceeded to specify the relevant considerations and characteristics in each component's area. The information component would indicate

whether target trainees were readers or non-readers, whether the environment was instructor-led or computer-based, and what stimulus modes of the task to be trained were involved. Instruction was divided into large periods or stages: setup period, initial presentation, and practice. Possible strategies were suggested for each stage as follows:

- Stage A (set-up):
1. grabber
 2. scenario
 3. reminder
 4. recall
- Stage B (presentation):
1. statement
 2. example
 3. label
 4. mnemonic
 5. discourse
 6. analogy
 7. elaboration
 8. human model
 9. question
- Stage C (practice):
1. practice
 2. assessment
 3. telling
 4. transfer

Gagne maintained that content should be categorized by five types of capabilities: intellectual skills, verbal information, cognitive strategies, motor skills, and attitudes. Gagne made it a point to distinguish what is learned (performance capabilities) from the content of a presentation. Gagne believes that content is overemphasized at the expense of learned capabilities.

In Gagne's AIDA, it is the type of capability more than any other factor that determines the selection of specific instructional strategies. Gagne lists four steps involved in instructional strategy selection: 1) choose the media, 2) establish integrative control, 3) classify the single capabilities to be learned, and 4) select and order appropriate instructional strategies for each capability.

Gagne claimed that the notion of an enterprise scenario was useful and he encouraged its elaboration. However, he admitted that it is not known exactly how to get from an enterprise scenario to individual capabilities, but that it was not a random process; rather, he suggested following some unspecified natural order.

Everyone seemed willing to accept most of what Gagne presented. In fact, one way to construe Gagne's contribution is as the rational middle ground -- whatever path gets explored or whatever system evolves, Gagne's viewpoints should be taken into consideration.

4.2.3 Halff's Cycle 2 Paper: Automating Instructional Design and Development

Summary

Halff began with a review of his interpretation of the AIDA concept. Put simply, AIDA is a description in information processing terminology of the design, development, and delivery of instruction. He distinguished two kinds of input to AIDA: 1) information about students, the learning environment, and the tasks to be mastered (SET), and 2) a specification of the content material to be mastered. The executive component maps the relevant spaces (students, environments, task, and content) into a set of instructional strategies. The instructional delivery component refers to the process of interpreting or running those strategies and is the ultimate output of AIDA.

Halff's paper continued with an elaboration of each of the AIDA components. With regard to the content component, Halff sees these three issues as problematic: the function, the structure, and the actual representation of a particular content area. The content must be represented in a generative, cognitive form (behavioral models do not allow complex instructional objectives to be represented nor do they allow for intermediate structures that support skilled performance); this results in a competence model and the problem of identifying the mechanisms whereby competence is achieved. The generative requirement implies a grammar for instruction and the separation of structure (syntax) from content (semantics) with an explicit representation of the instructional objectives in the content component. We have, as yet, no grammar for instructional design. Moreover, there is, on Halff's view, no uniform method for analyzing particular skills.

With regard to the SET component, Halff argued that the relationship to the content component is crucial and problematic: in some situations, the two components are functionally independent but in others they are closely interdependent.

The instructional strategies component is comprised of procedures for delivering instruction -- one strategy for a single instructional objective. The representation of instructional strategies is another crucial issue for AIDA. In general, there are two approaches, according to Halff: generative and schematic. The generative approaches assume the existence of instructional primitives and procedures for manipulating those primitives into strategies (a transformational grammar of sorts). Such approaches tend to be best tried in very narrowly confined domains, as we lack a general grammar of instruction. Schematic approaches are based on configurable black boxes or transaction frames which can be adapted to a wide variety of settings.

Halff also sees serious challenges for the AIDA executive component, which must analyze a broad range of content and SET information and produce a set of procedures to effectively teach the material. Being able to perform the required transformations on various representations into forms suitable for students, designers, and various automated devices is no simple task. The executive parses content into objectives and uses those and SET to determine the most promising strategy to pursue.

Since strategies have procedural representations, instruction can be delivered by executing the strategy. Taking into account the level of interaction implied in the procedure is a serious consideration. Another challenge is matching the power of the interpreter to the level of abstraction in the strategy specifications.

Halff stressed the importance of evaluation throughout the instructional process. Three levels of evaluation were identified: 1) quality control (Am I doing the process right?), 2) formative evaluation (Is it the right process?), and 3) summative evaluation (Are our underlying assumptions right?). Halff indicated that it was important to isolate the level of problems and to identify the particular AIDA component at fault.

Halff then imagined two incarnations of AIDA, one in an Air Force Technical Training Center (TTC) and another called CAI 'R Us. Halff indicated in his remarks that the TTC example represents the road not taken, although his previous remarks and paper indicate he believes this is the road most worth pursuing. The content domain for this AIDA is highly focused (e.g., radar maintenance), the SET characteristics are simple and straightforward, instructional strategies can be formalized, an executive built around ready-made plans and default slots can be implemented, and design and delivery can be automated for a variety of media. In short, Halff envisioned an AIDA that embodied instructional design theory as it pertains to radar maintenance.

The CAI 'R Us example presented a conception of AIDA for knowledgeable instructional designers that could be applied to many domains where computer-based instruction is being developed. This concept was aimed at providing automated implementation of CAI instructional strategies. To accommodate a variety of subject domains and yet minimize the number of representation schemes, CAI 'R Us used production systems to represent procedural knowledge, schema to represent declarative knowledge, and qualitative process theory to represent causal knowledge.

The SET component of this AIDA uses a simple, fixed vector of features. The strategies are collections of instructional schemata -- configurable and specialized to different levels of abstraction. The executive in this AIDA is a top-down course designer. Delivery of instruction is restricted to CAI systems with a middle level of interactivity.

The CAI 'R Us AIDA concept was also termed an 'implementor', in contrast with the 'embodier' model behind the TTC model. A third kind of AIDA was sketched briefly by Halff, and it was termed a facilitator. The facilitator offered timely reminders and guidance and was likened to Gagne's concept of AIDA.

Halff identified particular design and research issues for the two kinds of AIDA that he has proposed. The TTC AIDA is aimed at SMEs unskilled in instructional design. It assumes that Training Development Branches (TDBs) are organized along narrowly defined technical areas. It assumes that classes typically occur in small lecture-discussion settings with occasional use of a variety of supplementary media. Key design issues include the development of specialized curriculum templates appropriate to the particular domain, instructional strategies for the particular skills involved, and content representations sufficient to provide material for the curricula and instructional strategies. A critical research issue is an explanation of how instruction becomes progressively constrained as content becomes progressively specialized.

The CAI 'R Us AIDA is aimed at skilled instructional designers using SMEs as clients/consultants. This AIDA is intended to provide a means to build curricula for a variety of subject areas and to implement those curricula using CAI. Key design issues in this case include the development of a set of instructional strategies defining a course at all levels, transaction frames tailored to the methods and media available, and general knowledge representation mechanisms. Research issues include defining initial target domains, determination of the flexibility of a set of knowledge representations, and the assessment of the applicability of a top-down, hierarchically dependent development process.

4.2.4 Merrill's Cycle 2 Paper: "An AIDA Concept"

Summary

Merrill's paper and remarks were intended to provide coherence to the outline for AIDA suggested by Merrill and tentatively adopted at the December AIDA meeting. The paper consists of an elaboration of the attributes and range of values associated with each of the AIDA components.

Within the information component, for example, Merrill proposes that these attributes are pertinent to decision-making involving the audience: role, motivation, familiarity, mastery level, and ability. Sample values for the role attribute are consumer, supervisor, technician, and problem solver. The task subcomponent of the information component introduced the notion of enterprise as a complex, bounded, integrated meaningful human

activity. The inadequacy of behavioral objectives or goal lists to account for complex learning tasks brought the need for this concept to light. Seven enterprise classes were identified:

- denoting -- communicating the identity or describing the form or structure of some entity, activity, or process.
- executing -- performing some activity.
- evaluating -- judging the performance of an activity.
- designing -- devising a novel activity.
- manifesting -- making a process sequence evident
- interpreting -- analyzing the cause and effect relationships of a process.
- discovering -- bringing to light a new process.

With regard to the content component, Merrill indicated that he was already underway with this work as part of a Knowledge Acquisition and Analysis System being developed for IBM. Issues yet to be addressed include the rules governing necessary and sufficient associations among frames, the rules governing the propagation of information from frame to frame, and the rules to maintain consistency of information.

The elaborated frame network (EFN) approach was chosen because it represented a compromise between semantic networks (too low level) and frames or schemata. The nodes in the EFN are frames. A frame is elaborated in terms of its links to other frames. There are three kinds of elaboration: associations with other frames, membership in an abstraction hierarchy, and components consisting of all the knowledge and skill associated with a frame.

The AIDA executive takes the information and content components and prescribes strategies or transactions for the student. Two functions are important for this function: prescriptions and filters for knowledge acquisition, and 2) selection and configuration of transactions. Transactions are real-time, give-and-take exchanges between the student and an instructional system. Transaction shells provide the structure of a transaction identifying the parameters, interactions, content needed, etc.

Transactions may be expository or inquisitory, learner or system controlled, tutorial or experiential, and capable of multi-media support. Transactions can be grouped into enterprise transactions, association transactions, abstraction transactions, and component transactions. An enterprise transaction is the control structure for an entire course or unit of instruction.

It includes a primary sequencing strategy (encyclopedic, case study, or naturalistic) and a secondary sequencing strategy (vertical, temporal, graded, or abstraction).

A critical question to be addressed in an AIDA is to determine how to relate the knowledge base to various transactions. Merrill indicated that interface issues were separate from the system capabilities that he had been sketching. Merrill does believe that a system can be made accessible to novice instructional designers and that such a system should provide both explanations and alternatives.

4.2.5 Polson's Cycle 2 Paper: "AIDA Cycle 2"

Summary

Polson's approach was to interview a specialist from a Technical Training Center and to analyze Friedman's results as they pertain to AIDA. Polson reported that the single most time consuming task in developing CBT concerned the design and preparation of visual materials. The time-consuming nature of this task and the fact that it is not consistently well executed prompted the focus on graphically related issues.

The five problem areas identified and examined by Polson were: 1) Use of visual materials, 2) Evaluation, 3) Interactive Courseware Design, 4) Task or Instructional Analysis, and 5) Human Computer Interaction.

Polson cited major unresolved issues in the areas of interactivity and human computer interaction. In CBT settings, it is crucial to decide who (learner/system) should control what portions of the lesson, when particular control should shift, and how control should be made effective. To construct an AIDA which makes these decisions would require formalizing and systematizing those decision procedures.

Polson also suggested using a cognitive walkthrough document in order to make decisions about the future development of AIDA. The major sections of this document are as follows:

Initial Task Description

Describe the task from the point of view of the first-time user.

Interface Start-Up Description

Describe the initial state of the interface from user's point of view.

Action Sequence

Make a numbered list of the atomic actions that the user must perform to accomplish the task.

Adjusting the Goals

What do the user's current goals need to be in order to keep the user on track?

Discovering the Action

Describe the next atomic action that the user should perform (include prompts and time-outs).

Performing the Action and Observing its Results

Describe how the user will physically execute the action and simulate that execution.

Another use for the above kind of questioning would be in a system like Gagne's which attempts to prompt reasonably intelligent subject matter experts through the design and development of instruction. Asking the right kind of question at the appropriate time provides one kind of intelligent facilitation.

4.2.6 Tennyson's Cycle 2 Paper(s): "AIDA: Framework Specifications Document for an Instructional Systems Development Expert System"

Summary

Tennyson's paper argues that a cognitively updated, fourth generation of ISD (ISD-4) provides a useful framework for AIDA. Tennyson's ISD-4 rejects the behavioral bias of previous ISD models in favor of cognitive analysis of learning tasks. ISD-4 also rejects the linear approach to instructional design and development.

In addition, Tennyson proposed designing a system not just for novice instructional designers, because novices don't remain novices and Dallman had indicated a need to accommodate a range of users at the December meeting. As a result, Tennyson's AIDA would be an expert system(s) that has both diagnostic and prescriptive functions and coaches novices but advises experienced users. AIDA would employ a tutoring capability (ITS) aimed at improving the user's knowledge of instructional design. AIDA would have a definite cognitive bias in the analysis of learning tasks and in the design of user interfaces. The user could enter the system at a place appropriate to the individual needs at hand. Instructional training could occur in tandem with

the development of training materials. To accomplish such ambitious results, a mainframe with remote processing capabilities would be required, as would a structured query language and extensive data bases. Tennyson did point out that maintaining massive data bases is not a trivial task.

Although Tennyson barely mentioned his Appendix B (authoring activities knowledge base for ISD-4), the substance of Tennyson's detailed conception of AIDA is best represented in that appendix. The left column of the appendix represents the updated ISD phases; the right column represents the associated authoring activities, which would presumably represent the functional characteristics of an AIDA informed by Tennyson's updated ISD model.

Tennyson revised this paper several times. In the revisions, Tennyson dropped the notion of an intelligent tutoring system for ISD in favor of an updated ISD process with an intelligent interface. The revised notional structure consisted of an ISD Expert supported by three functional components: 1) Situational Evaluation/Diagnosis, 2) Recommendations/Prescriptions, and 3) Mini-Expert to Guide Users. The intelligent interface contains the ISD Expert, an ISD Model Knowledge Base, the Instructor's Model of ISD, and a Content Knowledge Base containing previously developed lesson materials. Complete novices are coached through the system by the ISD Expert which makes most of the decisions. More advanced users are advised through the system with users able to preempt system defaults and decisions.

Tennyson also dropped the requirement for a mainframe and restated that requirement in the form of a need for an open architecture and a centralized, large capacity database with remote access via personal computers or workstations. He estimated that it might take five years and \$10 million to complete such a system.

4.2.7 O'Neil's Cycle 2 Critique

Summary

O'Neil's purpose was to suggest what AIDA should contain and what is missing. His theme was that there was more on the AIDA plate than could imaginably be funded. Reducing the functionality of a first-cut AIDA while maintaining some diversity in the functional specifications would be a challenge.

O'Neil viewed the context as one of conceptualizing and prototyping a strawman system and then testing and fixing that system. O'Neil thought the inclusion of default values in the first-cut system was a good idea. He thought an explanation facility should be added to Merrill's transaction shells. A reference library has yet to be established to support that

facility; this could be the focus of a 6.1 basic research effort. O'Neil viewed Merrill's AIDA as full of diversity and relatively expensive. A first-cut AIDA would have to be more restricted than Merrill envisioned.

O'Neil said that Halff's contrast of CAI 'R Us and the TTC System was quite to the point. Another way to focus AIDA would be to aim the effort at tools to improve the contracting effort.

O'Neil thought Tennyson's revised cycle 2 paper was an excellent conception of the next generation of ISD. The next generation needed to consider the level of users and adjust the ISD model to the user's level -- hereafter dubbed AISD for adaptive ISD.

O'Neil identified two primary viewpoints with regard to cycle 2 AIDA conceptualizations: 1) A development view (Gagne, Merrill, and Tennyson), and 2) A research view (Halff, Polson, Friedman). As a consequence, O'Neil stated a need to reach closure on several of these issues: 1) Whether to include alternative configurations of AIDA, 2) Whether to use an incremental development model, 3) How to prioritize features, and 4) Whether to make an embedded AIDA (perhaps embedded in ATS, for example).

O'Neil made it a point to separate development and delivery issues in contrast to Merrill. He reiterated the need for an explanation facility. O'Neil also indicated the need to update the Friedman paper. If the focus continued to be on procedural learning, then it would be necessary to consolidate relevant research findings in one place. O'Neil indicated that it would be desirable to include some emphasis on metacognitive learning in an AIDA.

O'Neil indicated that AIDA needed an author management system and a course management system. Without computer-managed instruction there would be no benchmarks to determine progress and there would be weak Air Force support.

The AIDA project could also provide sets of lessons learned to transition to the field. Answering these questions would go a long way in that direction: 1) Why is traditional ISD dead in the DoD? 2) Why didn't the Air Force adopt ISS? 3) What success stories for authoring systems exist? and 4) What are the cost drivers and tradeoffs pertinent to authoring systems?

O'Neil stressed the need for a more attractive metaphor to improve the image of AIDA (Halff suggested La Boheme). It should be noted that one AIDA related SBIR effort does involve an explicit attempt to elaborate such a metaphor in terms of an instructional designer's work environment. The book metaphor behind IDEAL BookShelf was viewed as generally effective.

O'Neil cited the need to address procedural learning and metacognitive skills, the need to automate existing paperwork, the need to integrate an AI-based simulation authoring tool, and the need to include an evaluation tool kit in AIDA. O'Neil believes that CBT authoring will be team-based, yet he did not see how AIDA would handle team authoring; this underlined his interest in an author management system.

O'Neil maintained that AIDA should be able to handle existing media and be able to accommodate new media. He also claimed that it was not too early to give thought to what the user interface should look like. It should be noted that the SBIR effort referred to earlier is also providing a version of a user interface. In addition, evaluations of Merrill's transaction shells should provide further input data to user interface decisions.

O'Neil thought that if the near term AIDA were to be a research tool, then measurement and evaluation issues needed to be confronted directly and soon. More data gathering would have to be put into the system to allow it to function as a research tool.

O'Neil addressed 2 issues raised in Tennyson's paper: 1) A centralized facility for sharing courseware, and 2) A database of representative users. The ATC/XPC advisors reacted in a positive manner to these suggestions, although they are most likely expensive options. O'Neil also recommended targeting a particular Air Force system to use in developing instruction with an experimental AIDA. Dallman made a similar recommendation in his presentation on Day 1.

O'Neil concluded with a list of eight critical issues that needed to be addressed in an AIDA system:

1. An investment strategy.
2. Benchmarks.
3. An explanation system.
4. Prototype tryouts with users.
5. An R&D agenda.
6. A CMI system.
7. Focus on procedural and metacognitive skills.
8. State-of-the-art assessments.

By way of summary, O'Neil has recommended that we narrow the AIDA focus, but that we do not make it so narrow to exclude issues pertaining to the management and evaluation of courseware design, development, and delivery. Several of O'Neil's final eight suggestions have already been accepted (e.g., #1 and #5 above are already addressed in the AFHRL/IDC AIDA Long Range Plan and included here in section 1.2).

4.2.8 Reigeluth's Cycle 2 Critique

Summary

Reigeluth provided a much different perspective on how to proceed with implementing an AIDA. He believed that a first-cut AIDA system should epitomize the long range AIDA. As a consequence, it becomes more important to articulate the grand view of AIDA as much as possible. Reigeluth argued that developing an epitome system using simplifying conditions to enhance success and investment in all parts would simplify all four thrusts of the long range plan and provide a rational development model.

Reigeluth agreed with the focus on intermediate users in the first-cut system. He would further restrict the subject matter domain from electronics maintenance to something like avionics maintenance. He also agreed with the decision to emphasize an instructional design advising system first and worry about automated development and delivery later.

Reigeluth disagreed with the tentative plan to have the starting input to a first-cut AIDA be well-formulated learning capabilities. He preferred to start with the epitome of input, such as a cognitive task analysis or possibly an enterprise analysis.

With regard to the individual cycle 2 papers, Reigeluth made the general claim that all the authors needed to epitomize and to simplify. For example, with regard to Gagne's conception of AIDA, Reigeluth recommended omitting elaborations of features pertaining to non-readers, motivation, and instructor-based settings as a way of incorporating simplifying conditions in the first-cut AIDA.

Reigeluth argued that Merrill's conception of AIDA could be simplified in a number of ways (e.g., restrict the audience, restrict the environment, restrict the task, restrict the transactions involved, restrict user control, etc.).

Reigeluth found Halff's Figure 1 (Merrill's six functional blocks) thought provoking and offered a complicated extension. Reigeluth argued that the AIDA epitome should include nine mini-experts, but for highly restricted domains.

While his line of reasoning is similar to Halff's, Reigeluth did point out some differences with Halff. With regard to Halff's three dichotomies (general vs. domain specific, black box transactions vs. primitives, and general vs. detailed specifications), Reigeluth denied the inescapable nature of the dichotomies and recommended a compromise combination in each case.

Reigeluth warned against confusing the operationalization of strategies with the automation and instantiation of strategies. The former applies to particular content domains; the latter apply to particular delivery systems. In general, Reigeluth liked Halff's focus and viewed it as a version of epitomizing.

Reigeluth found many useful items on visual materials in the Polson/Friedman papers. However, he thought they were too advanced to be incorporated into a first-cut AIDA system.

Reigeluth questioned whether tutoring should be a primary feature of AIDA. Reigeluth indicated that it was not clear who Tennyson's users were. Reigeluth saw AIDA as replacing, not retraining, instructional designers. The idea of AIDA was to help SMEs develop effective courseware without resorting to the expense of human expert instructional designers. Reigeluth would omit the content knowledge base from the first-cut system.

Reigeluth also warned against attempting to break new ground in all areas. For example, AIDA should not try to break new ground in the areas of expert system methodologies.

4.3 SYNOPSIS OF MEETINGS

Five technical meetings were held as part of the Phase I AIDA effort. Hickey taped the meetings and provided transcripts of key discussions to participants. Spector compiled progress reviews distributed after each meeting. The information contained in the following summaries is drawn primarily from those reviews.

4.3.1 August Kick-off Meetings

The kick-off meeting was divided into three parts in order to accommodate the schedules of the consultants. In the first part, the history of the AIDA concept was reviewed, Mei Associates' statement of work was reviewed, and an agenda for the second part of the kick-off was developed. It was decided to divide the task into two cycles and to use two critiquers. Gagne suggested specific assignments for the consultants (see Appendix B for task assignments).

In the second part of the kick-off meeting, Merrill wanted AFHRL to provide more detailed and specific guidance about AIDA. Newcomb did provide additional detail but argued that since this was a 6.2 exploratory development effort that it was not appropriate to provide a requirements analysis and functional specifications; indeed, that was primarily what was sought from the consultants. Halff argued that very few general instructional design principles could be incorporated into a general purpose AIDA. As a consequence, he maintained that there would have to be many AIDAs. Tennyson saw a need to establish an underlying philosophy and set of assumptions before continuing with design requirements for AIDA. Gagne's task assignments were revised to reflect a shift in emphasis from theory development to the design of a prototype AIDA.

In the third part of the kick-off meeting, Gagne asked AFHRL to identify the products for Task 6. Newcomb indicated that the product was to be a description of the content of a potential prototype of AIDA; no software production was involved in Task 6. Polson wanted all consultants to respond to some common task so that there would be some basis for performing a synthesis of the responses. The degree of intelligence to be incorporated into AIDA was also identified as an issue in need of further analysis.

4.3.2 October Presentation Meeting

The October meeting featured papers submitted by the five consultants and a needs assessment report by Muraida and Spector. Areas of consensus and disagreement were identified (see section 4.3.3 below). All agreed that a key issue is determining the extent to which instructional design expertise can be automated. To make this determination, several instructional mini-advisors

will have to be built and issues concerning the tractability of the instructional design space will have to be resolved. Justifying and elaborating specific instructional design principles and identifying appropriate knowledge representation schemes were also considered important issues. There was also general agreement that cognitive psychology had a great deal to contribute to AIDA and that contextual knowledge required further analysis.

The principal points of difference concern the degree to which instructional design can be shifted from humans to computers, the usefulness of existing ISD procedures, and the extent to which instructional design principles are context bound.

4.3.3 December Consolidation Meeting

The December AIDA meeting featured a review of the cycle 1 papers by Muraida and Spector, critiques of those papers by O'Neil and Reigeluth, and planning for the cycle 2. The cycle 1 review indicated the following areas of agreement and disagreement:

Areas of Agreement

1. There is a lack of instructional design expertise in the Air Force. Tasks requiring training are becoming increasingly complex due to sophisticated weapons systems. Training environments are becoming increasingly complex due to advanced interactive technologies. As a consequence, the need for instructional design expertise is becoming increasingly acute.
2. Instructional design should reflect a cognitive perspective; behaviorism is not adequate in providing an explanation of complex learning, such as language acquisition.
3. Knowledge of cognitive structures and operations is incomplete. Cognitive models are proposed as tentative guides to understanding complex mental structures. Exactly how information is encoded and transformed in the mind is not known. That coding and transformation occur is undisputed. The details of the limitations of short term memory are not known, but that there are limitations is well established.
4. There are several high level instructional principles that have been derived from the cognitive sciences. Kintsch's 10 principles of instructional theory represent a good sample. Merrill's 12 pedagogy rules and Gagne's 12 instructional principles indicate much agreement and overlap at this level. There is also agreement that the detailed micro-principles have yet to be established but are well worth pursuing.

5. There are other areas of agreement with regard to the influences of cognitive learning theory on instructional design. For example, the situated and integrated nature of human activities is recognized as an important consideration in designing instruction. Polson's situational models and Merrill's enterprises reflect this view directly.

The emphasis on integrating new knowledge with previously acquired knowledge also reflects agreement in this area. Another area of agreement in this area is that the organization of knowledge in memory is the key to recall, retention, and transfer. As a consequence, instructional design should facilitate the organization of new knowledge in memory.

In addition, the distinction between declarative and procedural knowledge is fairly clear and basic. A third type of knowledge, contextual knowledge is also widely accepted.

6. Automating course design and development can potentially improve quality and/or reduce costs. Automation of instructional design expertise should contribute to consistent and possibly improved quality. Automation of the production of materials in accordance with that advice should reduce costs.
7. Developing an experimental prototype is needed in order to make real progress with AIDA related issues.

Areas of Difference

1. The extent to which instructional design expertise can be automated is in dispute; there is consensus that this dispute is best settled by experimental evidence.
2. The usefulness of a comprehensive theoretical basis for instructional design is not completely clear; some believe that experiments should aim toward justifying an integrated instructional theory (Merrill, Polson); some believe that intuitions of successful instructional designers are a sufficient foundation for proceeding (Reigeluth).
3. The transference of cognitive skills outside the domain in which they were acquired is in dispute; some believe that cognition is always situated (Halff); some believe that some cognitive skills are generalizable beyond the situation (Merrill, Tennyson, Gagne).

4. The extent of the influence of cultural factors is in dispute; most believe that cultural factors play a significant role in learning (Halff, Polson, Tennyson,); some believe that the resulting pragmatics of cultural influences cannot be captured in a computer program (Halff).
5. The usefulness of ISD is in dispute; some believe ISD is invaluable (O'Neil); some believe it needs modification to be useful (Tennyson, Gagne); some believe it can be disregarded (Merrill); some believe it is fundamentally mistaken (Halff).

O'Neil viewed the AIDA effort as ambitious but worthwhile. Desired AIDA capabilities would have to be prioritized due to budgetary constraints. He stressed the importance of assessment and evaluation, identified a variety of additional capabilities to consider, indicated several ways that AIDA could be made intelligent, and presented three sets of issues for AIDA in the area of project management, technology, and courseware authoring management.

Reigeluth argued that the AIDA effort should be based on an inductive approach since useful prescriptive instructional principles cannot be derived from existing theories of learning. Reigeluth supported the rapid prototyping of an initial system based on first generation instructional design principles.

The current task was narrowed to focus on the following: 1) target the domain of apprentice maintenance training, 2) target novice instructional designers, 3) build in as much intelligence as possible, and 4) automate as much of the production of instruction as possible. Assignments for cycle 2 were made based on a conceptual organization provided by Merrill.

4.3.4 February Presentation Meeting

The February meeting featured presentations of papers submitted by the consultants and planning for the remainder of this task.

Tasks for the April meeting were established. Four critiquers were tasked in the April meeting: Dallman, Marlino, O'Neil, and Reigeluth. Dallman's task was to select three maintenance training applications from the Lowry TTC, one to include a CBT example, for inclusion in a preliminary data base of training samples. The samples should include appropriate documentation. Dallman was asked to bring at least one CBT course/lesson to demonstrate at the April meeting.

Marlino agreed to evaluate IDIOM with regard to lessons learned, features and characteristics to include in AIDA, and things to avoid. She also agreed to provide a demonstration of IDIOM's capabilities at the April meeting. Merrill also agreed to demonstrate the naming-the-parts transaction shell.

This meeting produced six outstanding papers related to issues in automating instructional design and development. There was still a general core of consensus among the consultants about issues and directions, although significant differences did exist (e.g., whether to target novices or experienced designers; design a general purpose system or design a narrowly focused system; provide dynamic expert advice, constructive but inexperienced guidelines, or coach novice users; assist with just design, or design and development; etc.). There continued to be consensus on the need for a cognitive learning task analysis, although its relationship to a behavioral job task analysis was not clear (i.e., Should the behavioral job task analysis provide more than performance criteria for input to the design of instruction? If so, what is the form of that input and how should/could it be used?).

Halff proposed three levels of AIDAs: 1) AIDA as a facilitator (an earth satellite/Gagne's system), 2) a highly focused AIDA in the TTC (a lunar satellite/Halff's preference, or 3) a general purpose AIDA (Merrill's moonshot/CAI 'R Us). Halff proposed developing an investment strategy for each path and pursuing coordinated efforts along each path. The coordination could come in the form of tools developed at one level to provide useful inputs to the next level. The remainder of Halff's critique was made in terms of these three levels.

Halff described Gagne's AIDA as a system to provide constructive guidance to instructional designers and developers. It was definitely a level 1 system. It could be considered an intelligent job aid for instructional designers/developers. It would be an ID-1 system in terms of theory. It would require the developer to perform most of the course implementation. The advantage of doing work at level 1 would be to provide a body of consistently good instruction (especially good computer-based instruction). Tennyson's proposal to have a content knowledge base (previously developed courseware) can also be construed as a level 1 pursuit (Tennyson obviously proposed doing much more).

Halff described Merrill's AIDA as a level 3 system. It would have a wide area of applicability and the system would do much of the designing and developing of the instruction. Halff believes that it is too early to commit great resources to level 3, although a level 3 system is a reasonable long range goal. Level 3 systems are committed to ID-2, as are level 2 systems.

Halff sees level 2 systems as focused on very particular domains (e.g., radar maintenance) and providing a body of good instructional strategies to level 3.

Merrill responded by saying that there were already numerous attempts at level 1 with very questionable results. Tennyson, Newcomb, Ellis, and others questioned Merrill's conclusions about the generally poor quality of most CBT. There was apparent

agreement that collecting the data was important and needed; Tennyson's content knowledge base could be conceived as a repository for those data. Merrill, though, did not seem anxious to revisit level 1 systems (including SOCRATES, IDIOM, Arthur Andersen's Method E, IBM's system, Courseware's system, etc.).

Polson wanted to know if the level 1 user should be a novice or an experienced user. Halff's response was to use an expert if your goal is to get a body of good instruction developed to use in the other levels. However, Gagne's level 1 system is aimed at a relatively inexperienced instructional designer, as are SOCRATES and some of the other level 1 systems.

Halff insisted that developing a tool at level 1 to collect good instruction for some fairly focused area would make it obvious how to construct ID-2 transaction frames. He said that we should become good natural scientists and collect some samples.

Merrill proposed that Halff's three levels looked at AIDA in terms of tool building. That was just one dimension. We could look at AIDA in terms of instructional design theory (ID-1 and ID-2) or in terms of the targeted user (novice, experienced, expert instructional designer). Merrill insisted on the view that we should not be involved in automating the past (ID-1) and that we needed to attend to advanced technologies available and their peculiar characteristics. AIDA should confront the issues of interaction, multi-media, integration, sequencing, etc. raised by these new technologies.

Merrill indicated that it was possible to build sample transaction shells as a stand-alone set, without implementing all of his system. Merrill's modification of level 1 would be to construct such shells, test them, and collect some useful data.

The idea occurred to Newcomb that Merrill's transaction shell for naming the parts could be used in a stand-alone study to determine how much development time could be saved by the use of such shells. Merrill has another shell for teaching checklist procedures that subsumes the "naming" transaction shell; this shell might provide the means to carry out a more meaningful study.

Gagne indicated that we needed to pick a more serious shell than naming the parts, as it was too easy. He suggested that we try developing a shell for teaching procedures. Gagne's suggestion met with much approval on two counts: 1) We needed to establish priorities for the continuation of the project, and 2) We had already agreed to focus on maintenance training in which procedural knowledge would play a large role.

Halff and Merrill seem in agreement that a transaction generator guidance system to automate instructional design and development will be a critical component of AIDA. Halff believes it will have to remain focused on a particular domain. Merrill believes much will be generalizable across domains.

Polson saw Merrill's system as taking a vertical cut through the five problems uncovered in her interview with Dallman (graphics, evaluation, interactivity, task/instructional analysis, and human-computer interfaces), while Friedman's paper took a horizontal cut at the problems by addressing the use of graphics in all domains. She admitted that the vertical but focused approach might be the most productive.

Tennyson also proposed three different levels of systems. He agreed with Halff that ID lacked data; his level 1 system would focus on developing shells, studying user reactions, determining standards for shells, and experimenting with shells. He, like Halff, thought level 1 users would need to be experts. Tennyson's level 2 involves adding diagnosis so that prescriptions can be added to more sophisticated networks of integrated shells. His level 3 would be more fully automated and accessible to novice users.

Halff said that his three levels did not directly correspond to Tennyson's. Halff claimed that Tennyson's scheme involved ever larger chunks of curriculum at each level, while his own allowed all curricular structures at all three levels. Halff also claimed that artifacts could be collected at all levels. The curricular chunking issue does not seem a serious differentiator between Halff and Tennyson. However, there appears to be no place in Tennyson's three levels for Halff's level 2 system focused on a TTC.

Gagne asserted that AIDA should be primarily an advisor. Automating instructional development was not likely to work, although it might be worth a try. Gagne insisted that we needed to design for the five basic mental capabilities, and the system should offer advice, examples, and alternatives.

There was a discussion about the fundamental categories of capabilities to be dealt with in an AIDA, i.e., what is to be learned. Merrill favors denoting, executing, evaluating, etc. Gagne favors concepts, verbal information, rules, etc. Merrill agreed that some of his shells might apply to larger course units--more comprehensive capabilities--and not be the correct primitive level 1 shells. There was continued verbal dispute between Gagne and Merrill about what is to be learned, but there appears to be more similarity than disagreement (denotation = label information; classification = concepts; execution = procedures; etc.). Merrill admitted that Gagne's five capabilities must be accounted for at a basic level in any system.

Polson remarked that a critical difference between Gagne and Merrill involved how much control over the design of instruction should be given to AIDA. Gagne wants the human designer heavily involved in the planning and decision-making. Merrill would provide much control for the system, but he characterized his AIDA as an instructional spreadsheet.

There was agreement that many important research issues remain unsolved and there is a need to begin building a large data base of instructional artifacts and associated evaluations. There was agreement that AFHRL needs to focus and prioritize its AIDA related efforts before continuing to the next task. A long range planning document was suggested for this purpose. Since AFHRL does have such a plan, it has been included in this final report (see section 1.2).

The proposal to use Merrill's naming transaction shells in an evaluation study at several Air Force locations will be pursued by AFHRL/IDC independently of this task or the Phase II task.

It was agreed that O'Neil and Reigeluth would be asked to analyze and constructively evaluate the concept and functionality of AIDA, the long-range plan, and the associated investment strategy in a way that makes a smooth transition to the final report of this task and the beginning of the next task.

4.3.5 April Consolidation Meeting

This meeting featured demonstrations of three authoring systems/environments by Dallman, Marlino, and Merrill; critiques of the cycle 2 papers by O'Neil and Reigeluth; a review of ATC's ISD procedures by Clemons; a review of ARI projects by Seidel; and the completion of O'Neil's AIDA capabilities survey.

Marlino's IDIOM Demonstration

Dr. Mary Marlino demonstrated the capabilities of IDIOM. She began her discussion by identifying three levels in IDIOM: 1) a broad database, 2) a set of tools, and 3) a low level instructional design advisor. She indicated that IDIOM's strength was the breadth of its database. IDIOM's target audience is fairly general, containing both novice and intermediate instructional designers. IDIOM is an advising system developed for the domain of sales training. IDIOM supports both procedural and declarative knowledge types. Its instructional design theory is probably first generation. One can start anywhere in this easily accessible system. IDIOM has acquired a new user-interface and been renamed IDEAL BookShelf.

IDEAL BookShelf is a menu-/button-driven, hyper-media type system implemented on the Macintosh microcomputer. The opening menu contains the following choices:

IDEAL BOOKSHELF TABLE OF CONTENTS

PRELIMINARY RESEARCH

ANALYZE

DESIGN

DEVELOP

OVERVIEW

HELP

MANAGE

PRODUCE

IMPLEMENT

EVALUATE

BASIC TOOLSET

TOOL CATALOG

PROCESS GUIDELINES

To facilitate use of the system there are help and reference cards which comprise a database resource library. The help that is available at the top level table of contents (see above) consists of pull-down menus with the following items:

WHAT IS IT?

WHY IT'S DONE

WHAT YOU GET

JUDGING SUCCESS

HOW TO DO IT

These same items are provided for virtually any item in IDEAL. For example, one can use a submenu list under ANALYZE to find out what Mager's Goal Analysis Tool is and how to use it.

The level of detail behind the opening table of contents is relatively sophisticated. For example, DESIGN has the following items:

SPECIFY OBJECTIVES

SEQUENCE OBJECTIVES

DETERMINE STRATEGY

SELECT MEDIA

PREPARE ASSESSMENT

A number of tools for assisting with a particular item are available and indicated with an asterisk. The instructional designer tool is as interactive and as prescriptive as any in IDEAL BookShelf. It allows the creation of new instruction or the modification of existing instruction. It was noted that the

system was not fully integrated in that objectives indicated in SPECIFY OBJECTIVES did not carry forward to other parts of the system. Marlino indicated that Apple Computer was currently working on complete integration and on the PROCESS GUIDELINES.

Objectives are classified by performance (e.g., find, use, remember) and by content (fact, concept, procedure, and principle) as suggested in Merrill's Component Display Theory. Gagne's nine events of instruction were also a strong influence on the design of IDEAL BookShelf. For the first event, gain attention, the user is offered a variety of means to accomplish it, plus a rationale for doing so.

IDEAL BookShelf is not a lock-step system, however. The user can skip any item. The advice offered users generally comes in the form of a generality followed by one or more instances. Marlino classified IDEAL as a facilitator (Halff's first level) with very high user control. There was insufficient data to determine whether or exactly what using IDEAL contributed to the development of courseware.

The book metaphor is the guiding and operative metaphor behind IDEAL BookShelf, e.g., the table of contents through which one gains access to the system. As one digs deeper into the system, one finds some templates for course documentation provided in MacWrite. The output of the system consists of nicely formatted course materials. IDEAL BookShelf is not a delivery system; it is a design and development environment complete with a number of tools. IDEAL BookShelf is currently being Beta-tested by several companies, including Federal Express and Kodak.

Dallman and Ellis thought that SMEs who were novice instructional designers would not be able to use IDEAL immediately, because, for example, they would not know the difference between 'find' and 'use' or between 'verbal information' and 'cognitive strategy'. Reigeluth characterized IDEAL as a tutor and indicated that AIDA might be less of a tutor. Mattoon saw the lack of integration of what's entered into the system as a major limitation; most agreed.

Dallman's TTC Demonstrations

Dallman began his demonstration by stating his objective: to identify three maintenance courses which would comprise a training database for use in the AIDA program. He used four selection criteria: 1) Developed/maintained by the Air Force, 2) Reasonable examples of first generation instructional design principles, 3) Range of technical, operator, and soft skills addressed by the instruction, and 4) Development to occur over the next few years.

Dallman then reviewed common problem areas in CBT systems design: 1) Front-end analysis, 2) Content analysis, 3) Human-computer interaction, 4) Limited experience base, and 5) Complexities of interactive courseware design. Dallman focused on problems in the last category and further elaborated that category as follows: 1) Wrong or inappropriate objectives chosen due to the use of canned words, 2) Compiled knowledge not dealt with properly (failure to use bite-sized chunks and missing declarative/procedural knowledge in course materials), 3) Misconceptions about interactions (e.g., failure to require application of domain knowledge, failure to foster "deep" processing capabilities, etc.), 4) Poor or inappropriate use of graphics (e.g., creating dissonance, failure to encourage dual encoding, etc.), 5) Failure to perform formative evaluation with an instructional diagnosis, 6) Poor strategic and tactical instructional design decision making (e.g., overuse of tutorials; avoidance of simulations, modeling, and gaming; and overuse of instructional transactions that only required recognition, 7) Inappropriate use of learner control, and 8) Inappropriate mastery assessment without any adaptive testing (see #1 in this list).

Dallman then showed a film clip of the three training efforts he was recommending for an initial AIDA database. The group generally felt that the first effort, Apprentice F-16/A-10 Avionics Test Station and Component Specialist, was an example of excellent CBT and IVD using the QUEST authoring system. Dallman had the other QUEST system (no IVD involved) running on a Z-248 and presented its main features.

The other two examples involved a second course developed using QUEST and a course developed using AIS-II, both on Z-248 microcomputers. The two courses were generally regarded as less interactive than the first, although they contained many useful examples worth considering for an AIDA database. One course is for the apprentice space systems operations specialist, and the other is for the material storage and distribution exportable training system. The material storage and distribution course represented a future direction of some training -- toward more distance and on-job-site learning. Dallman classified the content as in the soft skills domain and indicated that declarative and procedural hierarchies were developed. Course authors were sensitized to information processing issues (e.g., short-term memory limitations, information chunking, the role of automaticity in compilation, and repair theory). Extensive use is made of dual encoding and visuals for motivation. An attempt to implement adaptive testing has also been made. Dallman noted that courseware with QUEST was requiring about 350 hours of development per hour of instruction (not counting supervisory hours); graphics production was particularly time-consuming.

The apprentice space systems operations specialist courseware involved satellite operations personnel and IVD. It represents an Air Force production effort made by personnel with no background in interactive courseware development. Dallman said there are various style guides for producing courseware pertinent to particular domains.

Reactions to the Demonstrations

Following the IDIOM and TTC demonstrations, Halff posed seven questions to consider in evaluating courseware needs:

1. What is/ought to be taught?
2. How should it be taught?
3. What is the development context? What is the corporate knowledge? What are the individual competencies?
4. What is actually developed?
5. What accounts for the differences in 1 through 4?
6. How do we implement fixes to the system?
7. If one had to build AIDA for all the systems involved in the demonstrations, then what would it be like? How would AIDA work?

Gagne indicated that all the AIDAs would look alike. Halff disagreed because he thought the development context would be a significant and major determinant of system requirements. Reigeluth pointed out that, regardless of the dispute between Gagne and Halff, there was too much complexity involved with a variety of domains, etc., and that such complexity could not all be handled at once. Simplifying assumptions had to be made that might compromise both Gagne's and Halff's positions.

O'Neil's AIDA Features Evaluations

One way to make the simplifying assumptions recommended by Reigeluth is to use O'Neil's evaluation results. The complete tabulation of O'Neil's evaluation matrix is included in Appendix D. An initial interpretation suggests the following:

1. Column 11 (feasibility to complete AIDA as resourced) should not be regarded as reliable due to insufficient responses.

2. If columns 2 and 3 (value to SME and Instructional Designer, respectively) are regarded as a measure of expected utility to AIDA users, then there is some agreement (and some disagreement) about what would be useful. Managers regarded most features as useful; a cost-effectiveness tool was ranked of medium value; automated ISD paperwork was ranked of highest value. Instructional designers also ranked a cost-effectiveness tool of medium value, but they ranked an explanation feature even lower; on-line documentation was ranked of highest value. Researchers ranked a cost-effectiveness tool relatively low and ranked intelligent help relatively high.
3. The use of templates was generally ranked of high value to the SME and of low risk. An ITS for ISD and an intelligent job aid were generally ranked of high risk.

Merrill's Transaction Shell Demonstrations

At the February meeting, Merrill had been asked if he would loan some of his transaction shells to AFHRL for an evaluation of their usefulness in Air Force settings. Merrill agreed in principle and further agreed to present a demonstration at the April AIDA meeting.

Merrill prefaced the April demonstration with the need to build a library of appropriate transactions for a variety of settings. He noted that Halff's claim that content and interaction are intertwined goes against the notion of second generation instructional design (ID-2) transaction shells. Merrill claimed that there are a limited number of interactions and they are fairly generalizable.

Merrill's transaction shells grew out of a CAI evaluation study which revealed that approximately 600 hours of development time were being used to develop an hour of very mediocre courseware. The transaction shells are written in Turbo Pascal 2.0. Merrill admits that the demonstration mode needs to be made more interactive, that constructed responses in practice sessions and tests need to be accommodated, that an authoring capability for some of the shells needs to be developed, and the graphics capability (currently Dr. Halo graphics compatible) needs to be integrated into the system.

Merrill noted that it was possible to control the interaction parameters, but as yet there was no guidance to advise users how and why parameters should be changed. It was also possible to limit or allow learner control, but again there was no guidance provided to advise why and when learner control was desirable. The shells did comply with some well-established principles from cognitive science. For example, it is impossible to make a list

or menu with more than seven items using Merrill's nomenclature shell, an application of Miller's principle "seven plus or minus two" as a production rule.

In addition to the nomenclature shell, which had a simple authoring interface, Merrill also demonstrated a checklist procedure transaction shell and a decision-making transaction shell. The checklist procedure allows the user to identify a term and function for a location on a diagram. This simple shell proved to be quite powerful by itself. Merrill claimed that it can be easily modified to accommodate animation. The decision-making transaction shell allowed the user to create a classification hierarchy organized by attribute. The database can be searched by attribute and items can be compared and contrasted.

The general feeling of the group was that Merrill's shells show great promise and potential, but important questions remained. Merrill himself contributed six such questions:

1. How can transactions be designed to incorporate the kinds of knowledge they require in order to be executed?
2. How should course materials be grouped and sequenced, given a particular set of constraints and a content area?
3. What are the different kinds of interaction modes and when is it appropriate to use each?
4. A display of parameter information is needed, along with a reconfiguration capability; how can these be provided?
5. How can transactions learn when and how to call other transactions?

Merrill saw two big advantages in using transaction shells: 1) They contribute to fast and productive courseware authoring, and 2) They allow low level strategies to be automated (i.e., courseware developers need not worry about paired associate learning). AFHRL will conduct a series of studies to determine the usability, generalizability, executability, and the productivity of using such tools in the instructional design process.

Responses to the Critiques

Tennyson reviewed the revisions he had made to his cycle 2 paper. In the revision, Tennyson has overtly dropped the notion of an intelligent tutoring system in favor of an updated ISD process with an intelligent interface. The revised notional structure contains an ISD Expert supported by 3 functional components: Situational Evaluation/Diagnosis, Recommendations/Prescriptions, and a Mini-expert to Guide Users.

The intelligent interface contains the ISD Expert, an ISD Model Knowledge Base, the Instructor's Model of ISD, and a Content Knowledge Base containing previously developed lesson materials.

Tennyson still envisions a system usable by both novices and experts. Complete novices will be "coached" through the system by the ISD Expert, which will make most of the decisions. More advanced users will be "advised" through the system with users able to preempt system defaults and decisions.

Tennyson also dropped the requirement for a mainframe and restated that requirement in the form of a need for an open architecture and a centralized, large capacity database with remote access via personal computers or workstations. He estimated that it would take about 5 years and \$10 million to construct such a system. As a consequence, he agreed with Reigeluth and Halff that it would be necessary to establish simplifying conditions in the beginning so that within 1 year a minimal system prototype could be built. In subsequent years, that initial system would need to be field tested and elaborated. Tennyson stressed that his overall aim was to build a total ISD environment and deliver yearly growth products along the way to that goal.

In order to make decisions about epitomizing and rapid prototyping, Merrill offered eight activities in a possible development plan:

1. Choose the environment, users, and content.
2. Identify a number of transaction shells to handle most of the instruction.
3. Identify initial parameters for those shells.
4. Build the initial shells.
5. Test, tryout, and modify as necessary -- loop #1.
6. Add intelligence and mini-experts -- loop #2.
7. Add management system -- loop #3.
8. Add integrating shells -- loop #4.

Merrill then warned of several hazards with such a plan. First, avoid the temptation to produce specifications all the way down to level #8. Second avoid the temptation to make specifications for multiple iterations at the looping levels. Third, make sure that there is a firm commitment to go through level 5 and one loop in the first attempt.

Reigeluth asked about expanding the number of shells. Merrill replied that iterations through the loops provided a mechanism to accomplish this. Reigeluth indicated that an alternative elaboration strategy would be to begin the second loop after a single trip through Merrill's first loop.

O'Neil stressed the need to build an evaluation system into the development plan and into the system. If the system collected data to be used for evaluation, then users could send in those data for possible use in refining AIDA.

Polson's response stressed a need to prioritize functions and features proposed for AIDA. She said that we should not view AIDA as a complete authoring system. We don't need CMI in the first-cut, nor do we need to worry about automating paperwork. In fact, part of the specification of the Advanced Training System (ATS) is to automate the ISD documentation. She agreed with Reigeluth's notion of epitomizing. She saw a need to have a system capable of handling a problem complex enough to show that AIDA was doing some good, yet the system should be simple enough to remain manageable. She agreed with O'Neil's need to prioritize, but disagreed with him about including metacognitive skills in a first-cut system.

Polson supported O'Neil's concept of commissioning papers on very specific issues and problems in the next phase effort. She said that it would not be necessary to update Friedman's paper unless or until a graphics mini-expert were to be included in AIDA; she did not think the first-cut system should include a graphics mini-expert as that would not be an easily manageable task.

The checklist procedure shell lacks a finished user interface.

Halff's response to the critiques by O'Neil and Reigeluth was that others had already made his points, but he indicated three concerns: 1) Would AIDA(n) be a smaller version of AIDA(n+1)? 2) Would AIDA(n) collect data to help with AIDA(n+1)? and 3) How would users be kept in the loop throughout the AIDA development? Halff liked Merrill's cyclic approach to the development and O'Neil's idea to collect data for the next version.

Muraida pointed out that one way of keeping users in the loop was to insure that AIDA communicated with them in their everyday language -- don't allow AIDA to intimidate or alienate them.

Merrill indicated that his tryout loops involved users. He took the occasion to add a fifth loop to his cyclic development involving automated learning systems. Such systems might be based on artificial neural networks and are clearly futuristic in an instructional design setting; however, they are not unimaginable or impossible (see section 1.1).

Halff again stressed that the context in which AIDA is used would be the major factor in determining what it should be like. Seidel said that academics did not have an exclusive hold on instructional knowledge; rather, there was a great deal of such knowledge in the intuitions and practices of users. As a consequence, users needed to be kept in the AIDA development loop in order to insure that their knowledge was imparted to AIDA.

Tennyson and Mongillo pointed out that aircraft designers did not consult pilots in designing planes until the design was fairly well along. Seidel countered that the instructional design domain was not so well formed as aerodynamics. Halff added that Merrill's strategy was designed to wash out useless ideas in the iterations through the loops.

Ellis and Merrill claimed that AIDA could act as a cognitive extender. Halff maintained that, for an explanation, users want examples and lessons learned, not academic references to articles in journals. Merrill described several levels of explanation that could be included. For example, one level might be a trace of the rules used in reaching a particular decision; a second level might be informal data in the user's terms. Merrill did not see an immediate use for O'Neil's citations of formal studies and experiments.

Polson wondered how users would react to a system that helped a lot with naming but not at all with using rules. Merrill and Polson agreed that one hazard of making a nomenclature transaction available would be that its ease of use and power might tempt users into using it in inappropriate situations. In Dallman's terminology, Merrill's Wrong-Objective-Syndrome could become Merrill's Wrong-Transaction-Syndrome.

Gagne said he was delighted at the amount of agreement among the consultants. He saw the group agreeing that we start slowly and simply, collect and interpret data, and involve users along the way.

ATC Views of ISD

Lt. Col. Clemons (ATC/XPCRI) reviewed Air Force manuals and regulations pertaining to instructional development. AFM 50-2, which contains the worker level description of the five ISD steps, is being revised. The new AFM 50-2 will incorporate much of AFR 50-8, which mandated the ISD model. The applications chapters are being removed from AFM 50-2, and a new series AFP 50-xx is being started to provide information pamphlets on a variety of topics. Clemons pointed out that the revision of the ISD publications did not imply that the Air Force was revising ISD, however. In fact, Clemons asked how the group thought ISD should be revised.

Tennyson's cycle 1 paper is on just that topic, and it has been provided to Clemons as a candidate for the AFP 50-xx series. Gagne thought that 'performance' needed to be well defined in the manual. Merrill thought that enterprises should replace objectives in planning instruction. Several individuals have already expressed the belief that any ISD material should be incorporate to AIDA in a way that is largely transparent to users.

Clemons also recommended targeting a second audience in addition to avionics maintenance training. He indicated that targeting the operations area would have significant political impact in getting support for AIDA. Therefore, he suggested targeting navigation training or undergraduate pilot training. Newcomb indicated a willingness to pursue this, but it would have to be coordinated with AFHRL/OT.

Mongillo liked Merrill's focus on the future. Rosamond again stressed the need to keep users involved and to consider novice users.

Seidel's Presentation of Related ARI Research

Dr. Robert Seidel presented a review of several projects in the area of automated training development underway at ARI. ARI has published a document on authoring system requirements and guidelines. ARI partially funded an earlier version of Merrill's ID Expert. ARI and AFHRL are involved in the development of the Automated Knowledge Acquisition Tool (AKAT). ARI is developing an Automated Systems Approach to Training (ASAT) that will be a kind of automated ISD system. ARI will publish a cognitive model of an expert author in FY 91.

These and other projects were of obvious mutual interest. All agreed that ARI, NPRDC, and AFHRL needed to continue to work in close cooperation and to share results.

Consolidation of Results

The remainder of the afternoon involved an attempt to consolidate results and develop a list of items about which there was consensus. Brown-Beasley claimed that we had resolved these issues:

1. The focus is on a near term AIDA.
2. The next year's goal is to implement an experimental vehicle which epitomizes AIDA.
3. Test the system in the field with users involved in the development.

4. Some kind of knowledge acquisition software would be needed to gather information about students, tasks, and the environment.
5. A rule base for instruction is required.
6. An inference engine would be required (e.g., CLIPS).
7. A database with parameters to drive Merrill-like transactions would be required.
8. Merrill's looping development approach should be used.

Halfp thought there were still unresolved issues concerning what AIDA should do. He did think however, that we had agreed to focus on CBT development and design and that we had identified the Technical Training Center CBT developers as a target user audience. It was noted that Reigeluth wanted the first-cut AIDA system to address the analysis phase of ISD and that Merrill wanted the first-cut system to automate the production of usable instructional materials.

Ellis suggested that the first-cut AIDA system need only incorporate nomenclature and checklist procedure transactions. Dallman agreed that these two transaction types mapped nicely onto the avionics maintenance area.

Gagne liked the focus on maintenance training, but wondered about the user interface and how information about students, tasks, and the environment would be collected. There was considerable discussion about what kind of explanations a first-cut AIDA should include, if any. This led to a list of issues that had obviously not been resolved:

1. What would be the entry into the system?
2. What computer platform would be used?
3. Would AIDA provide tutoring/training?
4. Would AIDA allow user overrides?

Merrill distinguished two kinds of rules currently in his transaction shells: 1) those which were parametrized, and 2) those which were not parametrized. Parametrized rules could easily be overridden by users, if/when that was deemed appropriate. Merrill then added a few items to the consensus list:

1. Rapid prototyping (AFHRL is calling this incremental development).
2. Built-in data collection on both instructors and students.

3. No content semantics in the first-cut AIDA.
4. Use of Merrill-like transactions.

The long term AIDA can then address such items as an intelligent advisor, integrated instructional strategies, an instructional model, etc.

There was a great deal said about satisfying the users' needs in the near term and delivering something useful to the field as soon as possible. There was also agreement that we needed to prioritize functions and features to add as resources allowed. A built-in form of data collection was viewed as an excellent way of collecting valuable information for evaluation purposes during the development of AIDA.

All seven academic consultants have agreed to participate in the Phase II AIDA effort, (Task 13) Polson has indicated an interest in doing a research paper on issues related to building a transaction shell for teaching procedural knowledge. O'Neil indicated an interest in assisting in the area of evaluation. Gagne expressed an interest in providing additional rules for a first-cut AIDA.

The third day of the meeting served as a kick-off meeting for the Phase II AIDA effort (Task 13).

4.4 AREAS OF CONSENSUS AND DISAGREEMENT

Here is a summary of the areas in which there was agreement and disagreement during the final AIDA meeting. They are restricted to the first-cut AIDA.

Areas of Consensus

1. Focus on CBT development and design.
2. Focus on maintenance training at a Technical Training Center.
3. Target current Air Force CBT developers.
4. Provide a help facility.
5. Provide some kind of explanation facility.
6. Allow limited user overrides of defaults.
7. Provide for the collection of information about students, tasks, and the environment.
8. Use the rapid incremental development approach.
9. Provide built-in data collection on students and users.
10. Do not attempt to provide content semantics.
11. Build on the concept of the transaction shell.
12. Adopt situated development.
13. Target intermediate users.
14. Involve users in the development process.

Areas of Disagreement

1. The number and type of shells required.
2. Whether or not to include the analysis phase.
3. Whether or not to include non-maintenance areas.
4. What the starting input to AIDA should be.
5. What computer platform/architecture to use.
6. Whether to provide tutoring and embedded training.

4.5 KEY PARAMETERS AND ISSUES

Based on the papers presented and the discussions at the AIDA meetings, 21 key system attributes have been identified. The attributes and the possible choices for each are listed below. The possible choices are not intended to be exhaustive.

Key System Attributes	Possible Choices
1. Targeted Users	novice, intermediate, expert instructional designers, variety
2. Type of Assistance	advising, coaching, constraining (shells), automated design and development, explanations
3. Targeted Subject Domain	maintenance, electronics maintenance, avionics maintenance, specific avionics device maint., general purpose
4. Instructional Design Theory	ID-1 or ID-2
5. Starting Input	task analysis, learning analysis, enterprise analysis, learning capabilities, flexible
6. Halff's 3 Levels	facilitator, embodier, or implementor
7. Tennyson's 3 Levels	shells, sophisticated shells, integrated system
8. Control of Instructional Design Process	user, system, mixed and dynamic
9. Priority Components	procedure transaction shells, graphics mini-expert, task analysis
10. System Organization	Merrill's 6 blocks, Tennyson's ISD-4 phases, Reigeluth's Structure, Merrill/Newcomb diagram, Brown-Beasley structure

11. ISD Scope	focus on design, development, delivery, analysis, and/or evaluation -- in existing AF model or in Tennyson's updated model
12. Use of AI	none, intelligent interfaces, expert advice, intelligent tutor, expert knowledge acquisition
13. Media Support	graphics and text only, full range of multi-media
14. User Interface	menus, pull-down menus and buttons, command language with macro capability
15. Data Collection	none, built-in data collection on users
16. Databases	content materials, instructional rulesets, courseware examples, research citations
17. On-line Support	automated documentation, on-line help, cost effectiveness tool, formative eval. tool, computerized measurement, authoring management and storyboarding tools, etc.
18. Learning Theory	update or use existing and established theories
19. Instructional Setting	computer-based and/or instructor-based
20. Organizing Strategy	transaction theory, component-display theory, elaboration theory, etc.
21. Knowledge Acquisition	none, built-in

SECTION 5. PROBLEM DEFINITION

The purpose of this section of the report is to recommend the narrowing of problems to be addressed by follow-on AIDA tasks. The recommendations are meant to be consistent with the AIDA Long Range Plan (see section 1.2) and are divided into immediate concerns (Task 13, BAA, SBIRs, and in-house efforts) and long range concerns (a fully specified contract) within these two areas: 1) scope or problem space, and 2) AIDA features and functions keyed to the scope of the problem.

5.1 SCOPE

The long range vision of AIDA should remain fairly intact. At the highest level of abstraction, AIDA is an automated and integrated collection of tools to assist in the design, development, and delivery of instruction (see section 1.1, or Spector's original concept paper, "Preliminary Design Considerations for an Advanced Instructional Design Advisor," AFHRL/IDC, September, 1988). The goal of AIDA is to provide intelligent and automated assistance throughout all phases of instructional development.

Of particular interest to the AIDA project is computer-based instruction. There are a number of reasons for this narrowing of the scope. First, not much is known about how to optimize instruction to be developed for new interactive technologies. Second, computer-based instruction has great potential and promise, if it is designed, developed, and delivered in a theoretically based, empirically justified, and principled fashion. Much more is known about how to make instructor-based instruction effective. What is most needed, therefore, are effective instructional strategies and principles appropriate to new technologies. Long range plans should include the widest possible conception of computer-based instruction, including all existing and planned computer related technologies. Immediate plans should focus on proving that automated tools can improve the process of designing, developing, and delivering instruction on existing microcomputers.

Another way the scope should be narrowed is in terms of subject matter domains. While strategies that become validated as AIDA is developed may prove to be effective across a number of subject areas, to insure that some progress is made that is of value in Air Force settings, the project should focus on the area of maintenance training. The long range goal of AIDA should be to provide intelligent and automated tools to assist in the development of maintenance training. Immediate goals should be more focused on a family of related areas, perhaps on electronics maintenance training.

A third way that the scope can be narrowed is with regard to users. The long range goal is to provide assistance throughout the ISD process to a variety of users (instructional designers, developers, instructors, students) at a variety of levels (novice, intermediate, expert). The tool set would be intelligent and adjust to the user in appropriate ways. Of particular interest is the ability to assist novice instructional designers develop effective computer-based instruction. The immediate goal should address intermediate instructional designers (perhaps the typical TTC designer) to prove that useful tools can be developed to improve their productivity and also improve student performance in computer-based settings.

5.2 KEY FEATURES

Section 4 listed 21 AIDA attributes gleaned from the various papers and presentations by the consultants. Given the long range plans (section 1.2) and the narrowing of scope just indicated (section 5.1), the following table is meant to represent a coherent and rational selection of choices for immediate and long range planning purposes:

Key System Attributes	Immediate	Long-Term
1. Targeted Users	intermediate	novices, et al.
2. Type Assistance	templates, shells, and explanations	advising
3. Subject Domain	avionics maintenance	maintenance, general purpose
4. ID Theory	ID-2	ID-2
5. Starting Input	learning capabilities	flexible and dynamic
6. Halff's 3 Levels	facilitator (using ID-2)	implementor
7. Tennyson's 3 Levels	shells and some sophisticated shells	integrated system
8. Control of ID Process	primarily user	mixed and dynamic
9. Priority Components	procedure transaction shells	generalizable transactions and mini-experts
10. System Organization	Merrill	Merrill/Newcomb

11. ISD Scope	DDD not bound by AF model	Tennyson model, all phases
12. Use of AI	intelligent interface to transaction shells	expert system for advising, intelligent knowledge acq.
13. Media Support	text, graphics, audio, video	full-range of support for interactive media
14. User Interface	pull-down menus with buttons	added command lang., macros, adaptive
15. Data Collection	built-in	built-in
16. Databases	instructional rulesets, and examples	courseware and content expanded
17. On-line Support	help, limited authoring mgt. and storyboard	expanded doc., authoring, and cost mgt.
18. Learning Theory	existing theories	update as necessary
19. Instructional Setting	computer-based	computer- based
20. Organizing Strategy	transactions	integrated transactions
21. Knowledge Acquisition	guided	guided

SECTION 6. PROPOSED SOLUTION AND RECOMMENDATIONS

The purpose of this section is to provide preliminary system specifications for the immediate conception of AIDA -- as a research tool and technology to use in accomplishing the goals of the near-term follow-on tasks (Task 13, BAA, SBIRs, in-house efforts). The first part describes the concept in terms of a functional architecture; the second part provides functional characteristics and preliminary specifications for the near-term AIDA; the third part recommends a development plan of action.

6.1 AIDA'S FUNCTIONAL ARCHITECTURE

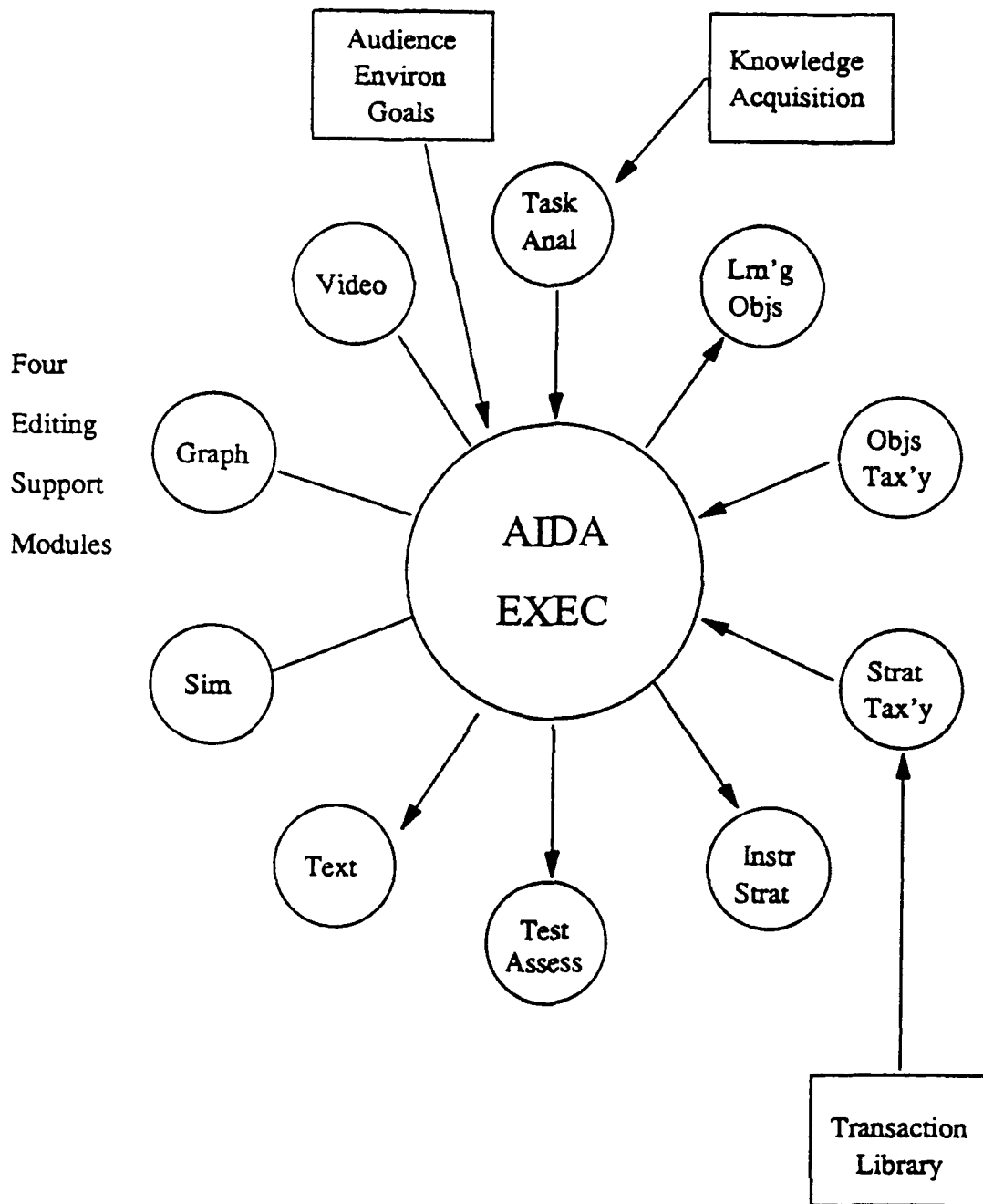
The organization of AIDA proposed by Merrill would be capable of providing the required near-term research results (the effectiveness of various ID-2 instructional design strategies, principles, and prescriptions).

Reigeluth's organizational scheme was judged appropriate for a commercial instructional design setting involving a team of design and development experts. Tennyson's organizational scheme based on a cognitively updated ISD model (ISD-4) incorporated a coaching module. This would probably be a worthwhile enhancement to a system, but does not appear possible in the near-term due to the inability to model in sufficient detail instructional design expertise. However, many of Tennyson's authoring activities identified in his Appendix B can serve as high level functional characteristics for a near-term AIDA (see especially B-4 and B-5).

The modified Newcomb/Merrill "virus diagram" is a reasonable organization scheme for the long-term view of AIDA (see Figure 6.1). Tennyson's ISD-4 model can also provide some worthwhile input to a long range model; Tennyson's support of mini-experts adds credence to this model.

The organizational scheme best suited to the near-term goal (building advanced transaction shells pertinent to CBT in an area such as electronics maintenance training) is that provided by Merrill. However, Gagne's advice to begin with the results of a learning analysis (learning capabilities) allows the AIDA project to focus on instructional strategies and transactions, especially as they can be optimized for CBT in the domain of electronics maintenance training. Because these strategies and transactions will need to be assessed with regard to their effectiveness, a delivery component will also be needed. In short, the near-term AIDA organization concept can be depicted as Merrill's diagram modified to include an evaluation component (see Figure 6.2).

AIDA FUNCTIONAL CONCEPT



NOTE: Boxes and arrows are Merrill's.
Analyses are inputs to EXEC.
Strategies & objectives are outputs.
Taxonomies belong in the EXEC.

Figure 6.1

AIDA CONCEPT

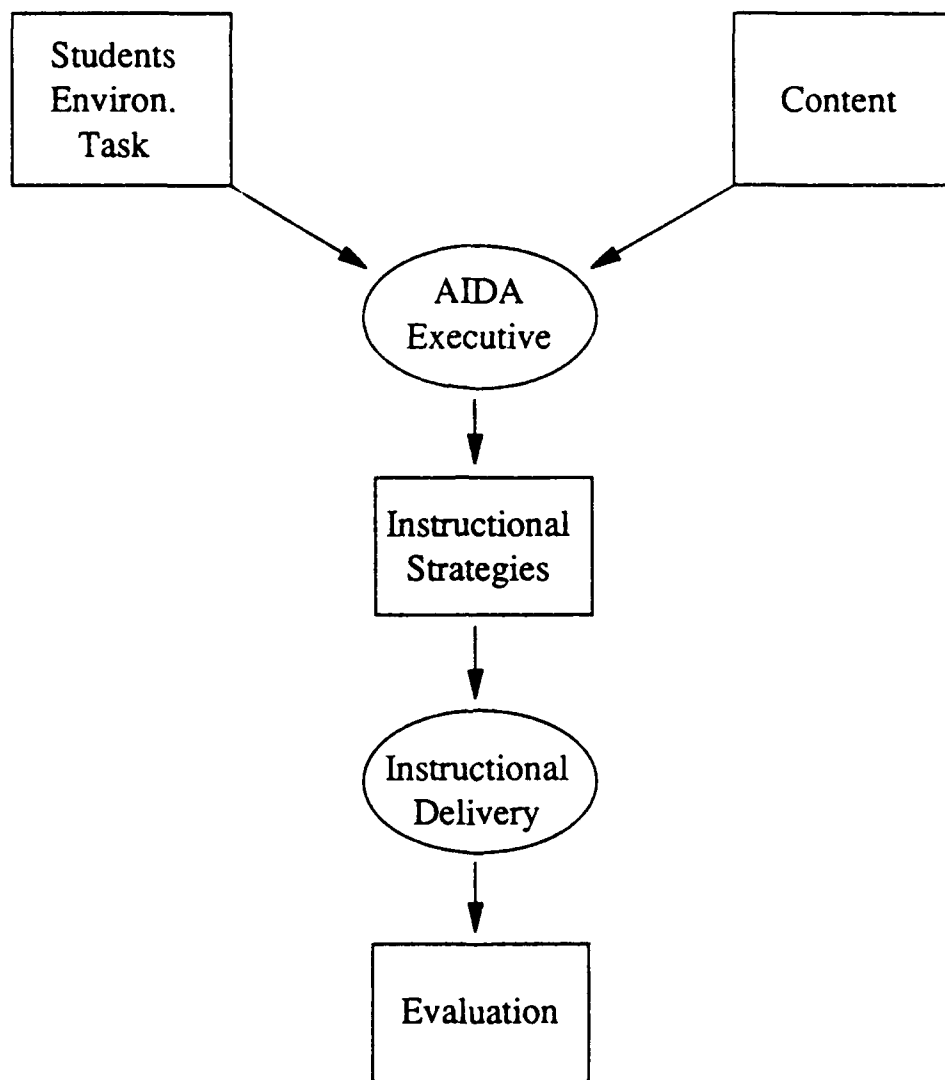


Figure 6.2

The concept of operations for the near-term tool is that an instructional designer with expertise in the subject area but limited knowledge of instructional design will input to AIDA particular learning capabilities. AIDA will be designed with basic information about the students, the environment, and the task already in the system. The instructional designer will be given the learning capabilities to enter. AIDA will then select and configure transaction shells appropriate to the specified capabilities. The instructional designer will then be prompted to enter any needed content knowledge to complete a frame appropriate to the particular knowledge type.

Because we are assuming a fixed environment (small class, computer-based instruction, located at a TTC) and students who are readers and reasonably motivated, that information can be hard-coded into the AIDA EXECUTIVE for the time being. Because we are focusing on teaching procedures for avionics maintenance training, we can customize an enterprise analysis pertinent to that domain and also customize an elaborated frame network shell pertinent to electronics maintenance training procedures. Because these are shells (and can also serve as variables in AIDA experimentation), they are depicted in Figure 6.2 as adjuncts to the AIDA EXECUTIVE.

A representation of this concept is provided in Reigeluth's model. Reigeluth's model is an elaboration of Merrill's organizational scheme in terms of specific conditions, methods, and results involved in nine AIDA functions.

6.2 AIDA SYSTEM FUNCTIONS AND CHARACTERISTICS

The near-term AIDA experimental system proposed herein will be a computer-based instructional design, development, and delivery (DDD) assistant for training development personnel at a TTC who have some instructional design knowledge and experience with courseware development. This system is described below in terms of functions supported, the expected hardware and software environment, and design details.

The near-term AIDA will not initially provide full support for all phases of the instructional system development process. Some phases will be supported only in terms of an epitomizing function, illustrating how the long-term system might function and what inputs and outputs it would provide.

6.2.1 Summary of AIDA Characteristics

Twenty-one AIDA characteristics or attributes of the near-term AIDA, taken from section 5, are listed below. Some characteristics are discussed in section 6.2.2, Functional Description.

Key System Attributes	Near-Term
1. Targeted Users:	intermediate
2. Type of Assistance:	templates, shells, and explanations
3. Subject Domain(s):	avionics maintenance
4. ID Theory:	ID-2
5. Starting Input:	learning capabilities
6. Halff's 3 Levels:	facilitator (using ID-2)
7. Tennyson's 3 Levels:	shells and some sophisticated shells
8. Control of ID Process:	primarily user control
9. Priority Components:	procedure transaction shells
10. System Organization:	Merrill
11. ISD Scope:	DDD not bound by AF model
12. Use of AI:	intelligent interface to transaction shells

- | | |
|----------------------------|--|
| 13. Media Support: | text, graphics, audio,
video |
| 14. User Interface: | pull-down menus with buttons |
| 15. Data Collection: | built-in |
| 16. Databases: | instructional rulesets, and
examples |
| 17. On-line Support: | help, limited authoring mgt.
and storyboard |
| 18. Learning Theory: | existing theories |
| 19. Instructional Setting: | computer-based |
| 20. Organizing Strategy: | transactions |
| 21. Knowledge Acquisition: | built-in |

Seven of these requirements are described in more detail in paragraphs 6.2.2.1 through 6.2.2.6. The detail has been abstracted from the consultants' papers summarized in Section 5.

6.2.2 Functional Description

We will use the tentative architecture (Information, Content, Executive, Strategies, Delivery, and Evaluation) described in Section 6.1 to organize the presentation of system functions in this section. As Halff observed, AIDA is a description in information processing terminology of the design, development, and delivery (DDD) of instruction. One way to describe information processing is the functional flow diagram. For example, an early functional flow diagram for instructional design at the molar level is shown in Figure 6.3 (Bunderson, 1967). A functional flow diagram specific to the near-term AIDA is found in Reigeluth's diagram (Figure 6.4).

Each of the sections 6.2.2.1 through 6.2.2.5 is a summary of options for system functions presented by individual consultants. The purpose of AIDA Phase II (Task 0013) is to select from this list the functions and characteristics that will be employed in the near-term AIDA.

6.2.2.1 Information (Knowledge Acquisition)

Information inputs required from the user (i.e., the instructional designer) will be elicited in easily comprehended ordinary language. AIDA will not require users to be conversant with any technical terms used below. The system will guide the developer through the knowledge acquisition (KA) process.

FUNCTIONAL FLOW DIAGRAM FOR INSTRUCTIONAL DESIGN IN CAI

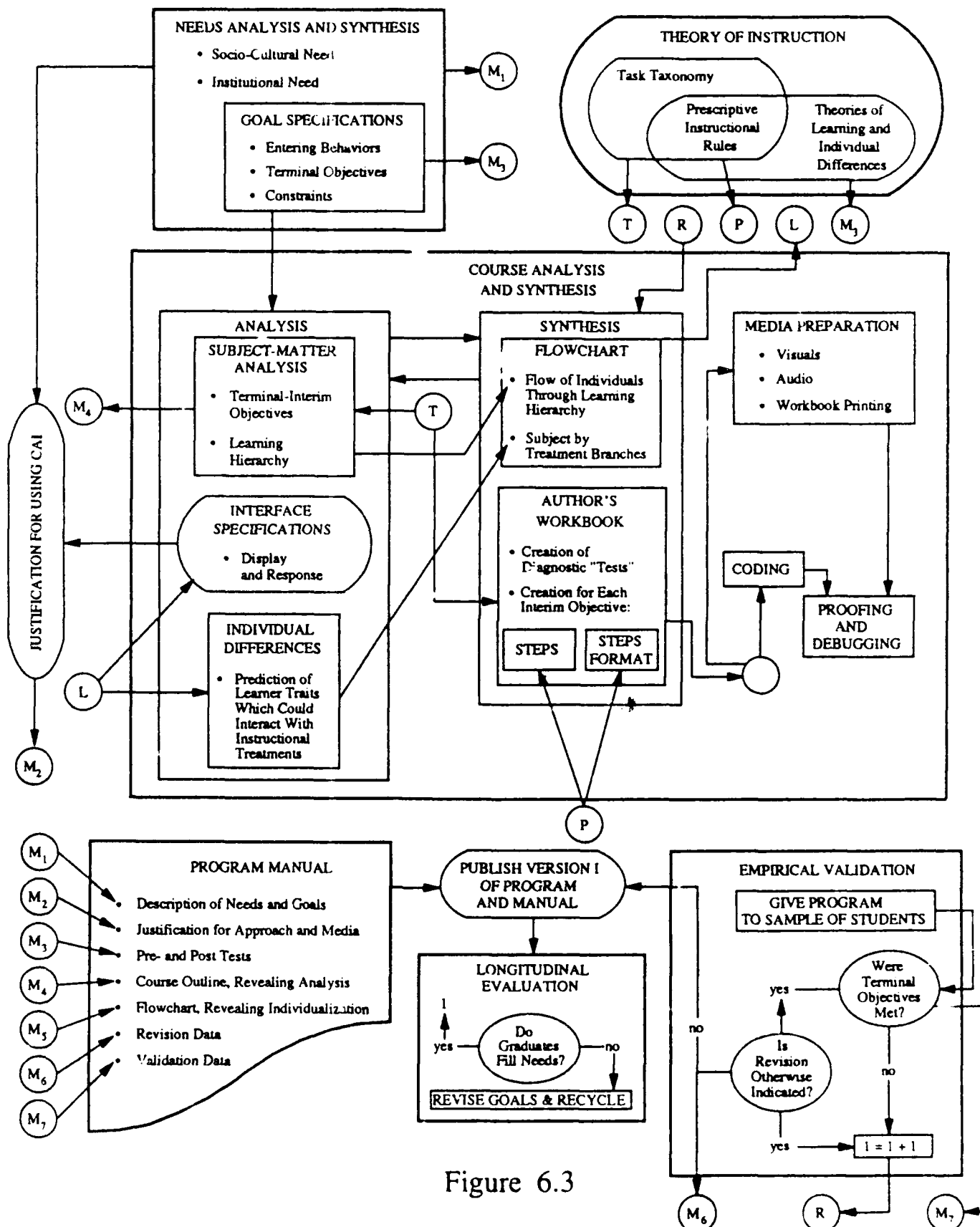


Figure 6.3

AIDA FUNCTIONAL FLOW DIAGRAM

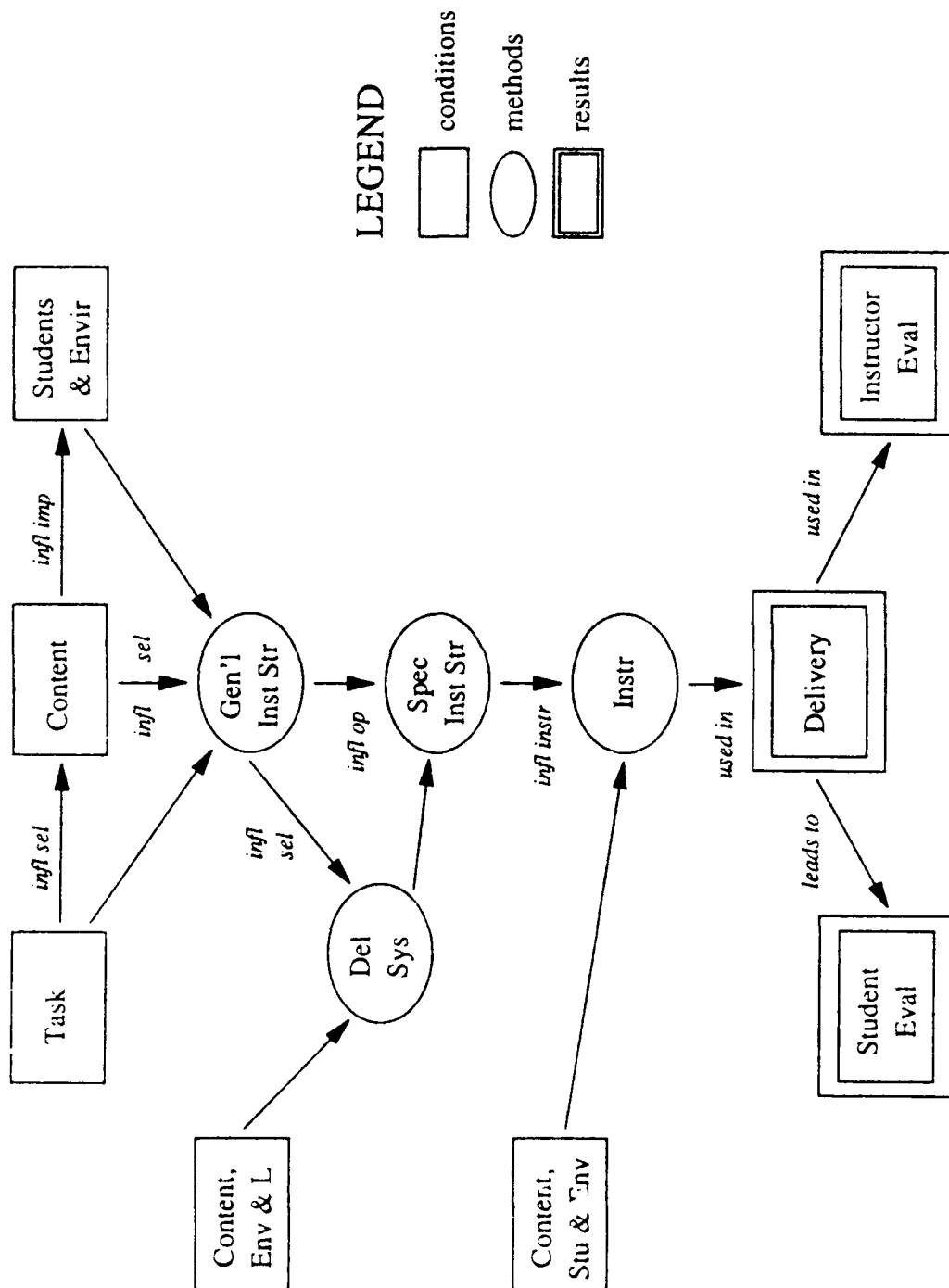


Figure 6.4

Halff has distinguished two kinds of input to AIDA:

1. Information about students, the learning environment, and the tasks to be mastered.
2. Information about the content material to be mastered.

Merrill proposes collecting the following information about the audience:

1. role (e.g., consumer, supervisor, technician, problem-solver)
2. motivation
3. familiarity
4. mastery level
5. ability

Merrill proposes collecting information about seven categories of enterprise (see page 37).

1. denoting
2. executing
3. evaluating
4. designing
5. manifesting
6. interpreting
7. discovering

Merrill proposes information be collected about content using the elaborated frame network (EFN) approach:

1. frames
2. associations with other frames
3. level in abstraction hierarchy
4. knowledge and skill

Spector proposes information be gathered in the following categories.

1. Enterprise input -- a description of the purposeful human activity that is to be trained.
2. Task input -- a description of specific tasks that comprise a particular enterprise.
3. Learning objectives -- descriptions of learning conditions and performance criteria appropriate to the training task.
4. Domain knowledge base input -- the information needed in order to train the enterprise.
5. Course organization -- the grouping and sequencing of information and objectives within the training task.

6. Transaction information -- information necessary to complete a transaction shell for a particular learning objective, including names of graphics files, desired levels of interaction, etc.
7. Graphics, audio, and video input -- allow users to specify file names containing multi-media support materials and indicate where in the course organization such materials are appropriate.

6.2.2.2 Instructional Rules (The Executive)

The rule base will contain at least the following principles, extracted from the consultants' concept papers as summarized in section 5.

- o Gagne's 12 principles of instructional theory (see page 13).
E.g.: Arouse student interest before initiating any other transactions.
- o Halff's list of cultural conventions used in instruction (see page 9).
- o Kintsch's 10 principles of instructional theory drawn from research on human cognition (see pages 16-17).
E.g.: Center instruction on the learner's own knowledge construction activities.

Teach new knowledge in a meaningful context.

Connect new knowledge to old knowledge.

Maximize learner involvement.

Put learner in control of the learning process.

Teach strategies in service of meaningful goals.
- o Merrill's 16 principles of pedagogy and content from ID-2 (see pages 13, 20, 21).
E.g.: To aid later retrieval, organize knowledge during learning.

To aid later retrieval, generate elaborations of knowledge during learning.

Is this an entity, activity, or process?

- o Merrill's 12 pedagogical rules (see page 22).

E.g.: Learners follow the path of least effort.

Learners learn what they do.

Learning improves when information is presented in multiple ways.

- o Polson's 7 principles of cognitive psychology (see page 25).

E.g.: First, analyze the knowledge structures of the expert.

Transform the naive mental models of the learner into increasingly more complex models adequate for solving larger sets of problems.

To represent declarative knowledge, use propositions, semantic nets, scripts, schemata, frames, or plans.

To represent procedural knowledge, use a production system containing production rules (see Newell and Simon, 1972).

Use control processes, including metacognitive knowledge, to guide the learner's processing of knowledge.

- o Tennyson's 6 cognitive principles (see page 28).

E.g.: Use a hierarchy to relate a learning problem to the total learning context.

Trace each instructional activity back to needs and goals of the curriculum.

In all, some 100 principles of instructional design have been extracted from the consultants' concept papers. The 100 principles are not exhaustive, but they are a starting point. The challenge in Phase II will be to restate these psychological aphorisms as IF-THEN rules useful in an expert system.

6.2.2.3 Instructional Strategies

Halff believes there are two ways to represent strategies:

1. In a narrowly defined domain: generative
2. Otherwise: schematic

Tennyson listed five instructional strategies (see page 27).

1. expository
2. practice
3. problem-oriented
4. complex-dynamic
5. self-directed experiences

Gagne suggested strategies for each of the following three stages of instruction:

1. Setup period

Strategy:

1. grabber
2. scenario (enterprise scenario)
3. reminder
4. recall

2. Presentation

Strategy:

1. statement
2. example
3. label
4. mnemonic
5. discourse
6. analogy
7. elaboration
8. human model
9. question

3. Practice

Strategy:

1. practice
2. assessment
3. telling
4. transfer

Gagne's four steps in instructional strategy selection:

1. Choose the media
2. Establish integrative control
3. Classify the single capabilities to be learned
 - a. intellectual skills
 - b. verbal information
 - c. cognitive strategies
 - d. motor skills
 - e. attitudes
4. Select and order appropriate instructional strategies for each capability

Halff's three representation schemes:

1. If procedural knowledge, then a production system.
2. If declarative knowledge, then a schema.
3. If causal knowledge, then qualitative process theory.

Merrill proposes transactions as the building blocks of strategies (see page 38). Transactions are real-time, give-and-take exchanges between the student and an instructional system. The structure of a transaction includes:

1. Parameters
2. Interactions
3. Content

A transaction may be:

1. Expository or inquisitory
2. Learner or system controlled
3. Inductive or experiential

Transactions may be grouped as:

1. Enterprise transactions
2. Association transactions
3. Abstraction transactions
4. Component transactions

6.2.2.4 Explanation

The near-term system will provide the user (developer) with the ability to request the following:

1. A statement of the instructional design philosophy incorporated into AIDA.

2. A statement of the roles of AIDA in the areas of authoring management and courseware design, development, and delivery.
3. An epitomizing description of the targeted student population, including skill levels and knowledge.
4. An epitomizing description of the AIDA learning environment.
5. Examples of enterprise analyses, task analyses, learning objectives, learning activities, and other items required by AIDA in order to develop and deliver instruction.
6. Documentation of lesson and course materials, including course syllabi, lesson plans, study guides, and practice problems.

6.2.2.5 Evaluation

According to Halff, there are three levels of evaluation:

1. Quality control (Am I doing the process right?)
2. Formative evaluation (Is it the right process?)
3. Summative evaluation (Are our underlying assumptions right?)

O'Neil proposes the following steps in formative evaluation.

1. Check design against specifications.
2. Check validity of instructional strategies with research literature.
3. Conduct feasibility review with instructor.
 - one-on-one group testing
 - small group testing
4. Assess instructional effectiveness.
 - cognitive
 - affective
5. Assess unanticipated outcomes.
6. Conduct revision.

O'Neil lists the following CAI lesson evaluation techniques.

1. Quality review
 - language and grammar (e.g., reading level)
 - surface features (e.g., uncluttered displays)
 - etc.
2. Pilot testing
 - Enlist about three helpers representative of potential students.

- Explain pilot-testing procedures.
etc.

3. Validation

- Use the lesson in the setting for which it was designed.
- Use the lesson with students for which it was designed.
etc.

6.2.2.6 Outputs

The near-term system will perform the following functions:

1. Identify appropriate presentation strategies for objectives.
2. Identify appropriate transactions to support those strategies.
3. Determine screen layouts and positioning whenever possible.
4. Develop a lesson prototype based on specified objectives, content, and selected transaction shell.
5. Provide the author with a lesson test and tryout mode with an editing capability.
6. Provide drill and practice and test generation and grading.
7. Collect data on instructor usage and student performance.

6.2.3 Design Details

Design details for three crucial areas (user interface, productivity tools, and learning enhancement) are provided below.

6.2.3.1 The User Interface

The primary user of the near-term AIDA will be the courseware developer, although, in later versions, the users may include the developer's manager, other members of the courseware development team, and even the student.

The critical factor in determining AIDA's acceptability to the developer is the user interface. The user interface includes the visual presentation of menus, choices, help, and information. The user interface also includes the semantic style and content of menus, choices, help, and information.

The system will begin with a log-on procedure which will determine if the user is a developer or student. Figure 6.5 below depicts a suggested opening menu for a developer.

AIDA - DEVELOPER'S MAIN MENU

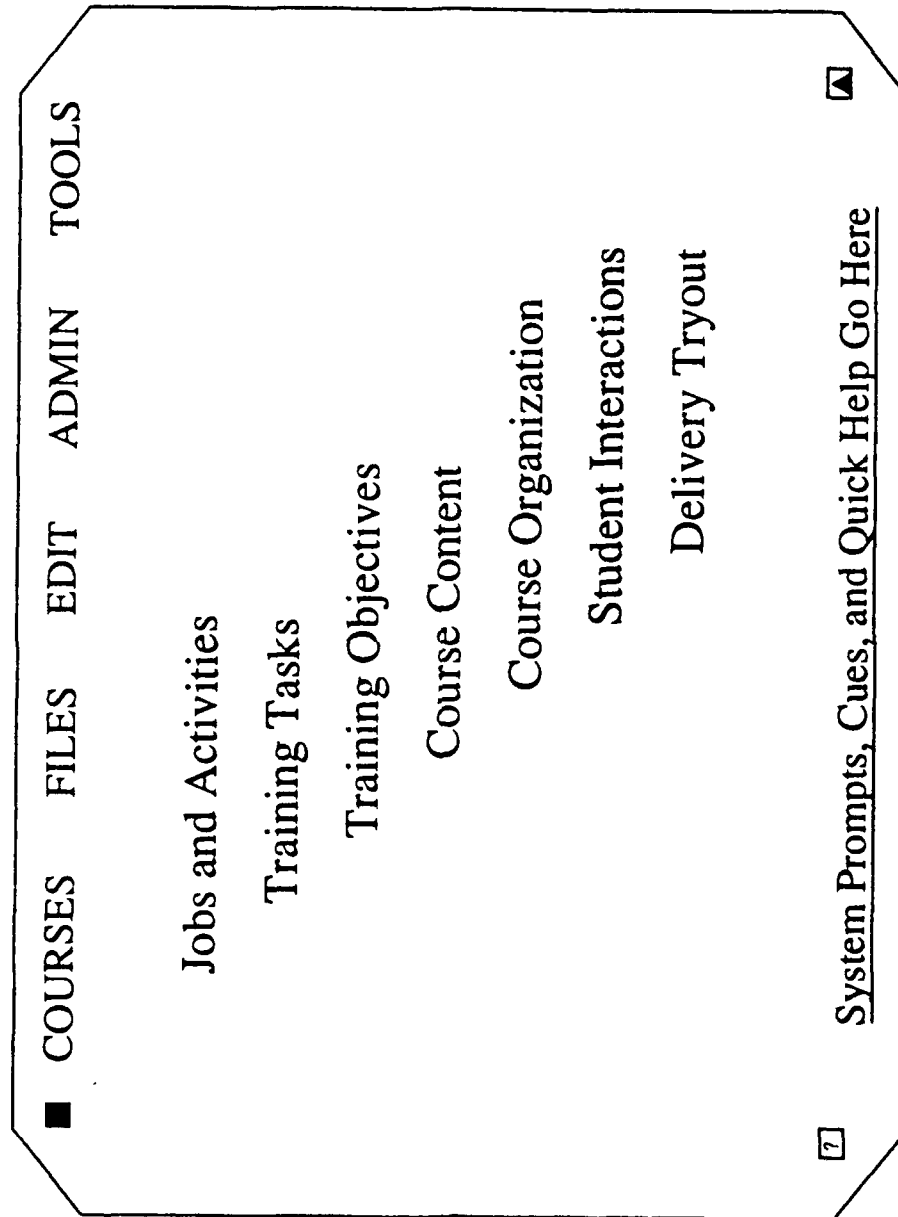


Figure 6.5

The items listed on the top line of Developer's Main Menu are system choices that are available throughout a development session. The seven items depicted in the middle of the screen represent the main steps through the design and development process. The system will direct the user through these steps in a sequential fashion. The system will indicate when a step has been completed (e.g., fading or a check mark). Completed steps can be revisited for editing purposes. The bottom line will be reserved for system prompts, cues, and general guidance.

The question mark button in the lower left corner represents the presence of a dynamic on-line help facility. The arrow button in the lower right corner represents a HOME button that will take the user back to the top level, offering an opportunity to save any work completed. The screen should also depict the mode (developer or student) and the current function and location. The diagram does not suggest how to represent these items.

When an item is activated by a button click, pull-down menus with appropriate selections will appear. Double clicking on a selection will provide the user with the specified item. Icons will be used when appropriate (e.g., in tool selection).

The student interface is not depicted. The expectation is that it will also involve pull-down menus, icons, and be button driven. There will most likely be fewer choices on the opening menu, and there may be fewer system choices across the top menu.

In addition to providing an easily accessible visual interface, AIDA should provide the developer with easily understood guidance through each process. To accomplish this, AIDA should provide all guidance in ordinary language and avoid use of the technical jargon of instructional design. In addition, AIDA should not overload the user's short-term memory. No AIDA menu should contain more than seven choices and nesting should be limited to three levels whenever possible.

The developer will be guided through the seven steps that comprise the opening menu in a straightforward manner. Steps that have been accomplished will be indicated and the system will automatically advance to the next step. However, users will be allowed to step back and edit any previous step. Changes will automatically be carried forward as appropriate, and the user will be returned to the next uncompleted step after an edit. If all steps have been accomplished at least once, the user will be returned to the opening menu.

It should be noted that these are recommendations and suggestions for the interface. The actual interfaces should be designed and developed with user involvement and consultation.

6.2.3.2 Productivity in Courseware Development

The critical factor in determining AIDA's success in improving the productivity of courseware development is the extent to which course design, development, and delivery processes can be automated. As already indicated, AIDA will automatically select strategies and transactions appropriate to those strategies. In addition, transaction shells will be executable with a minimum of input from users. This automation can be accomplished with extensive use of default values for parameters associated with transaction shells.

Some parameters associated with transaction shells will be alterable by users. As the system evolves, users will be offered more control and advice about various ways transaction shells can be customized and optimized for particular purposes. Users will have access to an explanation facility that provides, for example, a justification for beginning a procedural lesson with a scenario.

Transaction shells in each of Gagne's three stages (setup, presentation, and practice) should be provided in the initial system. In addition, the initial system should attempt to provide templates for as many of Gagne's strategies as possible. For example, when the user is sequencing a lesson, AIDA should provide the user with a setup menu and offer a grabber or scenario template followed by a reminder or recall transaction shell.

In addition to executable transaction shells, AIDA should provide easy access to multi-media support. A standard graphical user interface with all parts of the system accessible through that interface will contribute to improved productivity in this area.

6.2.3.3 Enhancement of Student Learning

The critical factor in determining AIDA's contributions to student comprehension, retention, and transfer is the optimality of instructional strategies and prescriptions provided for various training objectives. This initial AIDA system is intended as an experimental system. Data will be collected to determine the optimality of the initial instructional theory rule base. When evidence suggests that strategies, transactions, and sequencing selected by AIDA are less than optimal, appropriate modifications will be made to the rule base.

6.2.4 Expected Hardware/Software Environment

It is generally agreed that having software products that can be transitioned to the field as they are developed and validated is worthwhile. The first executable AIDA product is scheduled to be delivered in FY 92 with an experimental testbed system completed in FY 94.

The Air Force TTCs primarily use MS-DOS 3.0 Zenith Z-248 microcomputers with EGA monitors for CBT. It is expected that these will be gradually upgraded to 80386 systems with higher resolution monitors and additional peripheral devices.

As a consequence, Mei Associates recommends that the targeted computer environment for the near-term should be 80386 based systems with VGA monitors. Efforts should be made to develop a subset AIDA that could run under MS-DOS 3.0 on the Z-248s with EGA monitors.

Due to the expected use of many multi-media peripherals and the need for a standard graphical user interface (GUI), it is recommended that AIDA be targeted for a GUI that will be widely available for the targeted hardware. MicroSoft Windows 3.0, Hewlett-Packard NewWave, and OS/2 Presentation Manager are possible GUI candidates.

AFHRL should conduct an evaluation in FY 91 to determine the exact hardware and software environment desired for the near-term AIDA system.

SECTION 7. RESEARCH ISSUES

The purpose of this section is to identify specific research issues that pertain to AIDA. Research issues are divided into immediate and long-term concerns.

7.1 NEAR-TERM RESEARCH QUESTIONS

The following research questions were raised in cycle 1.

Research Issues Identified in Cycle 1

1. How should AIDA make use of artificial intelligence?
2. What particular functions and principles should be tested in an initial prototype?
3. What degree of specificity is required to implement a major functional component of AIDA (e.g., mapping learning objectives to micro- and macro-instructional strategies)? What knowledge bases and components are required to accomplish this?
4. By what process should new research be incorporated into AIDA's instructional design knowledge base?
5. Can AIDA provide instructional design advice across a wide variety of content areas? How?
6. To what extent can expert instructional design advice be automated?
7. To what extent can instruction be generated automatically based on the instructional design advice?
8. How does instruction become progressively constrained as content becomes progressively specialized.
9. How appropriate (useful, acceptable, etc.) is a top-down, hierarchically dependent development process.
10. Why is traditional ISD dead in the DoD?
11. Why didn't the Air Force adopt ISS?
12. What success stories for authoring systems exist?
13. What are the cost drivers and tradeoffs pertinent to authoring systems?

The following research issues were identified in cycle 2.

Research Issues Identified in Cycle 2

1. What transaction shells need to be included?
2. What representational scheme for the knowledge base will be useful for instructional purposes?
3. How can a representation scheme be mapped onto transactions in ways that guide the presentation of instruction to students?
4. What are the appropriate interaction modes within a transaction?
5. What transactions can be collected to build a database of examples and to use in abstracting common characteristics?
6. What rules can be found in the instructional, computer science, and cognitive science literatures that fit into our model?
7. How do we show that we are improving learning?
8. [How] Does knowledge representation lead to improved learning?
9. [When] Does interactivity result in improved learning?
10. What features of a CBT environment contribute to improved learning?
11. What determines a person's orientation to visual or verbal information? How do we determine a person's orientation?
12. How can transactions be designed to incorporate the kinds of knowledge they require in order to be executed?
13. How should course materials be grouped and sequenced, given a particular set of constraints and a content area?
14. What are the different kinds of interaction modes and when is it appropriate to use each?
15. A display of parameter information is needed, along with a reconfiguration capability; how can these be provided?
16. How can transactions be designed so that they communicate with other transactions?

7.2 LONG-TERM RESEARCH QUESTIONS

Many of the near-term research questions indicated above will continue to merit attention in the long term. This section presents additional long-term research issues.

AIDA's research agenda consists of two major streams:

1. Validation of instructional strategies, principles, and prescriptions with new interactive technologies.
2. Development of simple, effective methods of presenting online instructional design guidance to novice instructional designers.

The two streams are interdependent in that useful instructional design guidance must address the new interactive technologies available to CBI designers while ascertaining that the method of presenting the guidance online minimizes cognitive and ergonomic demands on the novice user. The value of AIDA will increase to the extent that research can coordinate these two concerns.

With respect to instructional strategies, one of the first issues that should be investigated is what strategies are actually taught on a wide basis. Recent observational research has pointed out the need for an inventory of instructional strategies actually being used in public education (Pressley, et al, 1990). It would be extremely useful to find out what instructional strategies are in use in military settings, coupled with data on their effectiveness. This would provide the basis for retaining the best of current military instruction in the AIDA knowledge base. The issue of determining which strategies (whether explicitly taught or not) are effective has been complicated because of research design flaws which fail to rule out alternative causes for performance effects. One of the most important questions about the success of instructional strategies is the degree to which they are influenced by individual differences in cognitive processes such as short-term memory capacity, intelligence, or expertise in a content area. Coupled with this question is the related issue of whether instructional strategies are differentially effective with culturally different populations. Quite apart from the answers to the strategy effectiveness questions it remains for research to address the issues of which procedures will most effectively teach the strategies and which procedures will produce long-term strategy use. The guidance AIDA can provide will be immeasurably more valuable to the novice designer if answers to the above issues can be located in the literature or derived from empirical work.

The question of conveying online instructional design guidance to the novice designer revolves around the relationship between user characteristics, interface configurations, and the resulting

CBI quality and effectiveness. One of the most pressing issues is the degree to which minimal user (novice designer) training in computer software use and instructional design can compensate for:

1. Deficiencies in those areas in cases where the authoring environment has no major flaws.
2. Flaws in the authoring environment in cases where users have experience/ability deficiencies.

A related question is whether training the designer in cognitive and metacognitive strategies will improve the quality of use, the resulting quality of CBI, and its effect on student performance. Finally, it would be useful to determine the possibility of matching user ability and experience profiles with particular authoring environment configurations. The purpose of this effort would be to minimize hardware/software development system and instructional costs, while optimizing the quality of instructional development and student performance. Informative studies relevant to these issues could make it possible in the foreseeable future to customize instructional design authoring environments for designers of different backgrounds and abilities, allowing them to make optimal use of instructional prescriptions and technologies.

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APPENDIX A

MEETING AGENDA

Table of Contents

Kick-off Meeting, Part I	6 Jul 90
Kick-off Meeting, Part II	18-19 Jul 90
Kick-off Meeting, Part III	8- 9 Aug 90
First Concept Design Meeting	17-18 Oct 89
Second Concept Design Meeting	6- 7 Dec 89
Third Concept Design Meeting	20-21 Feb 90
Final Concept Review Meeting	24-25 Apr 90

PROJECT AIDA

Kick-Off Meeting - Part II
July 18-19, 1989
Air Force Human Resources Laboratory
Brooks AFB
San Antonio, Texas

Attendees

Dr. Henry M Halff	Consultant	Halff Associates
Dr. M. David Merrill	Consultant	Utah State Univ.
Dr. Robert Tennyson	Consultant	Univ. of Minnesota
Dr. Scott Newcomb		AFHRL
Dr. Dan Muraida		AFHRL
Dr. J. Michael Spector		AFHRL
Dr. Albert E. Hickey		Mei Associates

Agenda

Tuesday, July 18

Project Organization & Administration

0900	Welcome	Dr. Newcomb
0915	History/Status of the AIDA Project	Dr. Newcomb
1000	Quick Review of the Revised SOW	Dr. Muraida Dr. Hickey
1030	Coffee Break	
1100	Schedule of Future Meetings	Dr. Hickey
1115	Consultants' Agreement	Dr. Hickey
	---	*** ---
1200	Lunch	---
		*** ---

The Conceptual Design of AIDA

1400	Discussion of the First Cycle	Dr. Hickey Moderator
	- Are these the right events?	
	- Are these three tasks the right tasks?	
	- Should there be other tasks?	
	- Are these the right task assignments?	
	- Is the role of the review consultants clear?	
	- Is the schedule realistic?	
1530	Break	

over...

1545 Discussion of Task 1. Dr. Tennyson
 Moderator

- Formulate a statement that defines Task 1.
- Is that the right number of principles?
- Formulate a TOC or outline for Task 1 reports.
- How long should the Task 1 reports be?
- List references dealing with these principles,
 whether or not you agree with them.

1530 Break

1700 Adjourn

--- *** ---

Wednesday, July 19

0900 Discussion of Task 2. Henry Halff, Dave Merrill
 Moderators

- Formulate a statement that defines Task 2.
- Formulate a TOC or outline for Task 2 reports.
- How long should the Task 2 reports be?
- List references, whether or not you agree with them.

1030 Break

1045 Discussion of Task 3. Henry Halff, Dave Merrill,
 Robert Tennyson
 Moderators

- Formulate a statement that defines Task 3.
- Is that the right number of principles?
- Formulate a TOC or outline for Task 3 reports.
- How long should the Task 3 reports be?
- List references dealing with these principles,
 whether or not you agree with them.

--- *** ---

1200 Lunch

--- *** ---

1330 Looking Ahead to the Second Cycle

1500 Adjourn

Reference: Phye, G.D. & Andre, T. (eds.) Cognitive Classroom
 Learning (1986). Academic Press (1-800-321-5068)
 \$32.50

Attachments:

1. Revised SOW
2. Specification of Consultant Tasks (Gagne)
2. List of Consultants
1. Proposed Schedule

PROJECT AIDA

Kick-Off Meeting - Part III
August 8-9, 1989
Air Force Human Resources Laboratory
Brooks AFB
San Antonio, Texas

Attendees

Dr. Robert M. Gagne	Consultant	Florida St. Univ.
Dr. Martha C. Polson	Consultant	Univ. of Colorado
Dr. Scott Newcomb		AFHRL
Dr. Dan Muraida		AFHRL
Dr. J. Michael Spector		AFHRL
Dr. Albert E. Hickey		Mei Associates

Agenda

Tuesday, August 8

Project Organization & Administration

0900	Welcome	Dr. Newcomb
0915	History/Status of the AIDA Project	Dr. Newcomb
1000	Quick Review of the Revised SOW	Dr. Muraida Dr. Hickey
1030	Coffee Break	
1100	Schedule of Future Meetings	Dr. Hickey
1115	Consultants' Agreement	Dr. Hickey
	---	*** ---
1200	Lunch	---
		*** ---

The Conceptual Design of AIDA

1400	Discussion of the First Cycle	Dr. Hickey Moderator
	- Are these tasks the right tasks?	
	- Should there be other tasks?	
	- Are these the right task assignments?	
	- Is the role of the review consultants clear?	
	- Is the schedule realistic?	
1530	Break	
1545	Discussion of Tasks 1, 2 & 3	Dr. Gagne
1700	Adjourn	

over...

Wednesday, August 9

0900	Discussion of Tasks 4, 5 & 6 from minutes of Part II	Dr. Muraida Dr. Hickey
1000	Break	
1015	Definition/selection of a task	Dr. Polson
1100	Summary of Kick-off Meeting, Parts I, II & III	Dr. Newcomb
1200	Adjourn	

Reference: Phye, G.D. & Andre, T. (eds.) Cognitive Classroom Learning (1986). Academic Press (1-800-321-5068)
\$32.50

PROJECT AIDA

First Concept Design Meeting
October 17-18, 1989
Air Force Human Resources Laboratory
Brooks AFB
San Antonio, Texas

Attendees

Dr. Robert M. Gagne	Consultant	Florida St. Univ.
Dr. Henry M. Halff	Consultant	Halff Resources, Inc.
Dr. M. David Merrill	Consultant	Utah State Univ.
Dr. Martha C. Polson	Consultant	Univ. of Colorado
Dr. Robert Tennyson	Consultant	Univ. of Minnesota
Dr. Scott Newcomb		AFHRL
Dr. Dan Muraida		AFHRL
Dr. J. Michael Spector		AFHRL
MAJ Bill Wimpee		AFHRL
Dr. John A. Ellis	Observer	NPRDC
Dr. Albert E. Hickey		Mei Associates

Agenda

Tuesday, October 17

8:30	Welcome back to HRL	Dr. Newcomb
8:40	Goals for this meeting	Dr. Muraida
9:00	AIDA Needs Assessment	Dr. Muraida Dr. Spector
9:30	Cycle 1 task results	Moderator: Dr. Muraida
	Task 1: "Major propositions derived from <u>cognitive learning research</u> "	Dr. Polson
10:00	Task 2: "Major distinguishing characteristics of the <u>contents of cognition</u> "	Dr. Polson
10:30	Break	
11:00	Task 3: "Twelve principles of <u>instructional theory</u> "	Dr. Gagne
12:00	Lunch at the Officers Club	
1:30	Task 4: "How AIDA would support the design of instruction in two instructional paradigms"	Dr. Halff
2:30	Task 5: "Merrill's concept of AIDA"	Dr. Merrill
3:30	Break	(more...)

3:45	Task 6: "The ISD model updated from advances in cognitive science, AI, and educational technology"	Dr. Tennyson
4:45	Check List for the General Discussion	Dr. Muraida
5:00	Adjourn for the day	

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Dinner on your own or at the Red Carpet

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Wednesday, October 18

8:30	Exploring the implications of different design approaches	Moderator: Dr. Spector
10:00	Break	
10:15	Alternative blending strategies	Moderator: Dr. Muraida
12:00	Lunch at the Officers Club	
1:30	Structuring the blenders' task	Moderator: Dr. Hickey
3:00	Break	
3:15	Drafting the October 31 letter to the two critiquers, O'Neil and Reigeluth	Moderator: Dr. Hickey
3:45	Planning the agenda for the December 6-7 meeting	Moderator: Dr. Hickey
4:30	Concluding remarks	Dr. Muraida, Dr. Newcomb
5:00	Adjourn	

PROJECT AIDA

Second Concept Design Meeting
December 6-7, 1989
Air Force Human Resources Laboratory
Brooks AFB
San Antonio, Texas

Attendees

Dr. Robert M. Gagne	Consultant	Florida St. Univ.
Dr. Henry M. Halff	Consultant	Halff Resources, Inc.
Dr. M. David Merrill	Consultant	Utah State Univ.
Dr. Harold F. O'Neil	Consultant	
Dr. Martha C. Polson	Consultant	Univ. of Colorado
Dr. Charles Reigeluth	Consultant	Indiana University
Dr. Robert Tennyson	Consultant	Univ. of Minnesota
Dr. Scott Newcomb		AFHRL
Dr. Daniel Muraida		AFHRL
Dr. J. Michael Spector		AFHRL
MAJ Bill Wimpee		AFHRL
Dr. John A. Ellis	Observer	NPRDC
LCOL Jerry Barucky	Mil. Advisor	USAFRS/RSCD
LCOL Dan Meigs	Mil. Advisor	3302d TCHTS/CC
LCOL Mike Bush	Mil. Advisor	USAFA/DEF
LCOL Rich Ranker	Mil. Advisor	ACSC/EPD
Mr. Brian Dallman	Mil. Advisor	3400 TCHTW/TTGCX
LCOL Mike Dickinson	AF Observer	Adv. Trng. System
CAPT James Coward	AF Observer	HQ ATC/XPCRI
Dr. Albert E. Hickey	Proj. Mgr.	Mei Associates

Agenda

Wed., Dec. 6: Finalizing Cycle 1

8:30	Welcome/Introductions	Dr. Newcomb
8:45	HRL's goals for the Meeting/Agenda	Dr. Muraida
9:15	Analysis of Cycle 1 Papers with Comments from Consultants	Dr. Muraida Dr. Spector
10:15	Break	
10:45	Critique of Cycle 1/Suggestions for Cycle 2 with Comments from Consultants	Dr. O'Neil
12:00	Lunch at the Officers Club	
1:30	Critique of Cycle 1/Suggestions for Cycle 2 with Comments from Consultants	Dr. Reigeluth
2:45	Short Break	

(more...)

3:00	Implications of the Cycle 1 Critiques	Dr. Spector
3:45	Short Break	
4:00	Implications of the Cycle 2 Suggestions	Dr. Muraida
4:45	Plan for Tomorrow	Dr. Hickey
5:00	Adjourn for the Day	

--- *** ---
Dinner on your own or at the Red Carpet
--- *** ---

Thur., Dec. 7: Planning Cycle 2

8:30	Refining the Concept - Task Assignments	Dr. Spector
10:00	Break	
10:30	Functional Characteristics - Assignments	Dr. Muraida
12:00	Lunch at the Officers Club	
1:30	Research Agenda - Task Assignments	Dr. Spector
2:45	Short Break	
3:00	Procedural Issues - AIDA Follow-ons	Dr. Muraida
3:45	Short Break	
4:00	Observations of Military Advisors	Dr. Spector
4:30	Concluding Remarks	Dr. Newcomb
5:00	Adjourn	

PROJECT AIDA

Third Concept Design Meeting
February 20-21, 1989
Air Force Human Resources Laboratory
Brooks AFB, San Antonio, Texas

Attendees

Consultants

Dr. Robert M. Gagne	Florida St. Univ.
Dr. Henry M. Halff	Halff Resources, Inc.
Dr. M. David Merrill	Utah State Univ.
Dr. Martha C. Polson	Univ. of Colorado
Dr. Robert Tennyson	Univ. of Minnesota

AF Human Resources Laboratory

Dr. Scott Newcomb	AFHRL
Dr. Daniel Muraida	AFHRL
Dr. J. Michael Spector	AFHRL
MAJ Bill Wimpee	AFHRL
Ms. Barbara Eaton	AFHRL

Military Advisors

Dr. John A. Ellis	NPRDC
LCOL Jerry Barucky	USAFRS/RSCD
LCOL Dan Meigs	3302d TCHTS/CC
LCOL Mike Bush	USAF/A/DFP
Dr. Mary Marlino	USAF/A/DFT
LCOL Rich Ranker	ACSC/EPD
Mr. Brian Dallman	3400 TCHTW/TTGCX
LCOL Mike Dickinson	Advanced Training System
CAPT James Coward	HQ ATC/XPCRI
MAJ Robert Mongillo	ATC/XPC
MAJ Karen Reid	ATC/TTIP
Dr. Ok-choon Park	Army Res. Institute

Mei Associates

Dr. Albert E. Hickey	Project Manager
Mr. Richard Vigue	Mei Associates/SA

Agenda

Tuesday, February 20, Presentation of Cycle 2 Tasks

8:30	Welcome Back	Dr. Newcomb
8:45	Goals/Agenda	Dr. Muraida
9:00	Presentation of Task Results	Dr. Muraida (moderator)
9:00	Dr. Robert M. Gagne	
10:00	Break	
10:30	Dr. Henry M. Halff	
11:30	Lunch	(more...)

1:00	Dr. M. David Merrill	
2:00	Short Break	
2:15	Dr. Martha C. Polson	
3:15	Short Break	
3:30	Dr. Robert D. Tennyson	
4:30	Wrap-up/Observations	Dr. Spector
5:00	Adjourn for the day	

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 Dinner on your own or at Tomatillo's
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Wednesday, Feb. 21: Integrating Task Results for the Final Report

8:30	Architectural Summary	Dr. Spector (moderator)
9:15	Break	
10:15	Functional Characteristics	Dr. Muraida (moderator)
11:00	Research Issues	Dr. Hickey (moderator)
11:30	Lunch	
1:00	AIDA Phase II (Task 0013) Requirements	Dr. Muraida
1:30	From Func Specs to S/W Specs	Ms. Barbara Eaton
2:00	Short Break	
2:15	Tasking the Reviewers	Dr. Spector
3:15	Short Break	
3:30	Wrap-up/Observations	Dr. Hickey (moderator)
4:30	Adjourn	

PROJECT AIDA
Final Concept Review Meeting: Phase I
April 24-25, 1990
Kick-Off Meeting: Phase II
April 26, 1990
Air Force Human Resources Laboratory
Brooks AFB, San Antonio, Texas

Attendees

Consultants

Dr. Robert M. Gagne	Florida St. Univ.
Dr. Henry M. Halff	Halff Resources, Inc.
Dr. M. David Merrill	Utah State Univ.
Dr. Martha C. Polson	Univ. of Colorado
Dr. Robert Tennyson	Univ. of Minnesota
Dr. Harold F. O'Neil	Univ. of S. California
Dr. Charles Reigeluth	Indiana University

AF Human Resources Laboratory

Dr. Scott Newcomb	AFHRL/IDC
Dr. Daniel Muraida	AFHRL/IDC
Dr. J. Michael Spector	AFHRL/IDC
MAJ Bill Wimpee	AFHRL/IDC

Military Advisors

Dr. John A. Ellis	NPRDC
LCOL Jerry Barucky	USAFRS/RSCD
LCOL Dan Meigs	3302d TCHTS/CC
LCOL Mike Bush	USAF/DEF
Dr. Mary Marlino	USAF/DEF
LCOL Rich Ranker	ACSC/EPD
Mr. Brian Dallman	3400 TCHTW/TTGCX
LCOL Mike Dickinson	HQ HSD/YA
CAPT James Coward	HQ ATC/XPCRI
MAJ Robert Mongillo	ATC/XPC
MAJ Karen Reid	ATC/TTIP
Dr. Ok-choon Park	Army Research Institute
LCOL Larry Clemons	ATC/XPCRI
Dr. Dee Andrews	AFHRL/OT
Mr. John LaBarbera	HQ USAF/DPPE

Mei Associates

Dr. Albert E. Hickey	Project Manager
Mr. Richard Vigue	Mei Associates/SA
Mr. Michael Brown-Beasley	Mei Associates/Lex

Agenda

Tuesday, April 24: Critique of Cycle 2 Tasks

8:30	Welcome Back	Dr. Newcomb
8:45	Goals/Agenda	Dr. Muraida
9:00	Summary of AIDA To Date	Dr. Spector

9:30	Demos of AIDA-related Systems	Dr. Muraida (moderator)
9:30	Demo of IDiOM	Dr. Marlino
10:30	Break	
11:00	Demo of QUEST	Mr. Dallman
12:00	Lunch at the Officers' Club	
1:30	Demo of SOCRATES	Dr. Spector
2:00	1st Critique of Cycle 2	Dr. O'Neil
3:00	Break	
3:30	2nd Critique of Cycle 2	Dr. Reigeluth
4:30	Responses to Critiques	Dr. Muraida (moderator)
4:30	Dr. Gagne	
4:45	Dr. Halff	
5:00	Dr. Merrill	
5:15	Dr. Polson	
5:30	Dr. Tennyson	
5:45	Adjourn for the day	

--- *** ---
 Dinner on your own or on the river
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Wednesday, April 25: Conclusions for the Phase I Final Report

8:30	Summary of the Critiques	Dr. Spector (moderator)
9:00	Research Issues	Dr. Muraida (moderator)
9:30	Transaction Shell Demo	Dr. Merrill
10:00	Discussion of Transactions	Dr. Merrill
10:30	Break	
11:00	Final Review of AIDA Specs	Dr. Spector (moderator)
12:00	Lunch at the Officers' Club	
1:30	Final Review of AIDA Specs	Dr. Spector (moderator)
3:00	Break	

3:30 Final Review of AIDA Specs Dr. Spector (moderator)
5:00 Adjourn for the day

--- *** ---
Dinner on your own or on the river
--- *** ---

Thursday, April 26: Kick-off Meeting for AIDA Phase II (Task 0013)

8:30 Review of the Agenda Dr. Muraida
8:45 Description of AIDA Phase II Dr. Muraida
9:00 Overall Plan of AIDA Phase II Dr. Hickey
Mr. Brown-Beasley
1. General Procedure
2. Knowledge Acquisition
3. Expert System Architecture
4. Demonstration of the AIDA Model
10:00 Break
10:30 Phase II Milestones Dr. Muraida
1. Cycle 1: Design Specs for Knowledge Bases
2. Cycle 2: Design Specs for Linking Knowledge Bases
3. Final Reports
12:00 Lunch at the Officers' Club
1:30 Role of the Consultants in Phase II Dr. Hickey (moderator)
2:30 Break
3:00 Addressing Research Issues Dr. Spector (moderator)
4:00 Developing a Test Plan Dr. Muraida (moderator)
5:00 Adjourn

APPENDIX B
TASKING ASSIGNMENTS

Table of Contents

Cycle 1

Design Tasks

1. Gagne
2. Halff
3. Merrill
4. Polson
5. Tennyson

Review Tasks

6. O'Neil
7. Reigeluth

Cycle 2

Design Task

1. Uniform Tasking Assignment for Gagne, Halff, Merrill,
Polson and Tennyson

Review Tasks

1. O'Neil
2. Reigeluth

PROJECT AIDA

SPECIFICATIONS FOR CONSULTANT TASKS

First Design Cycle

(Revised 10 August 1989)

AIDA seeks to develop instructions and job aids that will make instructional design efficient, particularly for those who are relatively inexperienced, and whose knowledge of the theoretical basis for instructional design is limited.

AIDA seeks to (a) define the nature and scope of relevant learning theory, knowledge theory, and instructional theory, and (b) to bring about a systematic integration of these three domains as a foundation for instructional design.

--- *** ---

Task 1, Polson: State the ten or twelve major propositions derived from cognitive learning research which would probably be agreed to by leading investigators in the field, and which have an essential relation to instructional design. Describe in terms as simple as possible why each principle is important to instructional design, and what effect knowing it may be expected to have on the performance of the instructional designer.

Task 2, Polson: State the major distinguishing characteristics of the contents of cognition, including the different kinds of knowledge and the different forms each type may take. Consider in your description the contributions of epistemologists (e.g., Michael Polanyi) and cognitive psychologists (e.g., Anderson, Simon). Restrict your answer to the forms of cognition which carry clear implications for the nature of instruction and its design. As an aim, describe what kind of "knowledge theory" must form a basis for the design of instruction.

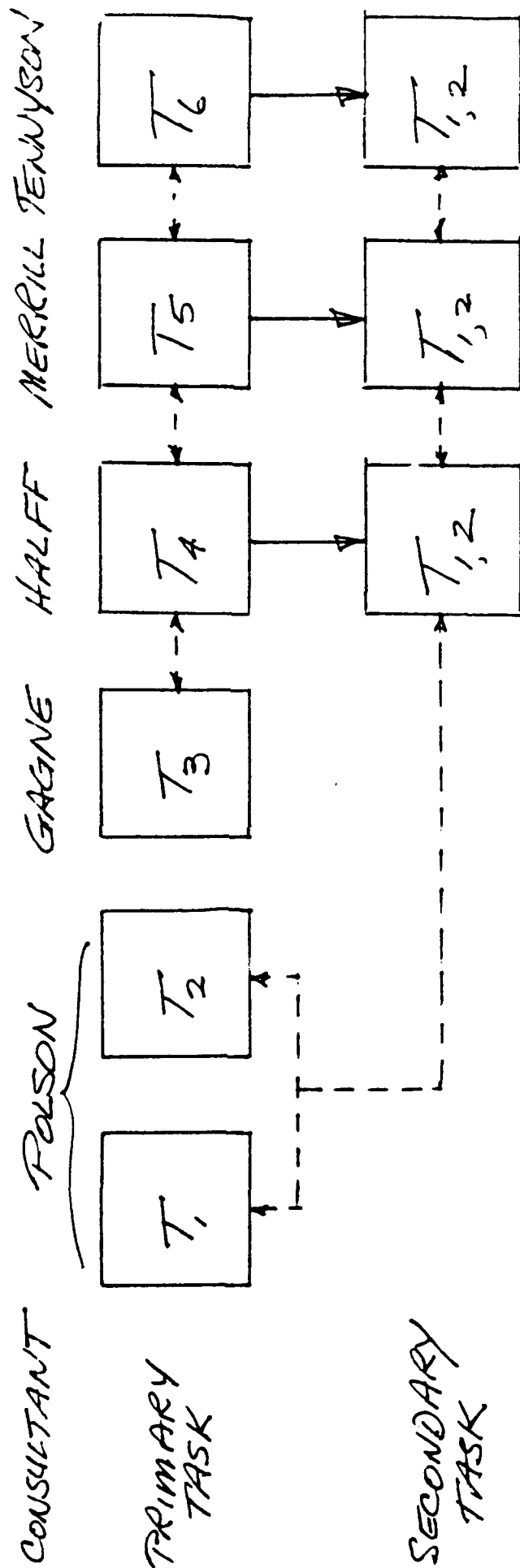
Task 3, Gagne: State the twenty (or so) principles of instructional theory (as exhibited for example in Reigeluth's book) which can be commonly held by all instructional theorists, and concerning which there is minimal or zero disagreement, except perhaps in priority of importance. Indicate common ideas and variant terminology; identify reasons for differences in terminology when possible. Consider the relative importance of these principles in determining the nature of instruction and the process of instructional design. When appropriate, indicate differences in the depth of knowledge about learning required by the instructional designer when using each of these principles in designing instruction.

Task 4, Halff: Provide a concept of how AIDA would support the design of instruction in two broad instructional paradigms to be selected. And identify the principles of learning and instruction that apply to the design of the two AIDAs and to their instructional products.

Task 5, Merrill: Define Merrill's concept of AIDA: the functions it should perform, including knowledge acquisition (see Task 2 above) and strategy analysis (see Task 3 above). And identify the principles of knowledge theory, learning theory, and instruction theory that underlie these functions.

Task 6, Tennyson: Update ISD model from advances in cognitive science, AI, and educational technology.

PROJECT AIDA CORRELATION SCHEME



MEI ASSOCIATES, INC.
1050 WALTHAM STREET, LEXINGTON, MASS 02173
(617) 862-3390

August 11, 1989

Dr. M. David Merrill
Instructional Technology Dept.
Utah State University
Logan, Utah 84322-3025

RE: Project AIDA

Dear Dave:

Now that the three kick-off meetings have been completed, we would like to summarize your task assignment for cycle 1. As you proposed, your primary task is to "define (your) concept of AIDA: the functions it should perform, including knowledge acquisition (see Task 2) and strategy analysis (see Task 3). And identify the principles of knowledge theory, learning theory, and instruction theory that underlie these functions." That is Task 5 on the attached list.

To help us correlate the results of Tasks 4, 5, and 6, please make a separate list of principles derived from research on cognition and cognitive processes involved in learning and relevant to your primary task. (This is akin to the subtask described in the second sentence of your own task definition. It is also an abbreviated version of Gagne's Tasks 1 and 2.)

The overall process of correlation, shown in the attached schematic, will begin when you submit your draft on October 10 and continue until we send the integrated results to Harry O'Neil and Charles Reigeluth on October 31.

Meanwhile, as you suggested, HRL will concurrently prepare:

1. A needs statement
2. A requirements document
3. A general specification, or vision of AIDA

On another subject, Scott Newcomb says that the JAG at Brooks AFB has declared that your work on this task will not preclude your bidding on any future procurements connected with AIDA.

Finally, if is agreeable with you, the meeting in October

will be moved up one day to Tuesday and Wednesday, October 17, 18, to avoid a conflict. Martha Polson is scheduled to chair a panel at the HFS on the 19th.

We believe the kick-off meetings have been productive and augur well for the AIDA project. I look forward to receiving your draft on October 10. If you have any questions, please call me directly at 617-862-3390, or fax 617-862-5053.

Sincerely yours,

Albert E. Hickey, PhD

Encl.:

Specifications of Consultant Tasks (6)
Schematic of Correlation Process
Letters to other consultants (4)

MEI ASSOCIATES, INC.
1050 WALTHAM STREET, LEXINGTON, MASS. 02173
(617) 862-3390

August 11, 1989

Dr. Robert D. Tennyson
178 Pillsbury Drive S.E.
University of Minnesota
Minneapolis, Minnesota 55155

RE: Project AIDA

Dear Bob:

Now that the three kick-off meetings have been completed, we would like to summarize your task assignment for cycle 1. As you proposed, your primary task is to "update the ISD model from advances in cognitive science, AI, and educational technology." That is Task 6 on the attached list.

To help us correlate the results of Tasks 4, 5, and 6, please make a separate list of principles derived from research on cognition and cognitive processes involved in learning and relevant to your primary task. (This is an abbreviated version of Gagne's Tasks 1 and 2.)

The overall process of correlation, shown in the attached schematic, will begin when you submit your draft on October 10 and continue until we send the integrated results to Harry O'Neil and Charles Reigeluth on October 31.

Meanwhile, as recommended by the consultants, HRL will concurrently prepare:

1. A needs statement
2. A requirements document
3. A general specification, or vision of AIDA

On another subject, Scott Newcomb says that the JAG at Brooks AFB has declared that your work on this task will not preclude your bidding on any future procurements connected with AIDA.

Finally, if it is agreeable with you, the meeting in October will be moved up one day to Tuesday and Wednesday, October 17, 18, to avoid a conflict. Martha Polson is scheduled to chair a panel at the HFS on the 19th.

We believe the kick-off meetings have been productive and augur well for the AIOA project. I look forward to receiving your draft on October 10. If you have any questions, please call me directly at 617-862-3390.

Sincerely yours,

Albert F. Hickey, PhD

Encl.:

Specifications of Consultant Tasks
Schematic of Correlation Process
Letters to other consultants (4)

MEI ASSOCIATES, INC.
1050 WALTHAM STREET, LEXINGTON, MASS. 02173
(617) 862-3390

August 11, 1989

Dr. Martha C. Polson
Institute of Cognitive Science
University of Colorado
Boulder, Colorado 80309-0345

RE: Project AIDA

Dear Martha:

Now that the three kick-off meetings have been completed, we would like to summarize your task assignment for cycle 1. As you proposed, your primary task is a combination of Tasks 1 and 2:

1. "State the ten or twelve major propositions derived from cognitive learning research which would probably be agreed to by leading investigators in the field, and which have an essential relation to instructional design. Describe in terms as simple as possible why each principle is important to instructional design, and what effect knowing it may be expected to have on the performance of the instructional designer."

2. "State the major distinguishing characteristics of the contents of cognition, including the different kinds of knowledge and the different forms each type may take. Consider in your description the contributions of epistemologists (e.g., Michael Polanyi) and cognitive psychologists (e.g., Anderson, Simon). Restrict your answer to the forms of cognition which carry clear implications for the nature of instruction and its design. As an aim, describe what kind of "knowledge theory" must form a basis for the design of instruction."

Tasks 1 and 2 will be correlated with lists of principles derived from Tasks 4, 5, and 6, as shown in the attached schematic. The correlation process will begin when you submit your draft on October 10 and continue until we send the integrated results to Harry O'Neil and Charles Reigeluth on October 31.

Meanwhile, as recommended by the consultants, HRL will concurrently prepare:

1. A needs statement
2. A requirements document
3. A general specification, or vision of AIDA

On another subject, Scott Newcomb says the JAG at Brooks AFB has declared that your work on this task will not preclude your bidding on any future procurements connected with AIDA.

Finally, if the other consultants are agreeable, the meeting in October will be moved up one day to Tuesday and Wednesday, October 17, 18, so you can participate in the HFS meeting on the 19th.

We believe the kick-off meetings have been productive and augur well for the AIDA project. I look forward to receiving your draft on October 10. If you have any questions, please call me directly at 617-862-3390, or fax 617-862-5053.

Sincerely yours,

Albert E. Hickey, PhD

Encl.:

Specifications of Consultant Tasks
Schematic of Correlation Process
Letters to other consultants (4)

MEI ASSOCIATES, INC.
1050 WALTHAM STREET, LEXINGTON, MASS. 02173
(617) 862-3390

August 10, 1989

Dr. Robert M. Gagne
233 East Hickory Knoll Rd.
Franklin, North Carolina 28734

RE: Project AIDA

Dear Bob:

Now that the three kick-off meetings have been completed, we would like to summarize your task assignment for cycle 1. As you proposed, your task is Task 3: "State the twenty (or so) principles of instructional theory (as exhibited for example in Reigeluth's book) which can be commonly held by all instructional theorists, and concerning which there is minimal or zero disagreement, except perhaps in priority of importance. Indicate common ideas and variant terminology; identify reasons for differences in terminology when possible. Consider the relative importance of these principles in determining the nature of instruction and the process of instructional design. When appropriate, indicate differences in the depth of knowledge about learning required by the instructional designer when using each of these principles in designing instruction."

The product of Task 3 will be correlated with the results of Tasks 4, 5, and 6, as shown in the attached schematic. The correlation process will begin when you submit your draft on October 10 and continue until we send the integrated results to Harry O'Neil and Charles Reigeluth on October 31.

Meanwhile, as recommended by the consultants, HRL will concurrently prepare:

1. A needs statement
2. A requirements document
3. A general specification, or vision of AIDA

On another subject, Scott Newcomb says the JAG at Brooks AFB has declared that your work on this task will not preclude your bidding on any future procurements connected with AIDA.

Finally, if is agreeable with you, the meeting in October

will be moved up one day to Tuesday and Wednesday, October 17, 18, to avoid a conflict. Martha Polson is scheduled to chair a panel at the HFS on the 19th.

We believe the kick-off meetings have been productive and augur well for the AIDA project. I look forward to receiving your draft on October 10. If you have any questions, please call me directly at 617-862-3390, or fax 617-862-5053.

Sincerely yours,

Albert E. Hickey, PhD

Encl.:

Specifications of Consultant Tasks
Schematic of Correlation Process
Letters to other consultants (4)

MEI ASSOCIATES, INC.
1050 WALTHAM STREET, LEXINGTON, MASS. 02173
(617) 362-3390

August 10, 1989

Dr. Henry M. Halff
Halff Resources Inc.
4913 33rd Road, North
Arlington, Virginia 22207

RE: Project AIDA

Dear Henry:

Now that the three kick-off meetings have been completed, we would like to summarize your task assignment for cycle 1. As you proposed, your primary task is to "provide a concept of how AIDA would support the design of instruction in two broad instructional paradigms to be selected. And identify the principles of learning and instruction that apply to the design of the two AIDAs and to their instructional products." This is Task 4 on the attached list.

To help us correlate the results of Tasks 4, 5, and 6, please make a separate list of principles derived from research on cognition and cognitive processes involved in learning and relevant to your primary task. (This is akin to the subtask described in the second sentence of your own task definition. It is also an abbreviated version of Gagne's Tasks 1 and 2.)

The overall process of correlation, shown in the attached schematic, will begin when you submit your draft on October 10 and continue until we send the integrated results to Harry O'Neil and Charles Reigeluth on October 31.

Meanwhile, as recommended by the consultants, HRL will concurrently prepare:

1. A needs statement
2. A requirements document
3. A general specification, or vision of AIDA

On another subject, Scott Newcomb says the JAG at Brooks AFB has declared that your work on this task will not preclude your bidding on any future procurements connected with AIDA.

Finally, if is agreeable with you, the meeting in October will be moved up one day to Tuesday and Wednesday, October 17, 18, to avoid a conflict. Martha Polson is scheduled to chair a panel at the HFS on the 19th.

We believe the kick-off meetings have been productive and augur well for the AIDA project. I look forward to receiving your draft on October 10. If you have any questions, please call me directly at 617-862-3390, or fax 617-862-5053.

Sincerely yours,

Albert E. Hickey, PhD

Encl.:

Specifications of Consultant Tasks
Schematic of Correlation Process
Letters to other consultants (4)

December 15, 1989

RE: Project AIDA, Your task in cycle 2

Following the meeting at HRL last week, this letter summarizes your task assignment for cycle 2.

As you recall, the goals for cycle 2 are to (1) define the AIDA concept, (2) define the functional characteristics of AIDA, and (3) list related research issues. During the meeting, a functional block diagram was used to organize cycle 2 tasks. The core functions are listed below.

1. Information
 - 1.1 Audience
 - 1.2 Environment
 - 1.3 Task
2. Content
3. Executive
4. Strategies
5. Delivery
6. Evaluation

In the enclosed guidelines, one page is devoted to each of the six functions. The questions on each page are intended to bring the AIDA concept to a new level of detail by defining the variables/attributes/characteristics of each function and specifying a scale of values for each variable. Please answer the questions, adding any functions or variables you think we have overlooked. Answer as many of the questions in as much detail as time allows.

As you answer the questions, please point out those questions you think raise research issues; that is, questions that cannot be answered completely until further research is performed. Make a separate list of specific research issues in need of attention.

Also enclosed is a transcript of that part of the meeting in which the cycle 2 tasks were discussed. As in cycle 1, these are guidelines only. Do not let them limit your approach to defining the functional characteristics of AIDA or identifying required

research.

You have been allocated eleven days to perform this task, plus two days to attend the next AIDA Concept Development Meeting, to be held at AFHRL February 20-21. Please send me your cycle 2 results to reach here by Thursday, February 15, so I can send them by Federal Express to the other consultants prior to the meeting. Call me if you have any questions.

See you in sunny San Antonio in February. As before, we have made reservations for you at the Sheraton Gunter Hotel, guaranteed for late arrival on February 19. Meanwhile, best wishes for the holidays.

Sincerely yours,

Albert E. Hickey, PhD
AIDA Project Manager

An AIDA Concept

Guidelines for the cycle 2 task:

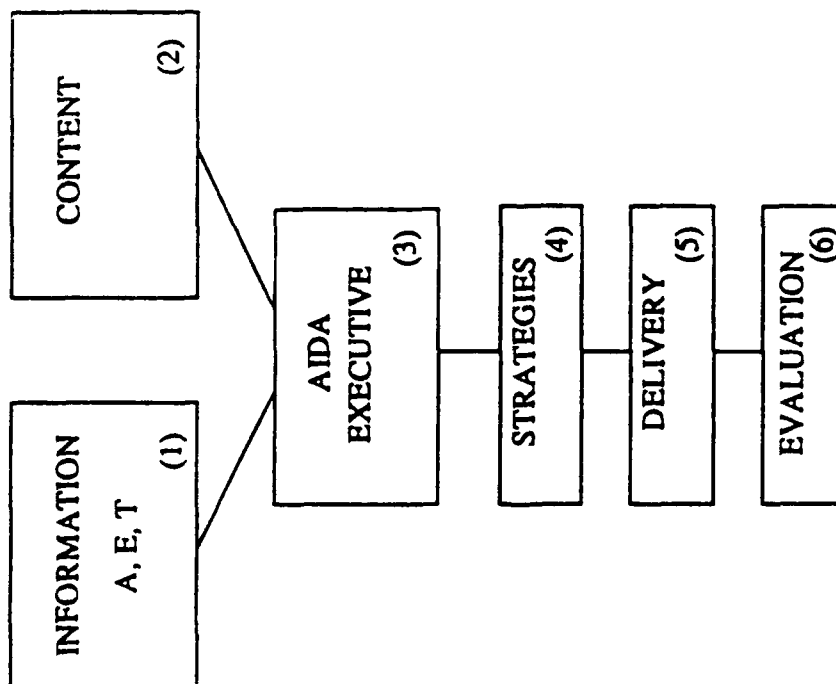
Each consultant should consider the attached "AIDA CONCEPT" diagram and the questions associated with each function identified.

Each consultant should respond to the questions related to some or all of the functions. This detailed information concerning an AIDA concept should facilitate the Phase II software specification. Each consultant should strive for internal consistency and be less concerned with whether the system they define corresponds with that proposed by any other consultant. During the discussion of cycle 2 on February 20-21 similarities and differences can be discussed and explored. The person(s) tasked with the specification then have a number of alternative ideas from which to choose.

Two places probably require some form of expert system (Merrill's opinion): the content (task) analysis (knowledge acquisition) function and the executive function. The form of the rules for the executive function has been suggested, but the form of the rules for the content (task) analysis function has not. The reason is that content analysis could take a number of forms and the nature of the rules (expertise) involved depends on which approach is used.

For every function only end information is requested by the question. For example, during the information gathering on students an important characteristic may be "student motivation". The values could be scaled on a 10 point scale with 10 being very motivated and a 1 being negatively motivated. This value for motivation could be used in the executive function to determine some strategy or some parameter value for some strategy. However, the user (designer or SME) may not know how to determine learner motivation. At this point a series of attributes or conditions that affect the learner, e.g., job change, increase in pay, required assignment change, etc., could be evaluated and a set of rules could lead AIDA to suggest the motivation level for the student.

Any piece of information requested by the system could have associated with it a "mini-expert" to help select the appropriate value for this information. The consultants should indicate what other attributes and values, known or hypothesized, might lead to a given value on a characteristic used in the executive.



This diagram indicates the primary functional components of an AIDA-like system.

(1) Gather information about audience, environment, task.

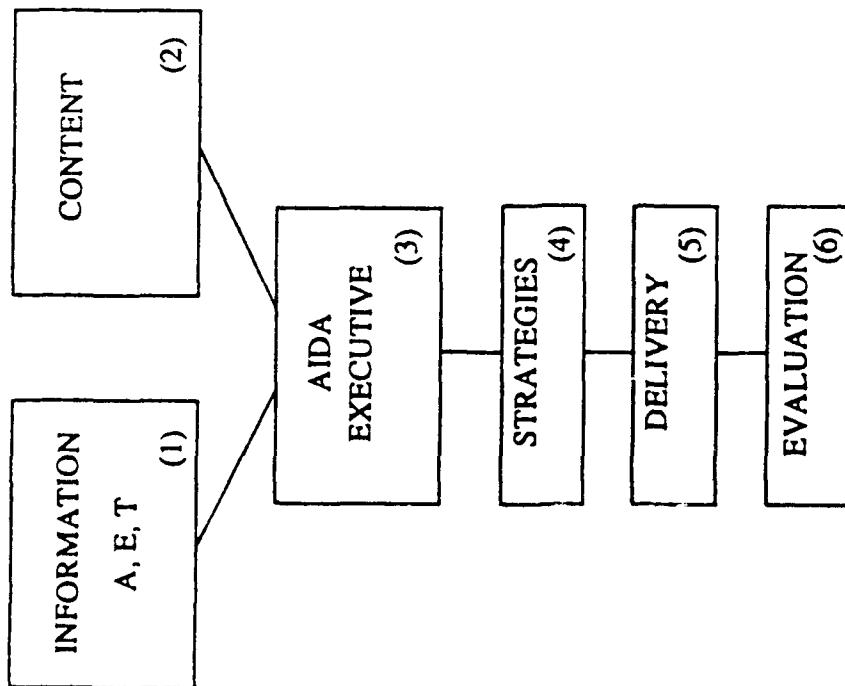
(2) Analyse the content - what to teach?

(3) Select strategies appropriate for a given content type - how to teach?

(4) Instructional strategies.

(5) Deliver the strategy to the student.

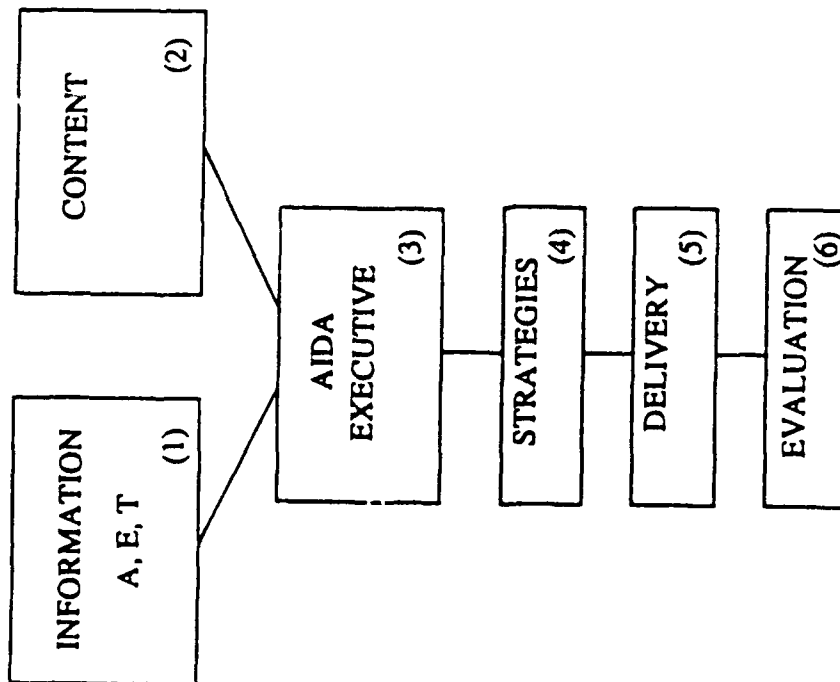
(6) Evaluate performance.



(1) INFORMATION:
What information do we need about:
Audience (students)?
Environment (setting)?
Task (enterprise, job)?

What (audience, environment, task)
characteristics do we need to consider?

What are the values which each of these
characteristics can assume?



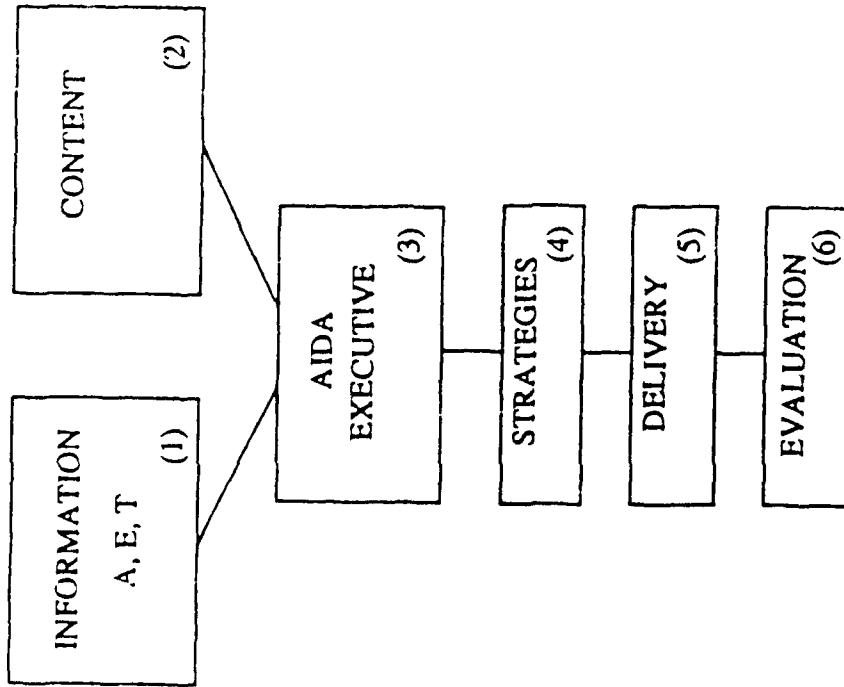
(2) CONTENT:

What information do we need about the content, (knowledge, subject matter, domain)?

How is this knowledge structured (relationships between components - integration)?

What are the types of knowledge (content, objectives) which need to be determined?

What values can these types of knowledge assume?



(3) EXECUTIVE:

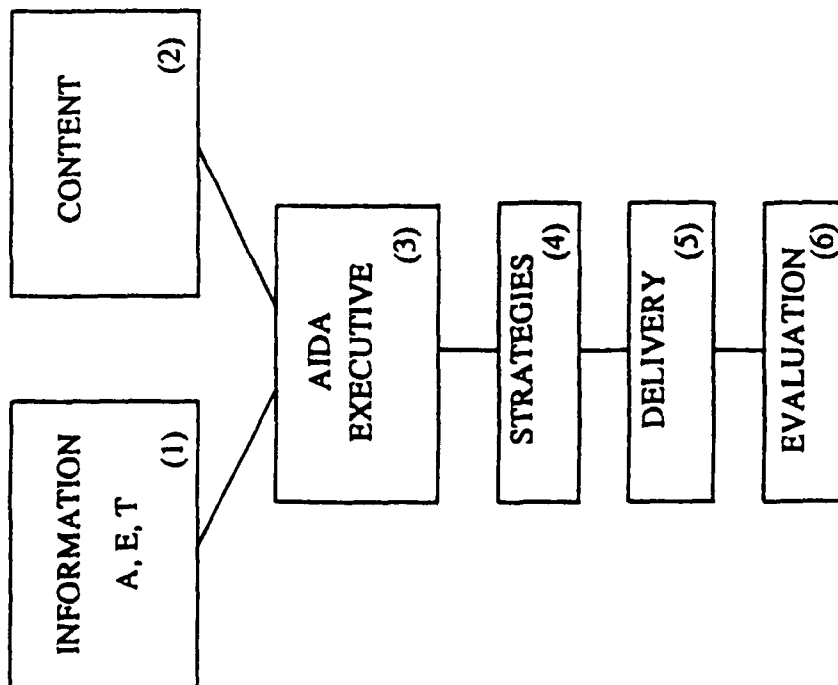
Instructional design decisions

What audience, environment, task and content information is required to select a particular strategy?

Strategy A = Function of

[audience characteristic(s),
environment characteristic(s),
task characteristic(s),
content characteristic(s).]

These functional relationships should specify the characteristics involved in a given decision and the values on these characteristics which determine the strategy selection.



(4) STRATEGIES:

What are the potential strategies?

How does each operate?

What is student interaction?

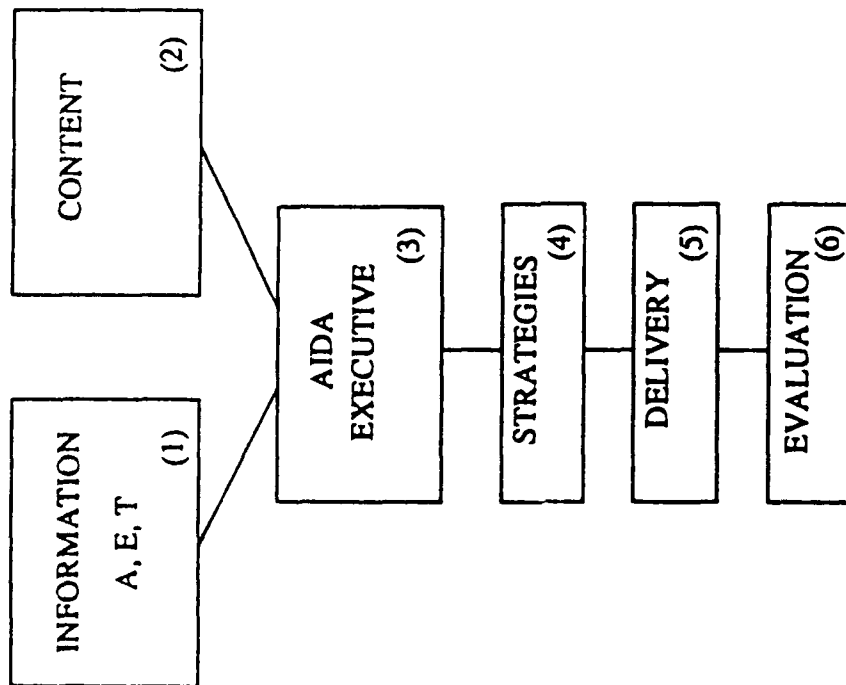
What content do they require?

What are their parameters?

What values can these parameters assume?

Can they be customized for a given audience, environment, task, content?

How?



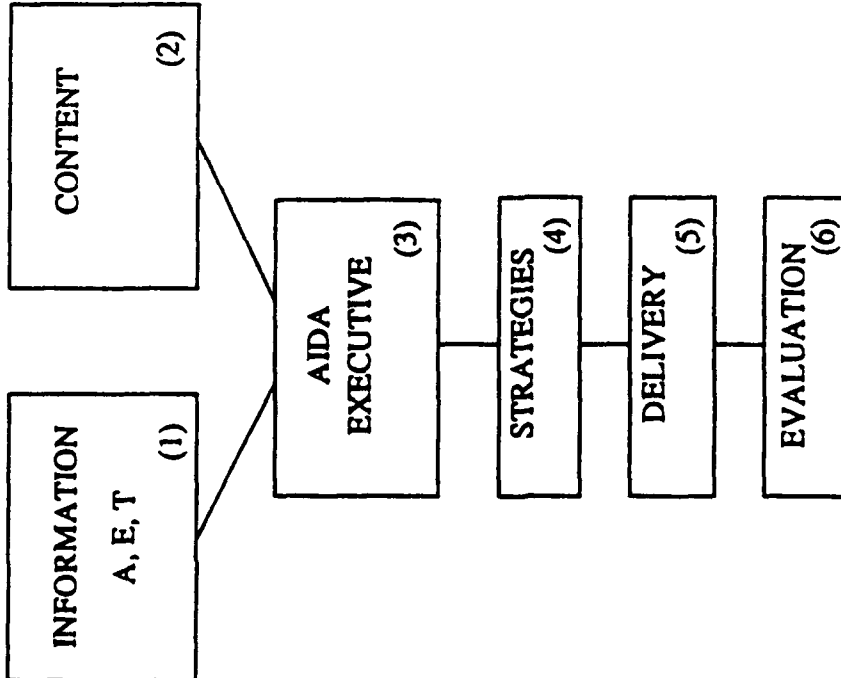
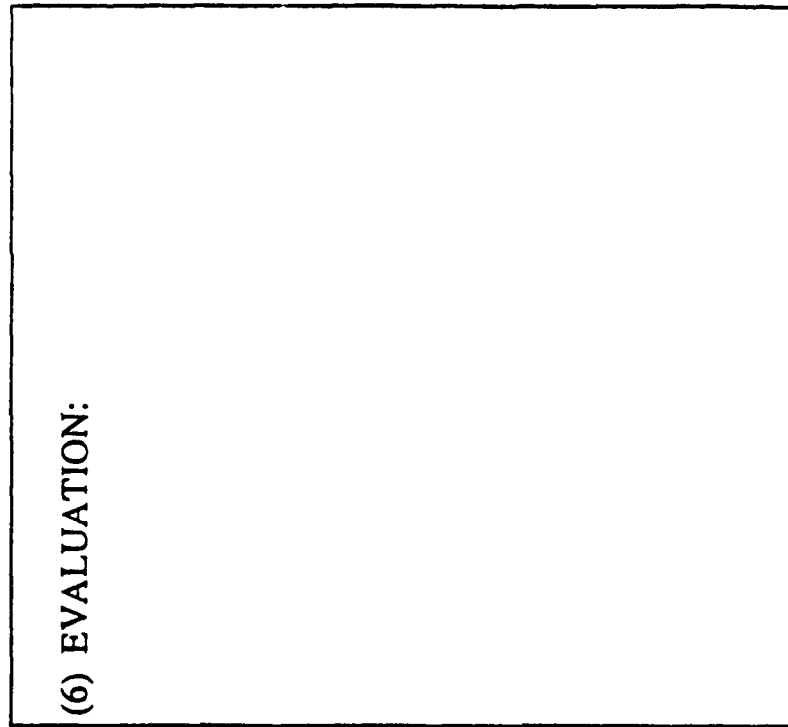
(5) DELIVERY:

Can strategy implementation be automated?

How ?

How do various strategies act under different delivery systems?

Can a "template" (shell, frame) be created to represent the strategy?



MEI ASSOCIATES, INC.
1050 WALTHAM STREET, LEXINGTON, MASS. 02173
(617) 862-3390

March 8, 1990

Dr. Harold F. O'Neil
Advance Design Information
15366 Longbow Drive
Sherman Oaks, California 91403

RE: Project AIDA, Your task in cycle 2

Dear Harry:

Further to my letter dated March 1, enclosed please find the following documents:

- (1) AIDA Progress Review dtd 28 Feb 90
- (2) AIDA Long Range Research and Development Plan (Draft)
(no date)
- (3) Task Order 0006 Final Report (Draft) dtd 2 Mar 90

As your task in cycle 2, you are requested to:

- 1. Review the six cycle 2 concept papers sent to you on March 1; the AIDA Progress Review; the AIDA Long Range R&D Plan (Draft); and section V.A, V.B and VI.A of the Task Order 0006 Final Report (Draft).
- 2. Provide a critique of the items cited in (1) with regard to AIDA's R&D coherence, soundness of investment strategy, and potential for success. Of special interest are alternative but promising conceptions of AIDA.
- 3. Provide an elaboration of sections VI.A and VI.B of the Task Order 0006 Final Report (Draft) based on your review and critique.
- 4. Identify pertinent research issues for sections VII.A and VII.B of the Task Order 0006 Final Report (Draft).

We have allocated 5 days for you to do this work and look forward to receiving your results on or before April 18 so that we can distribute your paper to the other consultants prior to the next meeting, scheduled for April 24-25 in San Antonio. (The kick-off meeting for Phase II (Task 0013) is scheduled for April 26.)

Aside from preparation of the final report, this is the last activity in Task 0006. Your paper will have an important effect on the future of AIDA.

Please call me directly if you have any questions. Since I will be out of the country until March 26, however, please feel free to call Dan Muraida or Mike Spector (512-536-2242) in my absence.

I look forward to seeing you in San Antonio in April. Meanwhile, you'll receive a second letter soliciting your participation as a consultant in AIDA Phase II (Task 0013).

Sincerely yours,

Albert E. Hickey, PhD

APPENDIX C

LIST OF DOCUMENTS PRODUCED IN TASK 0006

<u>Description</u>	<u>Date</u>	<u>Pages</u>
<u>Administration</u>		
<u>Request for Proposal</u>	24 Feb 89	5
<u>Preliminary Design Considerations for an AIDA</u> J.M. Spector		8
<u>Refinement Considerations for an Advanced</u> <u>Instructional Design Advisor</u> J.M. Spector	22 Aug 89	19
<u>AF Task Description/Specification, Task Order 0006.</u> <u>Title: Specifications for an Advanced Instructional</u> <u>Design Advisor (AIDA) for CBT</u>		5
<u>Task Order Proposal, Mei Associates, Inc.</u>	31 Mar 89	10
<u>Technical Task Description (Revised 11 July 89)</u>	11 Jul 89	8
<u>Agenda</u>		
Agenda: Kick-off Meeting, Part I	6 Jul 89	2
Agenda: Kick-off Meeting, Part II	18-19 Jul 89	2
Agenda: Kick-off Meeting, Part III	8- 9 Aug 89	2
Agenda: First Concept Design Meeting	17-18 Oct 89	2
Agenda: Second Concept Design Meeting	6- 7 Dec 89	2
Agenda: Third Concept Design Meeting	20-21 Feb 90	2
Agenda: Final Concept Review Meeting	24-25 Apr 90	3
<u>Transcripts of Selected AIDA Meetings</u>		
Kick-off Meeting, Part II	18-19 Jul 89	19
Kick-off Meeting, Part III	8- 9 Aug 89	56
First Concept Design Meeting	17-18 Oct 89	30
<u>AIDA Needs Assessment Report</u>		
D. Muraidd & J.M. Spector	2-6 Oct 89	9
<u>Task Assignments</u>		
AIDA Cycle 1 Task Assignments: Design Consultants (5)		2 ea.
AIDA Cycle 1 Task Assignments: Review Consultants (2)		
AIDA Cycle 2 Task Assignments: Design Consultants		

AIDA Cycle 2 Task Assignments: Review Consultants

AIDA Concept Papers, Cycle 1

Gagne, R.M.	<u>Principles of Instructional Theory</u>	1 Oct 89	5
Kintsch, E.	<u>Principles of Instructional Theory from Research on Human Cognition</u>		11
Polson, M.C.	<u>Cognitive Theory as a Basis for Instruction</u>	Oct 89	20
Halff, H.M.	<u>Prospects for Automating Instructional Design</u>	Oct 89	26
Merrill, M., Li, Z., and Jones, M.	<u>Project AIDA: A Concept Paper</u>	Sep 89	26
Merrill, M.D.	<u>Project AIDA: A Theory Paper</u>	Sep 89	12
Tennyson, R.D.	<u>Cognitive Model of Learning and Cognition</u>	11 Oct 89	5
Tennyson, R.D.	<u>Cognitive Science Update of Instructional Systems Design Models</u>	Oct 89	66

AIDA Cycle 1 Critiques/Reviews

O'Neil, H.F.	<u>Cycle 1 Critique</u>	6-7 Dec 90	45
Reigeluth, C.M.	<u>AIDA Synthesis/Critique</u>	30 Nov 90	4
Muraida, D. & Spector, J.M.	<u>Review of Cycle 1 Papers</u>	5 Dec 89	22

AIDA Concept Papers, Cycle 2

Gagne, R.M.	<u>AIDA - Concept of Operation</u>		6
Friedman, A.	<u>Designing Graphics for Courseware: The Role of Graphics in Knowledge and Skill Acquisition</u>	Dec 89	54
Halff, H.M.	<u>Automating Instructional Design and Development</u>	Feb 90	36

Merrill, M.D.	<u>An AIDA Concept</u>	13 Feb 90	15
Polson, M.C.	<u>AIDA Cycle 2</u>	Feb 90	12
Tennyson, R.D.	<u>Framework Specifications Document for an Instructional Systems Development Expert System</u>	Feb 90	38
Tennyson, R.D.	<u>Framework Specifications Document for an Instructional Systems Development Expert System Second Revision.</u>	Apr 90	33
<u>AIDA Cycle 2 Critiques/Reviews</u>			
O'Neil, H.F.	<u>AIDA Cycle 2 Critique</u>		45
Reigeluth, C.M.	<u>AIDA Cycle 2 Critique</u>		5
<u>AIDA Progress Reviews - J.M. Spector</u>			
No. 1		10 Aug 89	8
No. 2		27 Oct 89	12
No. 3		17 Dec 89	13
No. 4		28 Feb 90	21
No. 5		20 Apr 90	19

APPENDIX D. O'NEIL'S AIDA FEATURES EVALUATION

PRELIMINARY RESULTS

The forms were completed during the April AIDA Review Meeting. Respondents used LOW, MEDIUM, and HIGH to indicate the relative merit of 22 potential AIDA features with respect to 11 areas. Respondents were grouped with regard to their role in the training process: Managers, Instructional Designers, and Researchers. Results were averaged using a value of 2 for LOW, 6 for MEDIUM, and 10 for HIGH. Averages are presented below. It should be noted that in general there were not enough respondents in category 11 to place any confidence those results.

The 22 features are lettered A through V and represent the following:

- A - templates
- B - automated ISD paperwork
- C - cognitive science augmentation
- D - instructor aids
- E - computerized measurement
- F - type of media (multi-media)
- G - formative evaluation tools
- H - updated ISD model
- I - updated learning theory
- J - author management system
- K - cost-effectiveness tool
- L - task database tool
- M - catalog of courseware
- N - catalog of author aids
- O - research justification (explanation feature)
- P - ITS for ISD
- Q - intelligent job aid
- R - intelligent template interfaces
- S - intelligent help
- T - hyper-media
- U - on-line documentation
- V - portability

The 11 areas are numbered 1 through 11 as follows:

- 1 - technical merit
- 2 - value to the SME
- 3 - value to the instructional designer
- 4 - state-of-the-art technology
- 5 - R&D costs
- 6 - implementation costs
- 7 - risk
- 8 - Air Force gain/impact
- 9 - contribution to science and technology
- 10 - joint service utility
- 11 - feasibility to complete as resourced

O'NEIL'S EVALUATION RESULTS (8 RESEARCHERS)

	1	2	3	4	5	6	7	8	9	10	11
A	6.6	9.5	7.7	5.4	5.3	2.7	3.0	8.9	5.0	8.3	5.3
B	6.0	8.9	8.0	3.4	4.7	4.7	2.6	7.7	2.5	6.6	5.3
C	9.0	5.0	6.6	9.5	9.4	6.6	9.4	7.0	9.0	5.1	6.0
D	6.0	4.5	6.0	4.9	5.4	6.0	4.0	7.5	5.0	7.3	6.0
E	9.5	6.0	8.3	8.0	8.5	4.8	5.8	7.5	7.5	6.6	4.0
F	7.5	6.5	8.9	7.5	7.7	6.6	5.5	8.0	5.3	6.0	6.0
G	7.0	7.5	9.4	6.0	7.7	7.1	6.5	8.5	9.0	7.0	6.0
H	8.0	6.6	9.3	7.5	6.6	4.0	5.5	7.0	6.5	7.1	6.0
I	9.0	6.6	8.7	8.5	10.0	4.0	7.0	6.5	9.5	7.1	4.0
J	7.0	7.0	7.7	7.0	7.1	6.6	5.5	7.5	4.5	7.7	6.0
K	6.5	4.3	6.0	6.0	6.7	5.3	7.3	8.5	5.0	8.9	8.0
L	8.5	6.5	8.3	8.5	7.7	7.3	5.5	8.0	5.0	8.9	6.0
M	4.3	9.5	8.9	2.5	3.1	3.7	2.0	6.5	2.5	7.7	8.0
N	4.0	7.0	6.5	2.6	2.0	3.3	7.0	6.0	2.0	6.6	10.0
O	10.0	4.5	7.1	8.0	8.4	5.2	5.5	6.0	9.5	6.0	4.7
P	8.3	6.0	8.0	10.0	10.0	9.3	8.5	6.5	8.5	6.0	3.3
Q	7.5	7.5	8.3	9.5	8.7	6.0	8.5	7.5	9.0	7.5	6.0
R	7.5	7.5	9.4	9.0	8.0	6.0	9.0	8.0	9.0	6.0	4.7
S	8.3	9.0	9.4	9.5	8.7	6.0	8.3	8.0	8.5	6.6	4.7
T	7.7	6.6	10.0	7.7	6.0	5.2	8.7	8.3	8.9	6.7	6.0
U	5.0	8.3	8.7	4.3	4.7	4.0	3.0	8.5	3.5	6.0	7.3
V	7.7	8.3	7.3	6.7	7.3	6.0	6.0	9.4	3.7	8.3	6.0
	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0

O'NEIL'S EVALUATION RESULTS (6 INSTRUCTIONAL DESIGNERS)

	1	2	3	4	5	6	7	8	9	10	11
A	7.3	9.3	8.7	4.7	5.0	3.0	3.6	9.3	3.6	10.0	10.0
B	6.3	8.0	6.7	2.8	3.6	3.0	3.6	9.3	4.4	10.0	10.0
C	8.7	8.0	8.4	10.0	9.0	8.0	10.0	6.0	10.0	6.0	2.0
D	6.0	6.0	7.3	4.0	4.0	2.0	3.6	8.0	5.2	8.0	10.0
E	6.0	3.6	6.0	6.0	6.0	3.3	6.0	7.3	6.0	8.0	2.0
F	6.7	6.0	8.0	5.3	5.0	6.0	4.4	7.3	4.4	7.3	6.0
G	7.3	8.0	9.3	6.7	7.0	7.3	5.2	8.7	6.8	8.7	6.0
H	6.7	4.7	6.7	6.7	6.0	2.0	2.0	6.7	7.3	7.3	10.0
I	8.7	5.3	8.0	10.0	8.7	3.3	6.8	6.7	10.0	6.0	6.0
J	7.3	8.0	9.3	4.0	3.3	3.3	2.8	7.6	3.6	8.7	10.0
K	5.3	4.0	5.3	5.7	6.0	5.0	6.0	7.3	5.2	6.7	10.0
L	7.3	8.7	7.3	5.3	4.7	4.7	2.8	8.0	4.0	8.0	6.0
M	5.3	7.3	8.7	3.3	3.0	3.3	2.0	6.0	6.0	6.7	10.0
N	7.3	6.0	7.3	4.4	3.6	3.0	2.0	5.3	2.8	5.0	10.0
O	6.0	2.0	5.0	5.0	4.7	2.0	6.0	5.2	5.2	4.7	2.0
P	6.7	6.7	6.0	8.7	10.0	7.3	10.0	5.7	6.8	6.7	2.0
Q	9.3	7.3	9.3	10.0	10.0	8.0	9.2	8.0	7.6	8.0	2.0
R	8.7	3.0	8.7	9.3	8.7	4.7	9.2	8.7	7.6	8.7	2.0
S	10.0	8.0	9.2	10.0	10.0	4.0	8.4	8.0	6.8	8.0	2.0
T	6.7	6.0	7.3	8.7	6.0	4.0	2.8	6.7	3.6	8.0	10.0
U	9.3	9.3	9.3	6.0	3.3	3.3	2.0	6.7	3.6	8.0	10.0
V	7.6	5.3	6.7	8.4	10.0	4.0	8.4	8.7	7.3	9.3	2.0
	1	2	3	4	5	6	7	8	9	10	11

O'NEIL'S EVALUATION RESULTS (3 MANAGERS)

	1	2	3	4	5	6	7	8	9	10	11
A	8.7	10.0	8.7	3.3	3.3	3.3	2.0	6.0	6.0	10.0	10.0
B	10.0	10.0	10.0	6.0	4.7	4.7	3.3	10.0	7.3	8.7	10.0
C	8.7	7.3	7.3	10.0	7.3	6.0	2.7	7.3	7.3	10.0	4.0
D	10.0	7.3	6.0	6.0	4.7	4.7	3.3	10.0	4.7	7.3	6.0
E	8.7	6.0	8.7	4.7	4.7	4.7	6.0	8.7	8.7	10.0	6.0
F	7.3	8.7	8.7	8.7	7.3	7.3	7.3	6.0	6.0	8.7	6.0
G	8.7	7.3	7.3	7.3	4.7	4.7	4.7	7.3	7.3	10.0	8.0
H	8.7	7.3	8.7	6.0	4.7	4.7	4.7	7.3	7.3	6.0	8.0
I	8.7	7.3	8.7	6.0	3.3	3.3	6.0	7.3	7.3	10.0	10.0
J	8.7	8.7	8.7	7.3	6.0	6.0	4.7	7.3	6.0	10.0	6.0
K	10.0	6.0	6.0	7.3	6.0	6.0	6.0	8.7	8.7	10.0	8.0
L	10.0	8.7	10.0	7.3	6.0	6.0	4.7	8.7	6.0	4.7	6.0
M	8.7	7.3	7.3	4.7	4.7	4.7	2.0	7.3	3.3	6.0	8.0
N	8.7	8.7	8.7	4.7	4.7	3.3	2.0	7.3	4.7	8.0	8.0
O	10.0	10.0	7.3	6.0	4.7	4.7	3.3	6.0	4.7	6.0	6.0
P	8.7	10.0	8.7	10.0	10.0	8.7	10.0	10.0	10.0	10.0	2.0
Q	10.0	8.7	8.7	8.7	6.0	7.3	10.0	10.0	10.0	10.0	5.0
R	8.7	7.3	7.3	7.3	6.0	6.0	10.0	7.3	8.7	10.0	2.0
S	10.0	8.7	10.0	8.7	8.7	8.7	8.7	10.0	8.7	8.7	6.0
T	7.3	7.3	7.3	8.7	6.0	4.7	4.7	8.7	8.7	10.0	8.0
U	10.0	10.0	10.0	6.0	3.3	3.3	2.0	8.7	4.7	10.0	8.0
V	8.7	8.7	8.7	10.0	7.3	7.3	10.0	10.0	10.0	10.0	4.0
	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0

APPENDIX E. ABBREVIATED VITAE OF CONSULTANTS

DR. ROBERT M. GAGNE
Florida State University

Robert M. Gagne is a Professor of Educational Research in the College of Education, Florida State University. He received his undergraduate education at Yale University, and his doctoral degree in experimental psychology from Brown University in 1940. He has been actively engaged in research on human learning for many years. His college teaching career began at Connecticut College for Women. During World War II, he served as an Aviation Psychologist, engaged in the development of tests of motor and perceptual functions in the classification of aircrew.

His return to college teaching was at Pennsylvania State University and again at Connecticut College, where he also carried out a research project on the learning and transfer of skills. For eight years thereafter, he held positions as Technical Director in two Air Force laboratories engaged in research programs dealing with learning and methods of technical training.

From 1958 to 1962, Dr. Gagne held the position of Professor of Psychology at Princeton University. During this time, he designed and directed a program of research on conceptual learning, thinking, and the acquisition of knowledge. A textbook, Psychology of Human Performance, was co-authored with E.A. Fleishman; and an advanced text on human factors with a number of collaborating authors was published in 1962 under the title Psychological Principles in System Development.

From 1962 to 1965, he was the Director of Research of the American Institutes for Research, where he was concerned with general supervision of research programs on human performance, instructional methods, educational objectives design and evaluation of curricula and educational procedures. From 1966 to 1969 he was a Professor in the Department of Education, University of California, Berkeley, in the field of educational psychology. He directed the effort of establishing a regional educational laboratory, and managed a program of graduate training in educational research. At Florida State, he has completed research on learning hierarchies related to school instruction, research objectives derived from school needs, the utilization of research-based information in elementary schools, and studies of elaborative techniques in science instruction.

His publications in scholarly journals include more than one hundred articles on human learning and instruction. Major books have been translated and published in many countries. These are: Learning and Individual Differences, (Ed.), Merrill, 1968; Essentials of Learning for Instruction, Dryden Press, 1974; The Conditions of Learning, 4th Ed., Holt, Rinehart and Winston, 1985; (with Reiser) Selecting Media for Instruction, Educational Technology, 1983; Instructional Technology: Foundations (Ed.), Erlbaum, 1987.

DR. HENRY M. HALFF
Halff Resources, Inc.

Dr. Halff is a research psychologist with over fourteen years of experience in learning, instruction, and instructional technology.

Dr. Halff received his degrees in psychology from Stanford University and the University of Texas at Austin.

In 1984, Dr. Halff founded Halff Resources, an independent consulting firm. Halff Resources assists clients in computer-based instruction, learning and training, and related areas. Projects include design recommendations for a generic memory training system for the Army Research Institute (ARI), design of a computer-based tutor to train users of an occupational health information management system supported by the Navy Medical R&D Command, an analysis of government planning for future training technology as part of an ARI planning effort, documentation and training design for General Electric Information Systems Company, and materials design for Scholastic, Inc.

Prior to forming Halff Resources, Dr. Halff was a scientific officer at the Office of Naval Research. Dr. Halff planned and managed several nationally recognized basic research projects in educational methods and technology. These projects were implemented through contracts to university and private research institutions. They included research on cognitive models of real-world skills, advanced educational technology (including applications of artificial intelligence), individual differences in cognition, and computer-based psychological testing. Earlier, Dr. Halff was associated with the University of California at San Diego, and the Navy Personnel R&D Center. From 1970 to 1976 he was an assistant professor at the University of Illinois at Urbana-Champaign. While there, Dr. Halff conducted research on mathematical models of learning, on choice and decision theory, on real-time computer-based psychological research, and on psycholinguistics. He also taught statistics, mathematical psychology, and cognition.

He is a Fellow of the American Psychological Association, and a member of the American Association for the Advancement of Science, American Educational Research Association, and Cognitive Science Society.

DR. M. DAVID MERRILL
Utah State University

Dr. David Merrill is a Professor of Instructional Technology at Utah State University. He received his undergraduate education at Brigham Young University, and his doctoral degree in Psychology from the University of Illinois in 1964.

Dr. Merrill's major professional contributions include the TICCIT CAI System for which he developed the authoring system; Component Display Theory, an instructional design theory; and Elaboration Theory, developed in collaboration with Charles M. Reigeluth, an instructional design theory which extends Component Display Theory to content structure and sequence.

Prior to joining the faculty of Utah State University, Dr. Merrill was on the faculty of the University of Southern California (1979-1988), Stanford University (1967-1968), Brigham Young University (1966-1967, 1968-1979), and George Peabody College for Teachers (1964-1966). At Brigham Young University, he was founder and director of the Instructional Science Department and the Division of Instructional Research, Development and Evaluation. He was a founder, director and Vice President for Research of Courseware, Inc., and founder, director and President of Microteacher, Inc.

Dr. Merrill has performed major consulting contracts with Bell and Howell Schools, Arthur Andersen & Company, Data Design Laboratories, Hazeltine Corporation, Perceptronics Inc., and United Airlines Services Corporation. He has received research support from the National Science Foundation, Navy Personnel Research and Development Center, Army Research Institute, and Training Development Institute.

A prolific author, Dr. Merrill's publications include 8 books, 12 chapters in edited books, 38 journal articles, and 98 technical reports.

He is a Fellow of the American Psychological Association and the Association for the Development of Computer-Based Instructional Systems.

DR. HAROLD F. O'NEIL, JR.
University of Southern California

Dr. Harold F. O'Neil, Jr. is Professor of Educational Psychology and Technology at the University of Southern California and Executive Vice President of Advance Design Information. The company specializes in research and development for civilian education and Department of Defense training, particularly high technology solutions to education and training problems, and performance assessment and evaluation of complex systems.

Prior to joining the faculty of USC, Dr. O'Neil was Director of the Training Research Laboratory, Army Research Institute for Behavioral and Social Sciences (ARI) (1982-1985). He was responsible for the conception and implementation of all advanced technology projects in the behavioral and social sciences for the service function and training of U.S. Army Personnel, directing an annual budget of 30 million dollars and a military and civilian staff of approximately 200 people.

Dr. O'Neil also served as Team Chief of Manpower and Educational Systems, and Chief of the Instructional Systems Technical Area, (ARI) (1978-1982); Program Manager, Advanced Training Technology, Defense Advanced Research Projects Agency (DARPA) (1975-1978); and Associate Professor (tenured) of Educational Psychology and Computer Sciences, and Co-Director of the Computer-Assisted Instruction Laboratory, University of Texas-Austin (1971-1974).

Dr. O'Neil has published/presented over 190 research papers, technical reports, articles, chapters, and books. He is editor of Academic Press' "The Educational Technology Series". He has served on the editorial boards of, and as technical advisor to, 13 journals. He is a member/fellow of such scholarly societies as the American Association for Artificial Intelligence, American Educational Research Association, American Psychological Association, Human Factors Society, and the Association for the Development of Computational Instructional Systems.

DR. MARTHA C. POLSON
University of Colorado

Dr. Martha C. Polson is Assistant Director of the Institute of Cognitive Science at the University of Colorado, and Coordinator of the Human Computer Interaction Consortium. She received her undergraduate education at Alabama College, and her doctoral degree in Experimental Psychology from Indiana University in 1968.

Prior to joining the University of Colorado, Dr. Polson was a Research Psychologist at the Air Force Human Resources Laboratory, Lowry AFB, Colorado. Earlier she had been Assistant Professor of Psychology, first at the University of Texas and later at Southwest Texas State University.

Dr. Polson's publications include several journal articles on psychology and human information, and a major book, Foundations of Intelligent Tutoring Systems, (Ed.), Erlbaum, 1988.

DR. CHARLES M. REIGELUTH
Indiana University

Dr. Charles Reigeluth is a Professor in the College of Education, Indiana University. He received his undergraduate education at Harvard University and his doctoral degree in Instructional Psychology from Brigham Young University in 1977. Dr. Reigeluth's academic specialization is instructional theory, design, research, and computer-based education.

Prior to joining Indiana University in 1988, Dr. Reigeluth was a member of the faculty at Syracuse University. He has consulted to many companies and government agencies, including Motorola; IBM; Hewlett-Packard; Holt, Rhinehart, and Winston; HumRRO; and U.S. Army TRADOC.

Dr. Reigeluth has numerous publications, including 30 journal articles and chapters in ten books, but is best known for three important books: Instructional Theories in Action: Lessons Illustrating Selected Theories and Models (Ed.), Erlbaum, 1984; Extended Task Analysis Procedure: User's Manual (with Merrill, M.D.), University Press, 1984; and Instructional Design Theories and Models: An Overview of Their Current Status (Ed.), Erlbaum, 1983.

DR. ROBERT D. TENNYSON
University of Minnesota

Dr. Robert D. Tennyson is a Professor in the Department of Educational Psychology at the University of Minnesota. He received his undergraduate education in History at Brigham Young University, and pursued graduate studies in History and Psychology at the University of California at Riverside, and California State University. He received his doctorate in Psychology and Computer Science from Brigham Young University in 1971.

Prior to joining the faculty of the University of Minnesota in 1974, Dr. Tennyson was Assistant Professor and Director of the Center for Computer-Assisted Instruction at Florida State University. He has also been a Fulbright Research Scholar and Guest Professor at the Rheinisch-Westfälische Technische Hochschule in the Federal Republic of Germany.

Dr. Tennyson has over 100 publications including the book Concept Teaching: An Instructional Design Guide, with M.D. Merrill, Educational Technology Press, 1977. He is the recipient of numerous research and development grants, including grants from Digital Equipment Corporation, Control Data Corporation, the U.S. Army Research Institute, and John Wiley and Sons.

SUPPLEMENTARY

INFORMATION

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