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ABSTRACT

Many researchers are attempting to develop automated instructional development systems to guide subject matter experts through the lengthy and difficult process of courseware development. Because the targeted users often lack instructional design expertise, a great deal of emphasis has been placed on the use of artificial intelligence (AI) to incorporate instructional design knowledge in these automated systems. This paper presents a taxonomy describing various uses of AI techniques in automated instructional development systems. In addition, two specific systems being developed at the Air Force Armstrong Laboratory (AIDA and GAIDA) are reviewed. The initial formative evaluation of GAIDA is also reported. Some remarks about prospects for the future use of AI in automated instructional development systems conclude the paper. (18 references) (Author/BBM)

INTELLIGENT FRAMEWORKS FOR INSTRUCTIONAL DESIGN

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INTELLIGENT FRAMEWORKS FOR INSTRUCTIONAL DESIGN

Abstract

Many researchers are attempting to develop automated instructional development systems to guide subject matter experts through the lengthy and difficult process of courseware development. Because the targeted users often lack instructional design expertise, a great deal of emphasis has been placed on the use of artificial intelligence (AI) to incorporate expert instructional design knowledge in these automated systems (Duchastel, 1990). This paper presents a taxonomy describing various uses of AI techniques in automated instructional developments systems. In addition, two specific systems being developed at the Air Force Armstrong Laboratory (AIDA and GAIDA) are reviewed. The initial formative evaluation of GAIDA is also reported. We conclude with some remarks about prospects for the future use of AI in automated instructional development systems.

Background

Several Department of Defense agencies, educational corporations, and academic institutions are attempting to automate part or all of the Instructional Systems Development (ISD) process in an attempt to improve the productivity and effectiveness of novice training developers in designing interactive computer-based instruction (CBI) courseware (Duchastel, 1990). Use of expert systems, intelligent lesson templates, front-end analysis tools, and sophisticated CBI authoring environments are currently being designed, developed, and tested.

Typically, the designer of instruction in the Air Force is a subject-matter expert who has completed a brief course on designing instruction (Spector, Muraida, & Dallman, 1990). For example, he or she may be a staff sergeant who is experienced in some particular aspects of aircraft maintenance. With a small amount of training in instructional design, this person is asked to bring equipment-system knowledge to bear in the design of training for the maintenance of highly complex technical equipment.

In response to this situation, the Air Force Armstrong Laboratory (Human Resources Directorate) has an exploratory research and development effort in the area of automated instructional design called the Advanced Instructional Design Advisor (AIDA). AIDA will provide an intelligent, rule-based framework and a powerful collection of object-oriented authoring tools to assist the subject-matter expert in developing effective courseware. AIDA derives its primary theoretical basis from transaction theory (Merrill, Li, & Jones, 1990), which proposes executable and configurable frameworks (called transaction shells) for particular kinds of lesson objectives.

A complementary and parallel effort, the Guided Approach for Instructional Design Advising (GAIDA), is also being developed at Armstrong Laboratory. Robert M. Gagné, who has been serving as a National Research Council Senior Associate, is supervising the GAIDA project. GAIDA has goals similar to those of AIDA (provide a powerful and intelligent framework for instructional design), but it approaches those goals from the perspective of the human designer.

AIDA places a great deal of the burden for intelligent design on the design system. AIDA's intelligence appears in the form of a rule-based instructional transaction configuration system and in the form of default values for particular transaction shells that are appropriate for a specified type of lesson objective (Merrill, Li, & Jones, 1990).

The GAIDA system aims to provide guidance to Air Force instructional designers that follows the approximate sequence described by Gagné, Briggs, & Wager (1992) as the <u>nine events of instruction</u>. As indicated by these authors, the particular form of these nine events will be influenced by the intended capability to be learned, or in other words, by the particular kind of learning outcome that is expected.

Both GAIDA and AIDA share the view that instruction should be aimed at integrated and purposeful human activities, or enterprises (Gagné & Merrill, 1990). It is likely that the two systems will be integrated in a manner that allows GAIDA to serve in a stand-alone capacity to instructional designers or to provide on-line examples and guidelines to users of AIDA.

Intelligent Instructional Design

<u>Intelligence</u>

In order to provide a context for the two systems described below, we need a working definition of artificial intelligence (AI). There are, of course, many definitions of AI in the literature. Some emphasize the psychological aspects of human intelligence and various methods for modeling those processes.

Others emphasize the mathematical complexity of certain problems addressed by computer scientists. A more neutral approach is taken by Rich and Knight who define artificial intelligence to be "the study of how to make computers do things which, at the moment, people do better." (1991, p.3)

We propose this working definition of AI: Artificial intelligence refers to those aspects of computer science and engineering which are used in systems that most practitioners regard as intelligent systems. Our definition is intentionally weak and circular. It is not clear what benefits are to be derived from endless debates concerning the so-called intelligence of certain machines and computer programs. Another way of avoiding those debates is to use 'engineered cognition' in place of 'artificial intelligence'. [This is Gagné's suggestion for avoiding unnecessary difficulties on this issue.]

Moreover, AI is likely to make progress and change significantly over time, and our definition recognizes this basic fact concerning the emergence and evolution of AI. The techniques of computer science which are generally regarded as intelligent include those found in artificial neural networks, case-based systems, diagnostic systems, dialogue managers, expert systems, natural language processors, planning architectures, robotic systems, rule-based systems, semantic networks, and so on.

Instructional Systems Development (ISD)

The next element of our context pertains to the process of developing instruction. The most prevalent models of instructional development are those based on an engineering approach to curriculum and are called ISD models (Andrews and Goodson, 1980; Gagné, Tennyson, & Gettman, 1991). These models typically divide the process of developing instruction into five stages or phases (See Table 1 below). Older ISD models often fail to account for relevant cognitive aspects of the learning task. For example, a behavioral ISD model for performing task analysis might lead the instructional designer to describe particular procedures carried out by the troubleshooter without any mention of a mental model that might have influenced what was guiding a troubleshooter through a maze of subprocedures. Tennyson (Gagné, Tennyson, & Gettman, 1991) has argued that ISD should be updated to include relevant principles derived from cognitive psychology.

In addition, Tennyson argues that evaluation belongs in each of the phases and that formative evaluation is an on-going process. As a consequence, for our purposes in this pmxer we propose the ISD model in Table 1 (below).

Table 1

Typical ISD Model

ISD PHASE	TYPICAL GOALS
Analysis	Define training requirements. Analyze target populations. Establish performance levels.
Design	Specify instructional objectives. Group and sequence objectives. Design instructional treatments.
Production	Develop learning activities. Develop test items. Evaluate prototypes.
Implementation	Implement learning activities. Administer test items. Assess student results.
Maintenance	Revise course materials. Revise test items. Assess course effectiveness.

Table 1 should not be interpreted in a rigid manner. The purpose of this table is to provide a framework for identifying where AI techniques may have an application in the instructional development process. We mean only to suggest that the kinds of goals identified in the second column are typically associated with the ISD phase in the first column. We believe that the ISD process is iterative and cyclic by nature, that evaluations occur within each phase, and that the phases are intmxtwined and may not be accomplished in a strictly linear fashion.

INTELLIGENT FRAMEWORKS FOR INSTRUCTIONAL DESIGN

Intelligent Instructional Development

Having provided a working definition of AI and an ISD model, we are now in a position to provide a framework for incorporating AI into instructional design and to locate the area of our own research efforts. Table 2 provides a tentative taxonomy for the various ways that AI has been incorporated into the ISD process. We have included in each phase examples of AI efforts that have been developed or are at least in the design stage. The focus of our own efforts is in the instructional design phase, although AIDA does provide assistance with production and implementation.

These examples of applicable AI techniques in the ISD domain are not meant to be exhaustive. What we offer in Table 2 is a way to classify various efforts to develop intelligent instructional systems.

It is worth noticing that no examples of intelligent applications in the maintenance phase are identified. However, it is possible to imagine an automated instructional system that monitored either the instructional development process or the progress of learners using the system, processed the results, and filtered those results through a set of rules which prescribed certain types of modifications when particular kinds of results were noticed observed.

For example, a system could record and analyze answers to questions. If a particular question was never answered correctly, the system might recommend a remedy for the situation. A system might also monitor where learners spent most of their time with the system and analyze how that time contributed to learning outcomes. If it appeared that time was wasted in one part of the system, then the system might recommend some kind of remedy for that situation.

There is nothing in this schema to prevent a particular system from being categorized in more than one area. In fact, we view AIDA as an intelligent application in the middle three phases of ISD, although our research interests are clearly focused on the design phase.

Table 2

Taxonomy of AI Techniques in the ISD Process

ISD PROCESS	APPLICABLE AI TECHNIQUES
Analysis	Intelligent Training Requirements Tools Cognitive Task Analysis (e.g., GOMS, PARI) Decision Support Systems (e.g., TDS)
Design	Instructional Design Advisors On-line Examples & Guidelines (e.g., GAIDA) Rule- & Case-based Guidance (e.g., AIDA) Intelligent Tutoring and Critiquing Systems
Production	Intelligent Development Tools Mini-advisors for Graphics, Audio, Video, and Interface Issues Intelligent Lesson Templates (e.g., AIDA)
Implementation	Adaptive Delivery Systems Intelligent Tutoring Systems Adaptive Testing Techniques Non-intelligent Tutors (e.g., AIDA)
Maintenance	Monitoring & Feedback of Results

As already mentioned the two projects which are described below focus on the application of AI to the instructional design phase. It is worth noting that GAIDA and AIDA represent only two of a number of possible approaches to intelligent instructional design. Tennyson (1991) has proposed the more ambitious approach of building an intelligent tutoring system (ITS) for the domain of instructional design. Duchastel (1990) has proposed an expert critiquing system which can evaluate designs created by relatively experienced instructional designers. It is our belief, however, that is premature to proceed with such ambitious efforts. Indeed, the validated results of efforts like GAIDA and AIDA will form an essential part of an expert ISD critiquer or an ITS for ISD.

AIDA

Objectives of AIDA

The primary objective of AIDA is to encapsulate human knowledge about learning and instruction pertinent to electronics maintenance training tasks in an intuitive system accessible to Air Force training specialists. The motivation for this effort is the projected increase in demand for computer-based instruction coupled with declining training development budgets and a scarcity of courseware design experts in the Air Force. In short, the Air Force must use subject matter experts to design, develop, and deliver computer-based course materials.

This situation (using subject matter experts to design and develop instruction) is more tolerable with regard to classroom instruction, and it is the de facto norm in our society. However, what works in the classroom may not work well in a computer-based setting. Computers do not respond well to puzzled looks and bored faces. Great care must be taken in planning and implementing an effective computer-based learning environment. The challenge for the Air Force is to do the requisite careful planning with the talent on hand.

Theoretical Framework for AIDA

The theoretical framework consists primarily of Merrill's second generation instructional design theory (Merrill, Li, & Jones, 1990). Merrill's theory grows out of numerous inadequacies with previous instructional theories, including his own Component Display Theory, which failed to account for the integrated nature of learning tasks and the unique capabilities of computers to support specific learning objectives.

Second generation instructional design theory is built around integrated human performances called enterprises (Gagné & Merrill, 1990), which can be decomposed into various entities (abstract or concrete objects), activities (which involve humans), and processes (which proceed without human involvement). Merrill postulates specific kinds of instruction for each kind of object. For example, entities typically have named parts so paired associate learning can be encapsulated in a pre-designed framework (transaction shell) to initiate teaching about entities.

Human expertise about learning and instruction is being captured in a collection of transaction shells that are appropriate to electronics maintenance training. Additional human expertise will be captured in a front-end advisor which will interact with users (subject matter experts) to collect domain knowledge and information about the training setting and then configure an initial (but alterable) set of transactions for various lesson objectives.

Methodology

The methodology has been to pursue an incremental development of AIDA. The first phase included a needs assessment performed at an Air Force technical training center and an intense analysis of this challenging problem by seven noted educational researchers (Robert Gagné, Henry Halff, David Merrill, Harry O'Neil, Martha Polson, Charles Reigeluth, and Robert Tennyson) and numerous military advisors (including Jerry Barucky, Brian Dallman, John Ellis, Mary Marlino, Milt Nielsen, Rich Ranker, Bob Seidel, and Richard Thurman). The outcome of the first phase was a requirements analysis and a conceptual framework for AIDA (Spector, Muraida, & Dallman, 1990).

The second phase made use of the same academic and military consultants and focused on developing a refined set of functional requirements and conducting field tests of an initial authoring environment provided by Merrill. Also included in the second phase was a technology assessment of second generation instructional design theory (Canfield & Spector, 1991). The outcome of the second phase was a more detailed conceptual framework and a set of design specifications for an experimental system (XAIDA).

The project is currently in its third phase, which is an implementation and evaluation of the XAIDA. The software design and development is being performed by Mei Technology, Inc. Instructional design expertise is being provided on an on-going basis by Merrill and Halff. The system is being coded in an object-oriented environment (C++) and implemented on a DeskTop III (Intel 80386-based microcomputer).

Current Status of XAIDA

Field tests of initial transactions for teaching nomenclature (entities) and checklist procedures (activities) indicated that transaction shells provide an environment that is both meaningful and accessible to Air Force training specialists. Indications are that productivity can be greatly improved without sacrificing courseware quality (Canfield & Spector, 1991). XAIDA provides a robust environment to test a variety of specific instructional prescriptions. As a consequence, XAIDA is an excellent tool for conducting research and development that pertains to instructional strategies and multimedia presentations.

The first year XAIDA prototype has been completed and an evaluation plan set in motion. The evaluation plan begins with an internal review, expands the review to include informed military and academic advisors, and then evaluates field results in Air Force technical training settings. This evaluation will continue for two years, and XAIDA will be modified and re-tested accordingly. At then of this third phase (1994), a fully functional XAIDA will exist. Plans are to conduct additional evaluations and validation of the technology, and then to transition XAIDA into standard use as AIDA in 1997.

GAIDA

Background

Guided Approach: Instructional Design Advisor (GAIDA) represents an approach to the delivery of instruction embodied in a computer-based lesson on how to design instruction (Gagné & Hancock, 1991; Gagné, Dimitroff, & Whitehead, 1991). GAIDA takes the view that if a reasonably intelligent instructional designer is provided with meaningful and specific guidance and an elaborate and completely worked example that such an individual will be capable of constructing effective courseware.

As described earlier in this article, the design and development of instruction follows a five-step model. Details of the procedure are described in AFM 50-2, Instructional System Development, and in AFP 50-58, Handbook for Designers of Instructional Systems. Responsibility for training design in maintenance specialties is typically given to airmen of non-commissioned rank who have job-related experience with the equipment on which training is to be given. Instructional designers of this variety receive a small amount of professional training, although they may have considerable experience in on-the-job maintenance and as instructors.

As indicated in a recent report entitled "Revision of the Air Force Instructional System Development Process--Baseline Analysis Report" (Golas & Shriver, 1991), many instructional developers find the model described in these publications complex, inflexible, and difficult to apply to a variety of maintenance jobs. Such a finding suggests a need for simplification of the instructional design process. Since this need has actually been recognized for quite some time, a number of different suggestions have been put forward as remedies. Several of these involve the development of computer-based systems such as intelligent tutoring and expert systems. Still others depend on the use of systematic design procedures that are oriented to instructor-led classroom instruction as well as to the computer-based variety.

Training design at the level of the lesson continues to be an enterprise that challenges the ingenuity of the Air Force designer. When a new weapon system is adopted, or when an existing system is modified, the volume of new maintenance information to be taught is often very large. In dealing with the necessity of communicating such a mass of information, the designer may be sorely tempted to fall into two kinds of error in the attempt to simplify his task. These tendencies may be described as follows:

1. Reducing the knowledge to be acquired to the declarative form, and thus neglecting the procedural variety of knowledge; learning the names of equipment parts is not equivalent to learning how to use these parts.

2. Reducing the instructional techniques to only two, which may be called TELLING and PRACTICE; while these typically constitute the core of instruction, other features of instructional strategy, such as elaboration, interactivity, and feedback, are often found to enhance instructional effectiveness by significant amounts.

One promising approach to the simplification of the instructional design process is automating the procedure of design and delivery. An effort to develop and test automation techniques is involved in the project AIDA (Hickey, Spector & Muraida, 1991). This project is engaged in the development of computer shells representing a number of different instructional strategies, each of which pertains to a different learning goal. For example, one goal is identifying equipment and equipment parts, while another is executing a procedure, and a third is interpreting malfunctions. For any one of these goals, the shells of instructional procedures can be selected and put together so as to represent an effective module of instruction aimed at that particular goal. The content for the instruction, of course, must be selected and added, but how it is presented, in a manner conducive to efficient learning, depends upon the nature of the shell that is employed. Thus, AIDA uses automated computer-human interaction as a means of instruction for particular kinds of goals. The goals and the enterprises they represent must be identified by the instructional designer.

Simplification of the process of instructional design can also be done in a manner that does not require the degree (or kind) of automation involved in the approach of AIDA. Instruction, it is evident, consists of a set of events external to the learner that occur in a loosely invariant sequence (Gagné, 1985, 302-319). These events may be directions or suggestions to the learner about what to do next, demonstrations of action sequences, pointed references to aspects of the learners' environment, reminders of previously learned knowledge, solicitation of learner responses, feedback and corrections of learner responses, and others (Gagné, 1991). When a designer of instruction follows the prescriptions in this nearly invariant sequence (called the "Nine Events of Instruction"; Gagné, Briggs & Wager, 1992) further automation is unnecessary. As is true for AIDA, the content of these events must be identified and selected by the designer. Otherwise, however, a large amount of flexibility is possible in the design of specific learner-interactive events.

GAIDA is a project that follows this process of limited automation in presenting instruction on designing instruction. Because this approach leaves much of the details of design to the judgment of the designer, it was particularly appropriate that a study aimed at formative evaluation of GAIDA be carried out. Results of the initial formative analysis are reported below.

The GAIDA Project

Computer-based instruction (CBI) dealing with how to design instruction can deliver a set of directions to the novice instructional designer. The latter may find these directions easy or difficult to understand, easy or difficult to implement. For example, if the directions say, in effect, "at this point -

tell the learner to recall some previously learned knowledge that is relevant to the new learning task", the student designer should be able to comprehend the message with its inclusion of the concepts "this point", "recall", "previously learned", "knowledge", and "relevant". The GAIDA approach assumes that novice designers are capable of understanding concepts of this sort in their precise meanings. The further assumption is made that directions of this sort can be "followed", in the sense that concrete instances of such an abstraction as "relevant knowledge" can be identified and selected from the domain of the equipment data base being dealt with.

GAIDA provides to the novice designer, a set of nine directions, in sequence, which are intended to tell the designer what kinds of events to devise as instruction. In order, these events (Gagné, Briggs & Wager, 1992) are as follows: (1) gain attention; (2) describe the goal; (3) stimulate recall of prior knowledge; (4) present the material to be learned; (5) give learning guidance; (6) elicit performance; (7) provide feedback; (8) assess performance; and (9) enhance retention and transfer. How readily these directions are understood, and how well they are implemented, will determine the quality of the instruction that is designed. The need for formative evaluation is therefore apparent.

GAIDA provides printed directions for each of these nine events. An example lesson is used to demonstrate the events. In the case that was evaluated, the lesson aimed to teach the 32 steps in the procedure called "Functional Check of the M61A1 gun", which is the gun in the F-16 aircraft (Gagné, Dimitroff, & Whitehead, 1991). This preventive maintenance procedure is carried out with the use of a checklist. Since the system components are in two locations, one person executes some steps on equipment in the cockpit, while another carries out other steps by reaching connectors through panels on the underside of the aircraft. Another example pertaining to the training of a procedure that must be committed to memory also exists (Gagné & Hancock, 1991).

The lesson on this procedure is designed to support the learning of the following: (1) verbal identification of abbreviated names and phrases in the checklist; (2) identification of the objects (switches, connectors, etc.) named in the checklist; (3) identification of the location of these objects; (4) easy progression from each procedural step to the next, following the printed checklist. In addition to these basics, a few interactive steps are included with the aim of enhancing the "system knowledge" of the trainee. This is done by requiring answers to questions about the wiring system of the gun. Thus, the added objective may be stated as (5) identifying one or more probable causes of malfunction in the flow of current in the wiring system.

The Sample Lesson

The particular example employed in this lesson was the task of conducting a functional check of the M61A1 gun in the F-16 aircraft. This procedure employs a checklist to test the several different voltages in the electric circuits that activate the gun. The purpose of the present study was to seek evidence of the comprehensibility and workability of these directions for designing instruction in a number of Air Force personnel who were representative of potential users. These are typically airmen of intermediate rank who are well acquainted with the aircraft and its equipment, but are novices in instructional design methods.

The lesson on the functional check follows this outline:

Event 1. Gain Attention. The gun is named, and a graphic picture is displayed. A future development would use a picture with motion.

Event 2. Describe the Goal. A descriptive text, with accompanying pictures, describes the process of making the functional check. Included are the purposes of the check, the locations of switches and connectors, rules for gaining access to the gun and its components, rules for safety.

Event 3. Stimulate the Recall of Prior Learning. Messages of text remind the learner of previously learned information, safety rules, etc.

Event 4. Present Material to be Learned. A picture is to be shown of the initial page of the checklist.

Event 5. Provide Learning Guidance. This takes the form of displaying the direction for each step in the procedure, including expanded abbreviations, and an accompanying picture.

Event 6. Check Performance. The learner is asked to carry out the performance of the checklist. Also, questions are posed relating to the flow of current in the electric circuits.

Event 7. Provide Feedback. Corrective feedback is given as the steps of the checklist are performed. Feedback in the form of explanations are given to each choice made to multiple-choice questions, testing knowledge of current flow in the electric circuits.

Event 8. Conduct Assessment. The suggestion is made that additional practice be given on the checklist procedure.

Event 9. Enhance Retention and Transfer. For this checklist procedure, this event is considered to be adequately covered by events 6 through 8.

The novice designer, in responding to these events, was asked to write out a script that described the CB instruction to be designed. It was expected that such a script could be used by a computer programmer to devise the program of the lesson. A revised version of GAIDA is planned, which would enable a designer to display the contents of the nine events directly on a computer screen. This aspect of GAIDA design could not be included in the current formative evaluation study.

Formative Evaluation

According to Dick and Carey (1991), formative evaluation is conducted during the time in which instruction is being developed for the purpose of identifying strengths and weaknesses in the instruction and the need for revision. An essential early move in a formative evaluation study consists of "one-to-one trials", carried out with representative learners from the target group for whom the instruction is intended. These trials provide a look at the viability of the instructional linkings of content, setting, and learners. The three main criteria are considered to be as follows:

1. Clarity. Are the directions clear?

2. Impact. What is the effect of the instruction on the achievement of its objectives?

3. Feasibility. Given certain support and time allocations, how feasible is the instruction?

The formative evaluation study was conducted at Lowry Air Force Base. Six individuals participated in the study, each serving as a novice instructional designer. Five of these people were noncommissioned airmen who had experience as instructors in the Armament Specialist course. One was a civilian who was an instructional developer in various aircraft maintenance specialties. All of these participants were acquainted with the F-16 aircraft and its equipment, including the M61A1 gun. In the jargon of evaluation studies, they were considered to be SMEs (subject-matter experts). These men ran through the instruction individually, one in the morning and one in the afternoon, on each of three days.

Each "designer student" (hereafter called the student) was seated facing the computer monitor screen, which rested on a table in front of him. He was told the purpose of his participation as a try-out of a computer-based lesson on designing instruction, containing an example of the checklist procedure for the M61A1 gun in the F-16 aircraft. He was told the instructions would be given on the screen. The investigator (Gagné) would be seated at his back, and would be available for questions if there were any. Also, he would be alert for any hang-ups with equipment operation, and would help out if called upon. The student was to describe the lesson being designed by writing its description (in the manner of a "script") in a notebook provided. Available to the student were (1) a copy of the 32-step checklist, (2) a copy of the wiring diagram for the electrical circuits of the gun, and (3) a set of black-white drawings of the various components of the electrical system of the gun (switches, connectors, display panels, etc.). The checklist, of course, was an essential feature of the material to be taught. The wiring diagram was intended to provide a conceptual base for understanding the wiring system and its checking. The drawings of equipment components were to be used in assessing performance, after the check had been gone through at least once.

Each student was asked to describe his designed instruction, following the Nine Events as an organizing principle. In addition, each student was asked to "think aloud" concerning the three criteria of evaluation previously mentioned (clarity, impact, feasibility). Students wrote out the verbal communications they wished to make for each event, and also selected a drawn picture of a relevant switch, connector, or component, identifying it by letter from an array mounted on a display board. Students' oral comments were recorded by means of a tape recorder.

Duration of these sessions was approximately two hours, and was not recorded. At the close, each student was asked to state any general comments considered relevant, and helpful to the design and revision of the CBI.

General Findings

The following trends and generalities may be summarized from the preceding protocols of six individuals:

(1) Some errors of omission and transcription were noted by the students. These are correctable, and the revisions will lead to an improved lesson.

(2) It would appear to be essential to provide designer students with information about the status of knowledge in the trainees for whom the training is intended. In the case of this lesson, a functional check of the M61A1 gun, designers need to know that trainees are assumed to have prior knowledge about the conformation of the aircraft, the location and function of its main components, and fundamental safety precautions.

(3) Access to visuals as a component of instruction was given strong emphasis by these designer students. They tried to find and use the most detailed and realistic visuals that were possible to obtain.

(4) The description of the goal (Event 2), as presented in this lesson, appeared to the students to be highly compressed. To be most effective, the description of the goal needs to have a more articulated organization than it has in this lesson.

(5) The treatment of learning guidance (Event 5) in this lesson was considered appropriate by all the students. Essentially, this treatment consisted of: (a) presentation of the text of each step in the form of the checklist; (b) statement of the step directions in "plain English", by expansion of abbreviations; (c) a graphic presentation for each step that illustrated the particular equipment part and its location.

(6) Students approved of Event 6, Checking Performance, and Event 7, Providing Feedback. They were able to suggest subject-matter for four multiple-choice questions, relating to checklist steps 6, 15, 16, and 20. The investigator did not require them to spend time on the precise formulation of questions to accord with acceptable psychometric principles.

(7) Students agreed that an unprompted execution of the 32-step procedure was desirable for purposes of assessment. Scoring of performance could be done by checking off the steps, noting

where errors occurred.

(8) It was thought that transfer (Event 9) could best be identified in terms of performance of the procedure, with checklist, on the aircraft. Several other possibilities exist, including the gun system in other models of the F-16 aircraft and in the F-15 aircraft. Some students stated that using a checklist to make a functional check would probably transfer to other procedures, such as a check of the bomb release system.

(9) These students had no difficulties in comprehending instructional design processes, or in using them to devise a storyboard for a computer-based lesson on the functional check of the gun. While potential improvements such as pictorial additions were noted, students judged the lessons to be satisfactory and potentially effective. The GAIDA approach to teaching instructional design using a narrowly focused model appears to be feasible and capable.

(10) Students experienced no difficulties in comprehending the instructions, and no difficulties in using them to design a lesson on the functional check of the M61A1 gun. Students considered the resulting lessons to be satisfactory for the instruction of trainees in the Armament Specialist field. Possible improvements by the addition of high quality visuals were noted.

(11) It appears that this type of narrowly focused instruction, following the model for the particular task to be taught, is capable of mediating the production of reasonably good instruction. The resulting lesson design is produced with a small expenditure of time and effort. The question of transfer of learning from such an exercise to design for other varieties of task remains for future investigation.

Conclusions

It appears that the techniques of artificial intelligence do have legitimate applications in the domain of instructional systems development. We have described two research projects at the Armstrong Laboratory which incorporate some AI techniques. Other projects involving the application of AI to ISD exist and have met with some success (Duchastel, 1990).

There are a variety of interesting and worthwhile research projects to conduct in this area. For example, AIDA can be used to systematically vary specific instructional parameters (e.g., sequencing of events, placements of objects on the screen, time allotted for learning activities, etc.) in order to determine optimal default settings for a range of instructional settings (different learning objectives, learner profiles, delivery media, etc.). GAIDA can be used to determine what transfer of learning exists between the sample lesson development task and actual lesson development activities. Transfer of learning with regard to such complex enterprises as courseware development is a largely unexplored domain.

We have not devoted much attention to intelligent applications in the other four phases of ISD, but there is clearly a great deal of work being done in most of those areas as well. The exception is that very little use of AI has occurred in the maintenance phase. As a consequence, we urge exploration of AI applications in the maintenance phase.

Finally, since we are largely ignorant of the details of human intelligence, we believe there is little to be gained in debating whether and how machines exhibit intelligence. Rather, we should focus our attention on the useful tasks that machines can be made to perform. If we are thoughtful in our efforts, we may succeed in making machines that contribute to learning.

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