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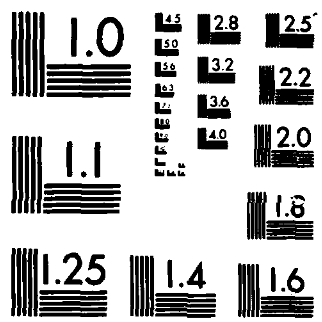

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COMPUTER-BASED TRAINING: IMPLEMENTATION AND SYSTEM EVALUATION

Joseph Y. Yasutake

TRAINING SYSTEMS DIVISION
Lowry Air Force Base, Colorado 80230-5000

January 1986

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The Advanced Instructional System (AIS) was developed to demonstrate the feasibility of managing and administering individualized instruction for up to 2,000 students daily in four Air Force technical training courses. A major state-of-the-art advancement was an integrated computer-based support capability that provided a full range of Computer-Based Instruction (CBI) functions, including course development and presentation, resource allocation and scheduling, and individual student management. A unique feature was the Adaptive Model that produced student prescriptions based on tradeoffs among learning requirements, student characteristics, and resource availability. To support the integrated CBI system, a higher-order language called CAMIL (Computer-Assisted/Managed Instructional Language) was developed. Hardware support was provided by a CYBER 73-16 computer with 10 management terminals and 56 interactive terminals.

Two categories of evaluation data were collected. In the first category were recurring evaluations measuring student time savings, paper-pencil test achievement, attitudes, attrition, and supervisor ratings. In the second category were system level evaluation data pertaining to the specific contribution of computer

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support functions to instructional effectiveness. From the beginning of AIS operations in 1975 to the completion of the system evaluation in 1979, well over 20,000 students graduated from the AIS courses with training time reductions ranging from 15% to 50%. This translated into 1,400 manyears and was a basic justification for the development of AIS. Student attitudes were quite positive; in general, 80% to 90% of the students reacted favorably. Comparisons indicated that the level of test achievement was at least comparable to conventional instruction. Attrition rates remained relatively constant. Finally, supervisors' ratings of field performance of the graduates were favorable.

The savings in training time can be attributed in large part to the instructional design process in self-pacing the course. Thus, a format systems test was conducted in an attempt to isolate the contribution of two specific CMI functions to training efficiency beyond the time savings attributable to self-pacing. The data indicated that approximately 3% time savings above and beyond the savings due to self-pacing could be attributed to individualized instructional assignment (IIA) where, for approximately 25% of the lessons in the course, students were given alternate instructional segments as a function of their individual characteristics. An additional 7% to 10% savings were attributable to the student progress management system that established differential course completion targets for individual students as a function of their aptitudes and past progress. The system operated with better than 95% reliability.

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SUMMARY

Following a series of preliminary studies in the early 1970's, the United States Air Force embarked on a major research and development effort to design, demonstrate, and evaluate a computer-based instructional system at a major technical training center. The system, called the Advanced Instructional System (AIS), was developed to demonstrate the feasibility of managing and administering individualized instruction for up to 2,000 students daily in four technical training courses. A major state-of-the-art advancement was an integrated computer-based support capability that provided a full range of computer-based instruction (CBI) functions, including course development and presentation, resource allocation and scheduling, and individual student management. A unique feature was the Adaptive Model, which produced student prescriptions based on tradeoffs among learning requirements, student characteristics, and resource availability. To support the integrated CBI system, a higher-order language called CAMIL (Computer-Assisted/Managed Instructional Language) was developed. Hardware support was provided by a CYBER 73-16 computer with 10 management terminals and 50 interactive terminals. This paper describes the background of the AIS, summarizes the evaluation data, and discusses current efforts underway as a result of lessons learned from the AIS demonstration program.

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COMPUTER-BASED TRAINING: IMPLEMENTATION AND SYSTEM EVALUATION

I. INTRODUCTION

Following a series of preliminary studies in the early 1970's, the United States Air Force embarked on a major research and development effort to design, demonstrate, and evaluate a computer-based instructional system at a major technical training center. The system, called the Advanced Instructional System (AIS), was developed to demonstrate the feasibility of managing and administering individualized instruction for up to 2,000 students daily in four technical training courses. A major state-of-the-art advancement was an integrated computer-based support capability that provided a full range of computer-based instruction (CBI) functions, including course development and presentation, resource allocation and scheduling, and individual student management. A unique feature was the Adaptive Model, which produced student prescriptions based on tradeoffs among learning requirements, student characteristics, and resource availability. To support the integrated CBI system, a higher-order language called CAMIL (Computer-Assisted/Managed Instructional Language) was developed. Hardware support was provided by a CYBER 73-16 computer with 10 management terminals and 50 interactive terminals. The purpose of this paper is to describe the background of the AIS, summarize the evaluation data, and discuss current efforts underway as a result of lessons learned from the AIS demonstration program.

II. BACKGROUND

Descriptions of the genesis of the AIS and of the total concept are available elsewhere (Nunns, 1982; Rockway & Yasutake, 1974). A brief description of the program is presented in the following paragraphs.

Four technical training courses were chosen to demonstrate the AIS capabilities: Inventory Management (IM), Materiel Facilities (MF), Precision Measuring Equipment (PME), and Weapons Mechanic (WM) courses. These courses represented approximately 1,500 hours of instruction and were selected because of the differences in course lengths, training content, technical complexity, and student aptitude requirements, plus the fact that they were relatively high-flow courses. During the demonstration period, the four courses had a student flow of approximately 7,000 per year.

Prior to the AIS program, these courses were taught in a conventional group-paced classroom environment. As the AIS segments were implemented, the classrooms were converted to learning centers with a variety of self-paced instructional materials. The role of the training cadre was changed from that of platform instructors to learning center managers and training facilitators.

Self-paced instructional materials were developed to replace conventional classroom instruction. For approximately 25% of the course content, optional tracks were developed. Some options used different presentation modes (e.g., printed texts and audiovisual presentation), while others differed in the strategy of presentation (e.g., the amount of redundancy). It was the availability of these options that allowed a test of the effectiveness of the Adaptive Model.

Computer support was provided by a Control Data Corporation (CDC) CYBER 73-16 with 10 management terminals (each consisting of a document reader, printer, and minicomputer) and 50 interactive terminals (plasma display and keyboard). A primary component of the software was CAMIL (Computer-Assisted/Managed Instructional Language), a higher-level language specifically designed to facilitate both computer-managed instruction (CMI) and computer-assisted instruction (CAI) using a common integrated data base.

The configuration of the AIS at the time of system evaluation was essentially that of a large-scale, self-paced CMI (SP/CMI) system. The CMI capabilities included standard features such as test scoring and analysis, student rosters, student progress records, and various course evaluation reports. In addition, two major unique features were designed and evaluated as to their effectiveness in enhancing training. The first was the individualized instructional assignment (IIA) capability and the second, the student progress management (SPM) system. In brief, the IIA provided each student with a specific prescription for the next sequence of instruction. The prescription was driven by a heuristically based Adaptive Model. A simplified diagram of the primary components of the model is provided in Figure 1. IIA selected an instructional sequence (from available alternatives) that was predicted to maximize student performance. Input data included past performance, student characteristics, and resource and lesson availability.

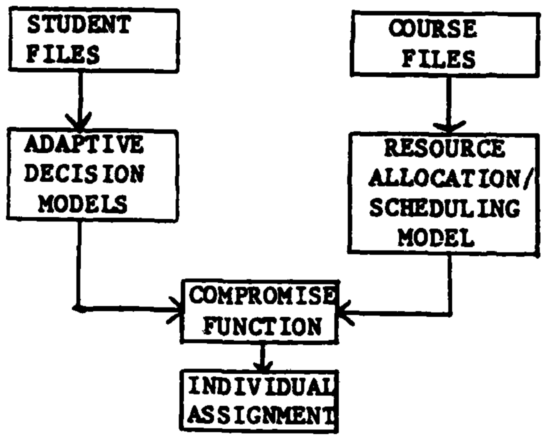

Figure 1. **Adaptive Model.**

The SPM capability maintained records of the rate of student progress and produced predicted completion times for segments of training, as well as for the entire course. Each student was able to track his/her own progress and to establish individual goals to meet the predicted completion time. Predictions were based on student aptitude, past performance, and historical data on past students with similar profiles. When necessary because of extraneous circumstances (e.g., illness), instructors were able to revise the computer-generated predictions.

III. EVALUATION OF ADVANCED INSTRUCTIONAL SYSTEM

Issues in Evaluations of Large-Scale Systems

A well-controlled evaluation of a large-scale system represents a particularly difficult task because of real-world constraints. Initially, consideration was given to freezing the content of the four courses during the AIS demonstration and test phase and to having a parallel control group (conventional classroom) and an experimental group (SP/CMI) within each course. In this manner, it would have been possible to introduce various conditions in the experimental group and to compare outcomes with the control group. However, real-world limitations (e.g., facilities and equipment) precluded such an approach. Rather, a decision was made to use a "pre" and "post" paradigm. Thus, for each course, "pre" data were collected on course length, attrition rates, test scores, and field supervisor ratings for a 1-year period prior to AIS implementation. These data served as a baseline for comparisons with data gathered after AIS segments were implemented. Although this approach was followed to the extent possible, changes in field requirements during the course of the demonstration dictated changes to training content. Thus, an issue of comparability of the pre- and post-course versions needed to be resolved. This issue was handled by carefully analyzing course content of the two versions (i.e., conventional and AIS) and making comparisons only with subsets of the courses which were common to both.

Evaluation Approach and Results

From the beginning of operations to the completion of the formal system evaluation, more than 20,000 students were graduated from the SP/CMI courses. Two major categories of evaluation data were collected during this time. In the first category were the recurring and periodic assessments of training effectiveness as measured by student time savings, achievement, student and instructor attitudes, and field supervisor ratings. These data were gathered systematically over a 3-year period to determine the extent to which instruction was functioning to meet stated training goals. The second major category of evaluation was the Integrated Systems Test (IST). Of particular interest during this test was the effectiveness of the IIA and SPM capabilities. Extensive data were also gathered regarding the reliability of computer hardware and software. The intent was to ensure that the contractual specification under which the AIS was developed had been met.

Training Effectiveness Evaluation

Four separate indices were used to assess the effectiveness of training: (a) student training time savings, (b) achievement on paper-and-pencil tests, (c) student attrition rates, and (d) field supervisor rating of the adequacy of training to meet job requirements. These data were collected at various times during the 4 years that the AIS demonstration was in effect.

Student Time Savings. Calculations of savings in student time were made based on the extent to which students met criterion under SP/CMI versus conventional instruction. Calculations were made only on those segments of the course that were common to both. Table 1 shows the time savings for each of the four courses. As can be seen, time savings ranged from 24% to 35%.

Table 1. Student Time Savings-SP/CMI

Course	% Saving
IM	35
MF	24
WM	31
PME	31

Paper-and-Pencil Test Scores Within-course achievement was measured by comparing test scores for instructional content common to both pre- and post-AIS implementation. Because of the difficulties in determining test item commonality, data were compared only for the IM course. Results shown in Table 2 indicate that test achievement under the pre- and post-conditions was quite similar.

Table 2. Conventional vs. SP/CMI Test Scores

Block	Conventional %	SP/CMI %
1	82	89
2	83	83
3	84	87
4	80	84
5	83	87

Student and Instructor Attitudes. After completion of the course, each student completed a 40-item attitude questionnaire. The questionnaire was designed to assess attitudes toward various aspects of the SP/CMI-supported instruction. On two occasions, instructor attitudes were also measured. In general, 80% to 90% of the students reacted favorably to their experiences. In contrast, instructors were generally negative. An interesting comparison between instructor and student attitudes toward similar items is depicted in Table 3. These findings are in general agreement with those of other studies (Carson et al., 1975; Seidel, Rosenblatt, Wagner, Schulz, & Hunter, 1978).

Table 3. Student (S)/Instructor (I) Attitudes

Student question	Attitude[a]	S (N=363) %	I (N=46) %	Instructor question
				(Compared to conventional instruction)
Compared to lecture, self-paced course is better way to learn.	D	15	57	Students learn as well under self-pacing.
	N	28	22	
	A	56	22	
The instructor was available whenever I needed him.	D	6	30	Under self-pacing, I have less time to spend with students.
	N	9	30	
	A	85	39	
Prefer future AF courses to be of this type.	D	14	59	Students seem to like self-pacing.
	N	26	26	
	A	60	15	
The programmed instruction was boring.	D	56	13	Self-paced materials are boring.
	N	31	28	
	A	13	59	

[a]D = Disagree.
N = Neutral.
A = Agree.

Academic Attrition. Although data on attrition were collected, it was recognized that they were not necessarily indicative of instructional quality. Various factors, such as field demands and changes in student quality, influence attrition. Nevertheless, the data were collected to determine whether any unexplained fluctuations occurred after AIS implementation. Table 4, adapted from the Orlansky and String (1981) report, shows that after an initial decrease, there was a trend toward increased attrition.

It is interesting to note, however, that during the same time period, attrition rose in all courses being taught at the training base.

Table 4. **Academic Attrition Percent**

Courses	Pre-SP/CMI	SP/CMI year 1	SP/CMI year 2	SP/CMI year 3
IM	1.2	.7	1.4	3.0
MF	3.7	1.8	3.2	2.7
WM	1.6	1.6	3.9	4.5
PME	16.5	10.8	6.4	15.3
All Other Courses	4.0	2.8	3.0	4.5

Field Supervisor Ratings. Approximately 6 months after students completed training, follow-up questionnaires were sent out to the field to obtain supervisor opinions of the performance of graduates. Table 5 shows the results. The data indicated that supervisor ratings were favorable regarding the performance of the graduates of the SP/CMI courses.

Table 5. **Field Supervisor Rating of Performance**

Rating[a]	IM (N=310) %		MF (N=235) %		PME (N=78) %		WM (N=147) %	
E	29	(27)[b]	25	(21)	45	(13)	18	(15)
VS	38	-	39	(48)	26	(31)	31	(35)
S	28	(72)	33	(28)	19	(52)	47	(50)
M	4	-	2	-	9	(2)	5	-
U	1	(1)	1	(3)	1	(2)	0	(1)

[a]E = Excellent.
VS = Very Satisfactory.
S = Satisfactory.
M = Marginal.
U = Unsatisfactory.
[b]Pre-SP/CMI Graduate Evaluation.

Integrated Systems Test

As may be recognized, the training time savings discussed previously could in large part be attributed to the instructional design process in self-pacing the four courses. A major goal of the AIS demonstration was to determine whether individualized instruction (i.e., prescribing instruction based on individual difference measures) could enhance training. Thus, the Integrated Systems Test (IST) was designed to determine the extent to which using the Adaptive Model for IIA and setting individual goals by use of the SPM capability could contribute to time savings above and beyond those attributable to SP/CMI.

A more detailed account of the IST may be found in a report by Lintz, Pennell, and Yasutake (1979). The discussion here is focused on the two major experimental issues; namely, the effectiveness of the IIA and the SPM. The IM course served as the main vehicle for investigation of the IIA. Data on SPM were collected for all four courses.

The evaluation design to study the effects of the IIA and SPM is depicted in Table 6.

Table 6. Evaluation Design - IIA and SPM

Condition	Phase I (12 weeks) SP/CMI	Phase II (12-17 weeks) CMI & SPM
Single-Track	A[a]	C
IIA	B	D

[a]Condition A - SP/CMI version of the course with a predetermined sequence of instruction.

Condition B - assigned modules which were "best" for that student based on personal characteristics and past achievements. "Best" was defined as the module that could be passed successfully in the shortest time.

Condition C - the same as A, except that students were given target completion times and a chart to track their daily progress toward that target.

Condition D - the same as B with SPM added.

Table 7 shows the results. The data indicated that approximately 3% above and beyond the savings due to SP/CMI could be attributed to IIA where students were given alternate instructional segments as a function of their individual characteristics. An additional 7% to 10% savings were attributable to the SPM system, which established differential course completion targets for individual students as a function of their background and aptitude. Although both of these figures are statistically significant, whether they are practically significant may be questionable (i.e., whether it's operationally effective to add individualized assignments and student progress management to a self-paced course).

Table 7. Time Savings

Condition	Course	Phase I SP/CMI % Savings	Phase II SP/CMI+SPM % Savings
Single-Track	IM	(Baseline data)	10
	MF		6
	WM		13
	PME		5
IIA	IM	3	13

It was disappointing that the magnitude of the IIA evaluation findings was not greater, although these results might have been expected due to the nature of the experimental conditions. At any rate, the research community still has much to learn about the transition of research findings regarding individual differences from carefully controlled small-scale experiments to large-scale, dynamic, real-world environments.

IV. LESSONS LEARNED

As a result of the experiences from the development, demonstration, and evaluation of the AIS, several observations can be identified as "lessons learned." Some are reaffirmations of findings from other similar experiences.

Instructional Aspects

Well-designed self-paced materials can provide training equivalent to that of conventional classroom instruction, in less time. Self-paced materials provide variety in instructional presentation techniques (e.g., use of multimedia) and have a mixture of learning activities to sustain student interest.

The state of knowledge regarding individual differences is still not advanced enough to have practical, significant impact on design of instruction. The computer software necessary to execute a sophisticated model of adaptive instruction carries a considerable cost in terms of system complexity. Further research is essential to make individualized instruction more cost effective.

Instructional goal setting is a very powerful motivational mechanism and can impact learning progress considerably.

The cost of self-paced instruction lies more in the instructional design and revision process than in instructional delivery. More efficient authoring capabilities and instructional development procedures are needed.

Organizational Aspects

The transition of a non-conventional instructional system into an operational environment is a very complex process. Many factors, including management and instructor commitment and administrative and logistics support mechanisms, are critical for sustaining a new system. The developing agency needs to serve as a transition agent considerably beyond the system development phase. Further study is required to investigate the factors required to enhance transition of new systems into existing environments (McCombs, Back, & West, 1984).

Instructor roles are changed dramatically under self-pacing. The selection and training of instructors and redefinitions of instructor roles in self-paced instructional environments require further study.

V. CURRENT RESEARCH AND DEVELOPMENT EFFORTS

During the 4-year demonstration period, more than 20,000 students were graduated from the four AIS courses, with training time savings representing more than 1,500 workyears. In terms of cost-avoidance, the training time savings helped to amortize the cost of system development.

Although the training effectiveness data were largely favorable, questions regarding the costs associated with a large mainframe approach led to a decision not to implement AIS as an operational system, but to explore more cost-effective alternatives for future use. There was wide recognition of the powerful CBI capabilities existing in the AIS software and the fact that this capability should be captured using a more modularized and transportable approach. The more recent advances in computer hardware/software technology and particularly the emergence of minicomputers and microcomputers have made such an approach technically feasible. These advances, together with many of the lessons learned from past efforts, have guided the direction of much of the more recent and current efforts in CBI research and development.

Instructional Support Software

The development of the instructional support software (ISS) was initiated in 1982. The functional requirements for ISS were established as a result of a review of the basic AIS capabilities and a survey of DOD agencies to identify any additional capabilities that were viewed as being desirable. The approach was to make ISS modular and transportable to a wide range of minicomputer and microcomputer configurations using Ada, the standard DOD language. The intent in modularizing the functional capabilities was to allow specific subsets (e.g., CAI, CMI, graphics, resource allocation, and course authoring) to be executed separately or together as a totally integrated system. The basic ISS is now completed and running on a Vax 11/780 computer system. Demonstration of the capability of specific subsets of the ISS to execute on a microcomputer has also been completed. Both capabilities are now under operational test. Once the ISS is stable, it is anticipated that it will be a part of a standard DOD CBI capability. A further description of the ISS may be found in a paper by Marshall (1983).

Computer-Assisted Instruction Handbook

Often, training managers are faced with the issue of whether CAI is appropriate for their particular training situation. To assist them in making informed decisions, a CAI handbook was recently completed (Kemner-Richardson, Lamos, & West, 1985). This handbook provides an introduction to the concept of CAI, describes various factors to be considered, and provides decision aids to assist users in systematically analyzing their requirements.

Personnel Roles in Non-Conventional Instruction

Past experiences clearly indicate the need to redefine the role of the instructional cadre in non-conventional instructional (NCI) environments. A study analyzed such requirements and developed recommendations for an instructor training curriculum (McCombs & Lockhart, 1984). In brief, the ideal role for an NCI instructor was determined to be that of a counselor, modeler, evaluator, diagnostician, remediator, implementor, and planner.

Automated Task Analysis Authoring Aid

Task analysis as the front end of the Instructional Systems Development process is a necessary, yet often tedious, requirement. Several efforts have been accomplished to provide analysts with various aids to assist in their job. The Automated Task Analysis Authoring Aid is an initial attempt based on procedures developed by DeVries, Eschenbrenner, and Ruck (1980) to provide an interactive, menu-driven system for conducting task analysis on-line. The intent is to facilitate timely task analysis by using computer support. Preliminary indications are that, with continued improvements, the aid will be very useful.

Intelligent Computer-Assisted Instruction

Recently AFHRL has initiated a systematic long-range research and development thrust to investigate the potential of artificial intelligence to job aiding and training. Current efforts are involved in preliminary investigations of expert systems and the establishment of an Intelligent Computer-Assisted Instruction (ICAI) test-bed. It is anticipated that these efforts will eventually lead to the development of a portable ICAI system.

VI. CONCLUSIONS

Computer-based instruction in military applications has been demonstrated to be a viable and effective alternative and supplement to more traditional means of training. The early promise of its potential is reaching fruition. Yet, there are still many issues to be resolved and new applications to be explored before its capabilities are fully exploited. A great challenge still remains for the research community in this area.

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