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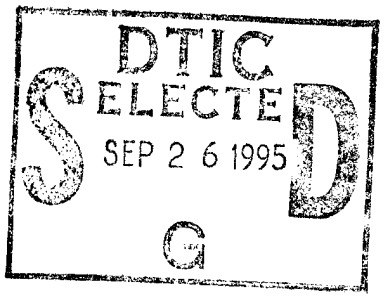
Evaluation of the Paperless Classroom



Barbara A. Morris

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13. ABSTRACT *(Maximum 200 words)*

The Paperless Classroom project explored the use of advanced technology to develop and demonstrate an interface to the large amounts of technical information available in electronic form. A prototype system was developed and field-tested at the AEGIS Training Center, Dahlgren, VA. Phase I designed and developed an electronic Instructor Guide (IG). Phase II improved the electronic IG and developed an electronic Trainee Guide.

The objective of this effort was to evaluate the effects on teaching and learning when instructors lecture from electronic instructional materials and access visual aids through the use of computer interfaces. Data from observations, surveys, interviews, test scores, and course critiques were collected to obtain information about the use of this technology in the classroom. The Paperless Classroom system was a success; a very useful tool for instructors to access technical information in electronic form as they lecture. The system was reliable and easy to use by both instructors and students. There was no negative impact on learning.

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Foreword

This effort was conducted under the exploratory development program element 0602233N, Personnel and Training Technology (NP2A), project number RM33T23. The sponsors included Office of Naval Research and AEGIS Training Center. The objective of this project was to develop innovative and effective technologies to increase the efficiency and cost-effectiveness of training. The Paperless Classroom task was initiated in FY91 to explore, develop, and demonstrate an interface to large amounts of technical information available in electronic form. A prototype system was developed and field-tested under this task.

The objective of this effort was to evaluate the Paperless Classroom to learn how use of this technology impacts teaching and learning.

J. McLACHLAN
Director, Classroom and Afloat Training

Summary

Problem

Information technology advances are changing the way Navy personnel operate and maintain equipment. Technical information and documentation required to support operation and maintenance of the equipment are being put into electronic form. Sailors are beginning to use Interactive Electronic Technical Manuals (IETM) onboard ship. In the classroom, training materials contain extensive cross-references to technical manuals and to other training materials or visual aids. Instructors and students need the capability to access this electronic information during classroom training. To address this problem, the Paperless Classroom project provided the instructor a tool to facilitate delivery of electronic training materials.

Objective

The objective of this effort was to determine the effects on teaching and learning when instructors lecture from electronic instructional materials and access visual aids through the use of computer interfaces.

Background

The Navy Personnel Research and Development Center (NPRDC) established a memorandum of agreement with the AEGIS Training Center March 1991 to develop an automated classroom. The NPRDC exploratory development project, Paperless Classroom, was part of the larger AEGIS Classroom of the Future effort.

The Paperless Classroom project explored the use of advanced computer technology to design and develop: (1) an electronic form of the Instructor Guide (IG), (2) a set of tools which permit the instructors to electronically personalize the IG, (3) a presentation interface to the electronic IG, (4) an electronic technical publication interface, (5) a student workstation/interface; and (6) an electronic form of the Trainee Guide (TG).

Approach

The AEGIS Fundamentals course (CDP 034Z) was selected and developed for computer display. This two week course held at AEGIS Training Center, Dahlgren, VA, prepares Fire Control students for advanced training in computer architecture. Our objective was to design, develop, and evaluate a system for a small application as a basis for moving to larger applications in the future.

Phase I of the Paperless Classroom project designed and developed an electronic Instructor Guide (IG). Phase II improved the electronic IG and developed an electronic Trainee Guide (TG).

Data from observations, surveys, interviews, test scores, and course critiques were collected to obtain as much information possible about the effect the Paperless Classroom system could have on teaching and learning. Observation data covered the learning and social environments, and course activities. A survey was used to gather demographic and opinion data.

Results

The Paperless Classroom system was a success; it was a very useful tool for instructors to access technical information in electronic form as they lecture. The system was reliable and easy to use by instructors and students. There was no negative impact on learning. Student exam scores were comparable between the Fully Automated and Electronic IG classes.

Conclusions

This evaluation of the Paperless Classroom was limited since it was tested on only one course. However, this was a good first attempt to access the vast amount of technical instructional materials. The instructor has been given a new tool for preparing and delivering these materials. An improved graphical interface has provided instructors and students a better means to review schematic diagrams, tables, figures, and flow charts.

As the use of electronic aids for classroom training increases, we expect improved instruction as measured by increases in student test scores, retention of course information, and job performance. These changes are expected because electronic aids to training delivery make better use of instructor and student time, smooth the flow of information, and improve instructor control over training content and training aids. Electronic delivery will lead to reductions in publishing costs since substantial amounts of training materials will no longer have to be printed. Personnel requirements, technical change management, and curricula distribution costs will be reduced.

Recommendations

It is recommended that the AEGIS Training Center automate additional courses as more interactive electronic technical manuals (IETM) become available. Consideration should be given to linking the Paperless Classroom system to laboratory systems. Instructors and students should be given more on-site training on the use of the Paperless Classroom system. Navy Instructor Training courses should include delivery of electronic curriculum.

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Introduction

Problem

Information technology advances are changing the way Navy personnel operate and maintain equipment. Naval vessels are inundated with paper--mostly technical information and documentation required to support operation and maintenance of the equipment. Sailors are beginning to use Interactive Electronic Technical Manuals (IETMs) onboard ship.

In training, the problem of dealing with extensive technical documentation is at least as severe as onboard ship. Instructor and student curricular materials contain extensive cross-references to the technical publications and to other training materials or visual aids. The Paperless Classroom project addressed this problem by building an interface to this information and providing the instructor a tool to facilitate delivery of electronic training materials.

Objective

The overall objective of the Paperless Classroom project was to explore the use of advanced computer technology to design and develop: (1) an electronic form of the Instructor Guide (IG), (2) a set of tools that permit the instructors to electronically personalize the IG, (3) a presentation interface to the electronic IG, (4) an electronic technical publication interface, (5) a student workstation/interface; and (6) an electronic form of the Trainee Guide (TG).

The objective of this task was to determine the effects on teaching and learning when instructors lecture from electronic instructional materials and access visual aids through the use of computer interfaces. The evaluation findings from Phase I reported in Morris (1993), provided information necessary to further improve the system during Phase II.

Background

The Navy Personnel Research and Development Center (NPRDC) began working with the AEGIS Training Center during FY92 to develop an automated classroom. The NPRDC exploratory development project, Paperless Classroom, was part of the larger AEGIS Classroom of the Future effort. Classroom of the Future includes development of Interactive Electronic Technical Manuals (IETM) and the Computer Aided Presentation Station (CAPS) for use at the AEGIS Training Center, Dahlgren, VA. The Paperless Classroom project examined the feasibility of building an interface to the large amounts of technical information available in electronic form to the instructor and students.

The AEGIS Fundamentals course (CDP 034Z) was chosen to receive the electronic instructional materials. This two week course held at AEGIS Training Center, Dahlgren, VA, prepares students for advanced training in computer architecture. There are over 400 printed pages in the IG, approximately 500 printed pages in the TG, and 200 transparencies of schematics, drawings, and tables. Students attend the AEGIS Weapons System (AWS), SPY Radar, Fire Control System/Operational Readiness Test System (FCS/ORTS), Display or Computer courses as follow-on to this course.

The Fundamentals course was authored using the Authoring Instructional Materials (AIM) program. AIM is a Navy automated system for curriculum development and maintenance. Course materials are stored in a relational database. This database was a logical source for retrieving course data in a form that could be readily converted and used with electronic book software to produce a final product for the Paperless Classroom.

At AEGIS, technical training is presented in the IG and TG. The IG is a detailed outline of instruction with references to supporting technical publications and training aids, from which the instructor lectures. It is the instructor's responsibility to "personalize" the IG by including detailed information about the discussion points. The instructor may use films, transparencies, handouts, or technical manuals to illustrate discussion points or to enhance his lectures. According to AEGIS instructors, they usually spend about three weeks personalizing the IG for a two week course. As a newer version of the IG became available, instructors copy the personalization into the new IG, which takes at least another week.

The TG contains Instruction Sheets, which provide students with more in-depth information about the topics discussed by the instructor. The TG may include several types of Instruction Sheets--Information, Diagram, and Problem. The Information Sheet, much like a book chapter, provides relevant information about a topic. Often a Diagram Sheet follows the Information Sheet to illustrate a topic. After students read the Information Sheet and study the Diagram, a Problem Sheet may follow to further increase understanding of the material.

Traditionally, the IG and TG are paper-based documents containing several hundred pages. For even a short course, there may be large numbers of drawings, schematics, and tables displayed as transparencies. In an effort to save development and printing costs, it was decided to develop electronic instructional materials for use during classroom lecture. The hardware configuration for the Paperless Classroom system (Appendix A) consisted of an Instructor Station (Sun SparcStation 10 with two 16" color monitors) and 12 Student Stations (Sun SparcStation LX with one 16" color monitor). Text files were converted from Unix Troff to Standard Generalized Markup Language (SGML) and displayed on the computer via Dynatext (Electronic Book Technologies, Inc.) software. Design and development of the Paperless Classroom system are beyond the scope of this report. See Morris & Dickieson (1995) for more detailed information.

Phase I of the Paperless Classroom project designed and developed an electronic IG. A prototype electronic IG was delivered and evaluated 7-18 December 1992. Phase II improved the electronic IG and developed an electronic TG. An evaluation was conducted from 31 May to 10 June 1994.

Phase I--Approach

As researchers, we realize it is difficult to generalize our findings based on a small sample of students and instructors. It is often very difficult to collect data due to budget, time, and travel constraints. When working with an actual school, however, often there are limitations placed on availability of information. Given these constraints, we attempted to compare the various course delivery methods as we evaluated the Paperless Classroom. These course delivery methods are

discussed throughout this report . We describe these methods as "traditional," which refers to paper-based, and "electronic" or "automated," which refers to computer-based.

The evaluation process began by first collecting baseline information from a traditional Fundamentals course. The evaluator observed a traditional class from 17-28 August 1992. Next, the evaluator observed the same course being taught with the electronic IG, 10-17 December 1992.

NPRDC staff provided system training for three AEGIS instructors. This training included an introduction to the Unix operating system and how to use the electronic IG for personalizing their lessons and for lecturing in the classroom. NPRDC developed a User's Manual to assist instructors as they prepared their instructional materials.

Subjects

The students were enlisted military personnel, primarily from the Fire Control Technician (FC) rating. One student was an Electronics Technician (ET). Military ratings are assigned for career fields, just as job titles are assigned for positions in industry. The majority of the students were junior level (FC3). The FC1 and ET2 are higher rating for enlisted personnel. Table 1 provides Student Rating for each condition, Traditional and Electronic instruction.

Table 1

Phase I--Student Rating

	Number of Students			
Type of Instruction	FC3	FC2	FC1	ET2
Traditional (N = 20)	16	1	2	1
Electronic (N = 19)	17	2		

Data Collection Methods and Instruments

Many factors may influence the success or failure of new technology being used in the classroom. Therefore, qualitative and quantitative data from classroom observations, opinion surveys, instructor interviews, test scores, and course critiques were collected. A description of the methods and instruments used to collect these data follows. Appendix B presents the Phase I survey instruments.

Observation: Information about the learning environment, classroom interactions, and course activities such as the flow of instruction, time spent on the various topics and number of transparencies provided baseline data for future evaluations. This information was gathered because any of these factors may impact teaching and learning.

Survey: A survey was designed to gather opinions from students and instructors. There were statements based on a five-point scale, "Strongly Agree to Strongly Disagree." followed by open-ended questions. The survey was administered to students and instructors at the end of the second week of instruction. Another survey was given to instructors to gather information about the time they spent personalizing the course.

Interviews: Informal interviews were conducted with instructors to learn about their experiences as they personalized and delivered their training materials.

Test Scores: Test scores were obtained for the written quiz and final exam. The quiz counted as 10% of the overall course grade. A score of 70% was required to pass the final exam. These tests were developed by AEGIS Training Center personnel.

Course Critiques: Course critiques were obtained from the students. The 40-item critique form was developed by AEGIS and covered the learning environment, training materials, equipment, instruction, instructor, testing, written test, and performance test. The students were given a six-level ranking scale, "Outstanding" to "Not Applicable," from which to select their responses.

Phase I--Results

Traditional Instruction

Observation

Learning Environment: Training was held in a long narrow classroom with tables and chairs to accommodate 20 students. See Figure 1 for a layout of the classroom. The room was in an environmentally controlled building; comfortably air conditioned and heated. Security was of utmost importance throughout the building. All of the doorways were electronically controlled and the classroom door was equipped with a combination lock. There were no windows. The room was well insulated. The walls were off-white in color and the carpet was beige. Large white boards were mounted on the front wall (behind the instructor) and at the back of the room. These walls were painted deep orange. The fluorescent lighting was adequate and pleasant.

An overhead projector and a pull down film screen were in the front left of the room. Two TV monitors were ceiling mounted in the upper right corner and right side midway of the room. A VCR and two closed-circuit cameras were placed on the left side of the room. Bookcases were on the left of the room adjacent to student tables. Technical manuals and course materials were stored in these bookcases.

The chairs were uncomfortable straight gray armchairs with stationary legs. Each student had a table with adequate space for course materials. The instructor taught from a podium and table located at the front of the room. The instructor preferred to walk down the aisle between the groups of tables to have closer contact with the students and to make sure they could hear the lecture. He often carried the IG, TG, or textbook as he discussed the material.

Classroom Interaction: There was respect for military rank between the instructor, indoctrination speakers, and students. The instructor was an enlisted member of the military. He was very professional and confident with the material. Students commented that he was very helpful when responding to their questions. The instructor interacted very well with the students. The military and civilian personnel who spoke to the class during the course indoctrination were genuinely concerned about the morale and well being of the students and their families; offering

counseling and assistance as needed. By the second day, students began to feel comfortable and talked freely among themselves and with the instructor. One of the students was the class leader and had responsibility for the duty roster. Some of the students had served in the fleet and shared their experiences with other students.

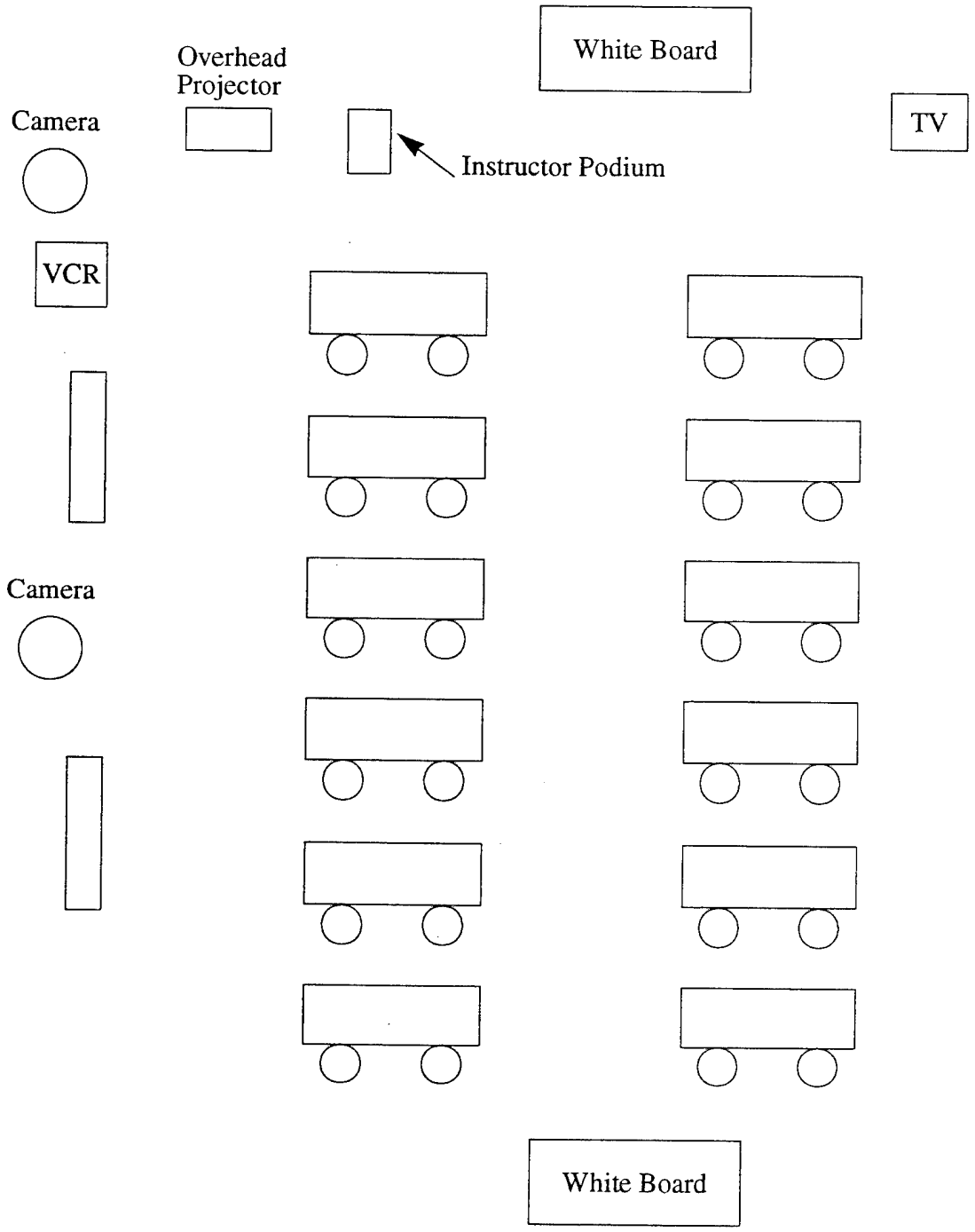

Figure 1. Phase I--Traditional instruction classroom layout.

Course Activities: The evaluator was present during the entire two week course. The course was conducted during normal duty hours the first week. During the second week, the course was conducted from noon into the evening. The first three days included indoctrination to the base and the training center, welcoming by various base organizations, a discussion about safety, and time to take care of housing, dental, or medical needs. Lecture began on the fourth day.

Topics covered during the course were Digital Systems, CPU and Microprogrammable Control Units, Computer Interfaces, Memory Architecture, Executive Operating Systems, Utility Programs, Diagnostic Programs, Peripheral Devices, and General Physical Description of AEGIS Combat System. There were 20 transparencies shown from an overhead projector, some more than once, to illustrate topics during lecture. A 30-minute video about safety was shown. The white board was used extensively to further explain a discussion point during the lectures. Seven wall charts were used to discuss the general layout of the various ships, overall system architecture, and types of personnel onboard each ship. Students completed a laboratory exercise on the AEGIS Combat System Interactive Trainer (ACSIT). At the end of the course, AEGIS course critiques were completed by students.

One written quiz, consisting of five multiple choice questions, was given during the second week of instruction. Students could use their books and notes. A written exam, which was open-book, was given the last day of the course.

Survey: Since this was a paper-based course, the opinion survey on the use of our system was not applicable.

Interviews: Informal interviews were conducted with two instructors. The instructors were very confident with the material and enjoyed teaching. Instructors reported it took them as long as three weeks to personalize the paper-based IG. This was a substantial amount of time given the course is only two weeks long. When the course is revised, their notes have to be transferred to a new copy of the paper-based IG. The personalization literally had to be re-written on the newly printed IG.

Test Scores: For this traditional group (N = 20), student final exam scores ranged from 75-100%, class mean = 88.75. Quiz scores ranged from 60-100%, class mean = 94. The cumulative course mean = 89.28. This mean included the quiz scores.

Course Critiques: The majority of students found the classroom environment to be excellent; the quality of training materials good to excellent; and equipment, instruction, ability of instructor, testing policy, and clarity/adequacy of the written test to be excellent. Students were concerned about the organization of the subject matter. The order of topics taught did not agree with that of the textbook, resulting in a lot of "jumping around" in the text.

Electronic Instruction

Observation

Learning Environment: Training was conducted in a rectangular, somewhat crowded, classroom with tables and chairs to accommodate 20 students. See Figure 2 for the classroom layout. The building was comfortably air conditioned and heated. Security was of utmost

importance throughout the building. All of the doorways were electronically controlled and the classroom door was equipped with a combination lock. There were no windows. The instructor taught from a podium, which could be raised, lowered, or tilted at the front of the classroom. The keyboard and mouse were placed on this podium. The computer monitor was located on a table to the right of the raised podium. The room was well insulated. The walls and carpet were grey. The chairs were armless with chrome trim, stationery legs, and blue cushions. Large white boards were mounted on the front wall behind the instructor podium. The white board was used extensively to illustrate a topic. The fluorescent lighting was adequate and pleasant. An overhead projector, a pull down film screen, and two TV monitors (mounted in the upper right corner and right side midway of the room) were in the front of the classroom. A VCR and two closed-circuit cameras were placed at the back of the room. The course was video-taped to allow the system developers to review sessions as they made improvements. Bookcases were on the right and left of the room adjacent to student tables. Technical manuals and course materials were stored in these bookcases.

Each student had a table with adequate space for course materials to be stowed in a tray underneath the table top. The tables were arranged with an aisle down the left side. The evaluator sat at a table in the back right of the class. Another instructor sat at a table to the evaluator's left. He was auditing the course to prepare for teaching the following month. There were two computers at the back of the room. These were instructor workstations installed to give instructors an opportunity to personalize their lectures and to become familiar with using the electronic IG program.

Classroom Interaction: The instructor was an enlisted member of the military. He had four years of computer experience and had been teaching for three years. He had a good rapport with the students and was confident using the electronic IG as he lectured. The instructor interacted well with students and responded to their questions with ease.

After a couple of days, students interacted freely. The class leader was responsible for the duty roster and kept students informed of upcoming events on a daily basis. Some of the students had fleet experience. Because of this experience, other students felt comfortable asking them questions relevant to equipment and duty onboard the ships. Most of the students had just attended their first level of training at "A" school and did not have fleet experience.

Course Activities: The evaluator was present during the entire two week course. The course schedule was the same as that for the traditional course. During this course, an electronic IG, a paper-based TG, technical manual, and textbook were used.

There were no delays during the course, no hardware or software failures. The instructor was very comfortable with the electronic IG and seemed to enjoy using it. Noticing something he wanted to add to a discussion point, he personalized his lesson "on the spot," without interrupting the class.

The same topics as those for the traditional course were taught. The only difference noted was that fewer transparencies were shown to illustrate topics during lecture. As in the traditional course, the white board was used extensively to further explain a topic. Five wall charts were used to discuss the general layout of the various ships and overall system architecture onboard each type of ship. A 30-minute video about safety was shown during the course.

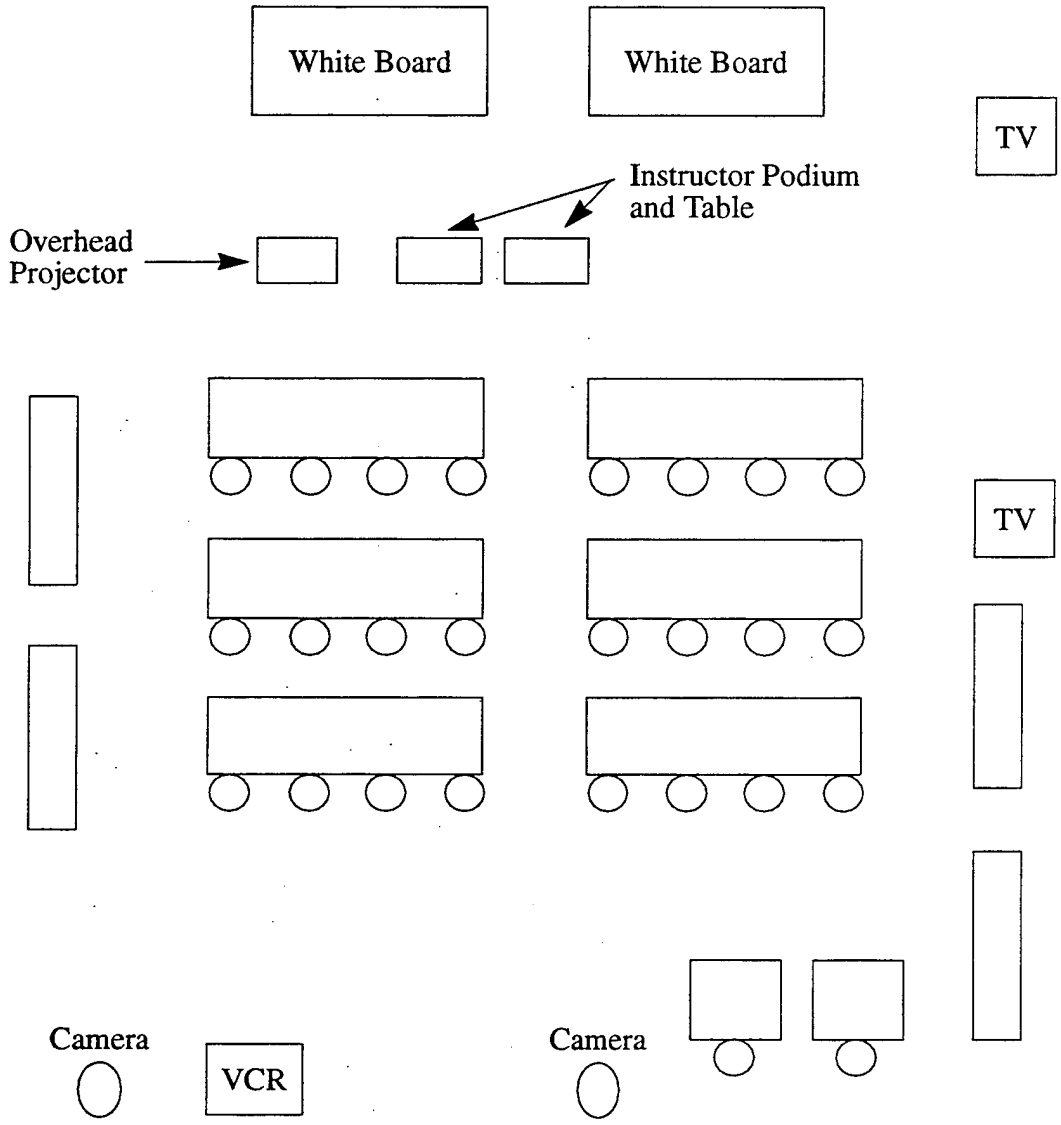

Figure 2. Phase I--Electronic instruction classroom layout.

The same procedure for testing was followed for this group as for the traditional instruction group. Students completed a laboratory exercise on the AEGIS ACSIT. At the end of the course, AEGIS course critiques were completed by students.

Survey

Instructor: To summarize survey findings (Appendix B, Table B-1), the instructor supported the use of electronic aids for personalizing his lecture and for delivering classroom training. He had used computers for about four years and had three years teaching experience. The instructor strongly agreed that new media should be used in the classroom, that he could save time preparing

the IG, and that use of the system would be useful for the life-cycle management of the course. He expressed confidence with using the system as a tool for course development and lecture.

Student: A summary of student (N = 19) survey responses (Appendix B, Table B-2) revealed that more than half of the students had computer experience, mostly four years or less, but few had used a computer in a classroom setting. Six of the students said they had no computer experience, and one had experience of less than a year. The majority of students favored the use of media in the classroom and did not think the flow of instruction was adversely affected by the instructor teaching from an electronic IG. Some students selected an "undecided" response to the statements about hardware and software problems because they could not view the Electronic IG. They based their responses on the instructor's reaction to any problems related to the system.

Suggestions made by five students for improving the use of this technology in the classroom included (1) eliminating transparencies by displaying the graphics on a computer, (2) installing computers for students, and (3) including a study module on student computers. Other comments made by students were "the paperless classroom was a great idea whose time had finally come" and that automating the class would make learning more interesting because of the interaction. They also thought it was difficult to follow where the instructor was in the material because the textbook topics were not in the same sequence as the electronic IG. Students wanted to see networked student workstations in their quarters so they could use the system for extra study and homework.

Interviews: The instructor suggested the electronic IG be improved by organizing it by topics so the scroll bar reflected where he was in the topic rather than in the entire IG. This would make it easier to judge how much of the topic is remaining and how much time is required to finish the discussion. He suggested a status line be added at the top to inform the user of the location within a topic. Another suggestion was that the bookmark icon be a different color to distinguish it from other icons used for personalization. A bookmark is a place holder noted by an icon displayed next to associated text on the computer screen. The instructor thought the Table of Contents (TOC) should close automatically instead of requiring the instructor to close it. He identified a problem when using the arrow up or down keys. As the computer screen refreshed, text was displayed improperly. If he used the Page Down key to refresh, the problem was gone. All of these suggestions and problems noted were given to the system developers for consideration as the program evolved.

Test Scores: For the electronic instruction class (N = 19), student final exam scores ranged from 75-100%, class mean = 89.21. Quiz scores ranged from 53-100%, class mean = 80. The cumulative course mean = 88.29. This mean included quiz scores.

A comparison of test scores for the Traditional (N = 20) and Electronic (N = 19) instruction classes is shown in Table 2. The results of an analysis of variance (ANOVA) found no significant differences between these exam scores, $F(1,37) = .0401, p > .05$.

Table 2

Phase I--Student Scores

	Class Average (%)		
Type of Instruction	Quiz	Exam	Cum. Course
Traditional (N = 20)	94	88.75	89.28
Electronic (N = 19)	80	89.21	88.29

Course Critiques: Students found the classroom environment to be excellent; the quality of training materials good to excellent; and equipment, instruction, ability of instructor, testing policy, and clarity/adequacy of the written test good to outstanding. Students commented negatively about the logical arrangement of the subject matter. The IG and TG did not follow the same sequence of topics as that of the textbook used in class. Some students commented that the written test was of poor printed quality. The course managers seriously considered comments and recommendations made by students.

Phase II--Approach

The Paperless Classroom system was ready for field testing May 1994. Because of an increase in the number of students attending the Fundamentals course between January and June 1994, training was conducted in two classrooms, one equipped with an Electronic IG (no student workstations) and one Fully Automated (instructor and student workstations). The term "fully automated" means the IG was displayed on the instructor workstation, the TG on the student workstation, and graphics on both workstations.

A chief complaint during prior traditional classes was that the course materials (IG, TG, and textbook) did not cover topics in the same sequence. Students frequently commented about the confusion created by "jumping around" through the course materials. The course was not rewritten, but the text was incorporated into the TG and the sequence of topics put in better order. All of the transparencies, tables, and figures were re-authored and included in the computer system. Thus, the paperless classroom became a reality.

This evaluation was conducted by collecting information from one Electronic IG and one Fully Automated class. One evaluator observed the Electronic IG class conducted from 23 May to 3 June 1994. Another evaluator observed the Fully Automated class conducted from 31 May to10 June 1994. Their goals were to observe the course being taught and to collect data relevant to use of the system, learning environment, student/instructor interaction, and opinions. A survey was administered to collect demographic and opinion data.

NPRDC staff provided system training for AEGIS instructors. This training included how to use the Electronic IG for personalizing their lessons and for lecturing in the classroom. The system User's Manual, delivered during Phase I, was revised and provided to the instructors. This manual was a reference to assist instructors as they prepared their instructional materials using the Paperless Classroom system.

Subjects

The students were enlisted military personnel of the Fire Control Technician (FC) rating. Table 3 shows the majority of the students were junior level (FCSN and FC3). The FC1 is higher rating among these enlisted personnel.

Table 3

Phase II--Student Rating

	Number of Students			
Type of Instruction	FCSN	FC3	FC2	FC1
Electronic IG ($N = 22$)	5	12	4	1
Fully Automated ($N = 9$)	3	3	2	1

Data Collection Methods and Instruments

Data based on classroom observations, survey of students and instructors, interviews with instructors, and test scores were collected. The methods and instruments used to collect these data are described below. Appendix D present the survey instruments.

Observation: Evaluators were present to observe the Electronic IG course (paper-based TG, no student workstations) and the Fully Automated class (electronic IG/TG and student workstations). The flow of instruction, time spent on the various topics, and interaction between the instructor and students provided valuable information about use of the Paperless Classroom system.

Survey: The survey administered during Phase I was revised to include open-ended questions asking students and instructors to list what they liked most and least about the classroom interaction, instructional strategies, equipment, subject matter, instructor, and facilities. The survey was administered to students and instructors at the end of the course. Instructors were also given a survey regarding the time spent personalizing the paper-based and electronic IGs.

Test Scores: Test scores were obtained for students attending the classes we observed during the May-June 1994 time frame. In addition, test scores were obtained for recent paper-based, fully automated, and electronic IG classes that could be relevant to this evaluation (see Appendix C, Table C-1).

Course Critiques: AEGIS course critiques were not available during Phase II evaluation.

Phase II--Results

Data from the observations, surveys, and interviews are reported for the Electronic IG class and the Fully Automated class.

Electronic IG Instruction

Observation

Learning Environment: The Electronic IG instruction was held in the same location as the Phase I Traditional Instruction class previously observed. The classroom layout, as shown in Figure 1, was also the same. Students were given two binders containing the TG and technical manual, and the textbook (Mano, 1993). These materials were used by students during lecture and could be taken home for study. There were no student workstations in this classroom.

The instructor lectured from the electronic IG. The computer was placed on a table to the left of a podium, at the front of the room. The paper-based TG and transparencies of the graphics were used during the lecture. A cable was accidentally disconnected during a lecture, but no other equipment or problem failures were noted.

Classroom Interaction: The instructor was an enlisted member of the military. He was very professional, had been teaching for a year, but had never lectured from a computer. Students commented that the instructor was very helpful when they asked questions. The instructor interacted very well with the students. This was the first Fundamentals course to have a female student in attendance. The male students accepted her and everyone felt comfortable. By the second day, students began to talk freely among themselves and with the instructor. One of the students was the class leader and had responsibility for the duty roster. Quite a few students had served in the fleet prior to this training. They shared their experiences with other students.

Course Activities: The evaluator was present during all of the instructional sessions. The course was conducted during normal duty hours the first week. During the second week, the course was conducted from noon into the evening. The first three days included indoctrination to the base and the training center, a topic about safety, and time to take care of personal business. Lecture began on the fourth day. The same topics were taught as those in the Fully Automated class. As in the other Fundamentals classes, a 30-minute safety video was shown. The white board was used extensively to further explain a discussion point during the lectures.

The same testing procedures as for the other Fundamentals classes were followed; one written quiz and a final exam.

Survey

Instructor: To summarize results of the survey (Appendix C, Table C-2), the instructor had about nine years computer experience, but had no previous experience using a computer in a classroom setting. He had one year teaching experience and was supportive of having new media in the classroom; he felt confident using the computer. In spite of this confidence, he disagreed that

he could personalize the IG with ease using the system or that it would save development time. And, he was undecided about using computers in a classroom to enhance training.

When asked "**Do you have suggestions for improving the use of this technology in the classroom?**," the instructor suggested he would like the capability to search for keywords in the course personalization and to have more colors available for highlighting personalization. The present system does not support searching for keywords within the personalization notes, only in the basic IG outline. The personalization text can be shown in various colors (the system now presents this text in blue), but a change could be made by the system designer. The instructor would also like to have the on-line TOC broken down to discussion point level. Presently the TOC displays the IG in part, section, and topic levels. An optional TOC can be retrieved that lists figures and tables within these levels. The instructor also stated he would like to have the capability to add his own graphics and to transfer graphics from the computer to an overhead screen.

To gain an overall opinion about the learning environment, the instructor was given various categories (classroom interaction, equipment used, subject matter, facilities) and asked to comment about what he liked "most" and "least" about the course. He stated the new system "forced him to really study curriculum." He reported that the system didn't crash in class and that other than the use of a computer for lecture, there were no differences between this class and a paper-based class as far as facilities and subject matter. At times, the instructor found it difficult to respond to student questions because he could not find the answer in the Electronic IG promptly. The instructor felt confined to the computer. He was used to walking around the room when teaching from a paper-based IG. The instructor thought it took too much time each day to prepare for lecture. He had to log into the computer, access the program, and find his place in the IG. He also said he would like to see a different podium/workstation layout. The instructor stated he would like his personalization notes to be a preset size so he would not have to resize the window each time. The system designers felt the personalization text would not be very lengthy. A small window is first displayed for input of personalization text, but the present system design gives the instructor the capability to size the window.

Student: Twenty-two students responded to the survey. See Appendix C, Table C-3 for the survey results. The majority of students (17) had computer experience, but most had not used a computer in a classroom setting. Students had used computers for quite a few years; with close to half having 6-12 years experience and only five had no computer experience. Students were supportive of using new media in the classroom and thought that the instructor had few problems as he lectured from the electronic IG. They felt the system was reliable and thought use of the electronic IG did not adversely affect their learning.

To gain an overall opinion about the learning environment, the students were given various categories and asked to comment about what they liked "most" and "least" about the course.

When asked **"What do you like *MOST* about the course?"** with respect to these categories, students made the following comments.

Classroom Interaction: Six students felt there was a lot of classroom interaction/discussion and that they were acknowledged when they had questions. One student thought other students

asking questions helped him understand material. One student commented that he liked that personal experiences of students were allowed during discussions. Two students thought the course flowed smoothly.

Instructional Strategies: Four students said the course was "excellent," "successful," "moved very quickly," and with "good structure."

Equipment Used: Three students stated that the computer seemed to help instructor discuss the material.

Subject Matter/Curriculum: Five students commented that the course was "Very interesting to learn." One said the course was a good introduction to computer architecture.

Instructor: Nineteen students thought the instructor explained the material well, seemed quite confident, and well versed in the subject matter. They also thought he clarified and answered all of their questions completely. One student said the instructor was motivated and energetic.

Facilities: Twelve students commented that the facilities were excellent and comfortable.

When asked **"What do you like *LEAST* about the course?"** given the following categories, there were few comments.

Classroom Interaction: One student commented there needed to be more diagram tracing. To clarify, he meant the instructor "traces" by hand, with a pen, on a schematic drawing as he discusses a topic. This is commonly done on transparencies when displaying with an overhead projector. For instance, the instructor may trace the flow of electricity through a circuit. One student stated there was not enough interaction due to time constraints.

Instructional Strategies: Three students commented on this category. One said he would like more time to cover the material, one said there should be more student participation, and the other student stated there were "Not enough visual aids to add interest in times of dry material."

Equipment Used: Six students commented about equipment. Three thought student workstations would greatly improve classroom participation. During this instruction, only the instructor had a workstation. One commented that the transparencies were not very state-of-the-art, and he suggested the use of computer-based graphics.

Subject Matter/Curriculum: Seven students commented that the subject matter was "dry, very repetitive, not presented in a way that it can be discussed or practiced."

Instructor: No comments.

When asked **"Do you have suggestions for improving the use of this technology in the classroom?"** four students offered suggestions. Two students suggested providing computers to each student and adding lots of visuals. One student suggested better placement of the instructor's computer monitor. He thought the addition of a large screen monitor in the back of the room would allow the instructor more flexibility as he walked through the classroom lecturing. Another student suggested a ceiling mounted monitor so students could follow along as the instructor lectures.

Interviews: Only one instructor, teaching in the Electronic IG class, was interviewed during the field test of the Paperless Classroom system. The instructor was very confident with the material and enjoyed teaching, but had no experience lecturing from the computer, which during this study was his main source of information for the lecture. He felt hindered from walking around the classroom. He stated he preferred to walk down the aisle between the groups of tables. He felt he could have closer contact with the students and make sure they heard his lectures. He often carried the paper-based TG as he discussed the material. The instructor felt he had difficulties tracking the Electronic IG with the paper-based TG.

Test Scores: Test scores for the Electronic IG class ranged form 72-98%, with a class mean = 90.5. Quiz scores were not available.

Fully Automated Instruction

Observation

Learning Environment: There were no paper-based instructional materials used during the class or given to students for study purposes. Students used the computer for their reading and study. Training was conducted in a small rectangular room, located in the same building as the classes studied during Phase I. See Figure 3 for classroom layout. There were no windows. The room was separated from an adjacent classroom by an accordion folding door, mounted between the rooms. The room was well insulated with grey carpet and grey fabric covered walls and comfortably air conditioned. The fluorescent lighting was adequate and pleasant. A pull down film screen and one TV monitor (mounted in the upper right corner) were in the front of the classroom. A VCR and one closed-circuit camera were placed on the left side at the back of the room. One bookcase was at the front left of the room. The chairs were comfortable with padded cushion and chrome arms.

Student workstations consisted of an embedded and angled monitor, covered with a smoked colored glass shield that was flush with the table top (See Figures 4 and 5). This provided good visibility for students and instructor. The keyboard tray pulled out for keyboard adjustment. A mouse was connected to the side of the keyboard. The workstations were grouped in pairs on each side of the room with a center aisle between.

The instructor's workstation consisted of two computer monitors, with the IG displayed on one monitor and the TG displayed on the other. He accessed the IG and TG with the keyboard, a mouse or trackball. The instructor podium was at the front of the classroom with a white board mounted on the wall behind. The instructor placed the keyboard and mouse on the podium. His workstation was networked with student workstations. The instructor was given control to display the materials to the students as he lectured. Students did not have access to the IG. Graphics were displayed on the student workstation monitors. In traditional classes, the instructor illustrated topics with poor quality transparencies and schematic drawings. Students had difficulty seeing the detailed transparencies from a distance. Now, with the Paperless Classroom system, graphics were more readable on the computer monitors. The instructor directed the students to a problem sheet or allowed them to navigate the TG, by turning "tracking" on or off.

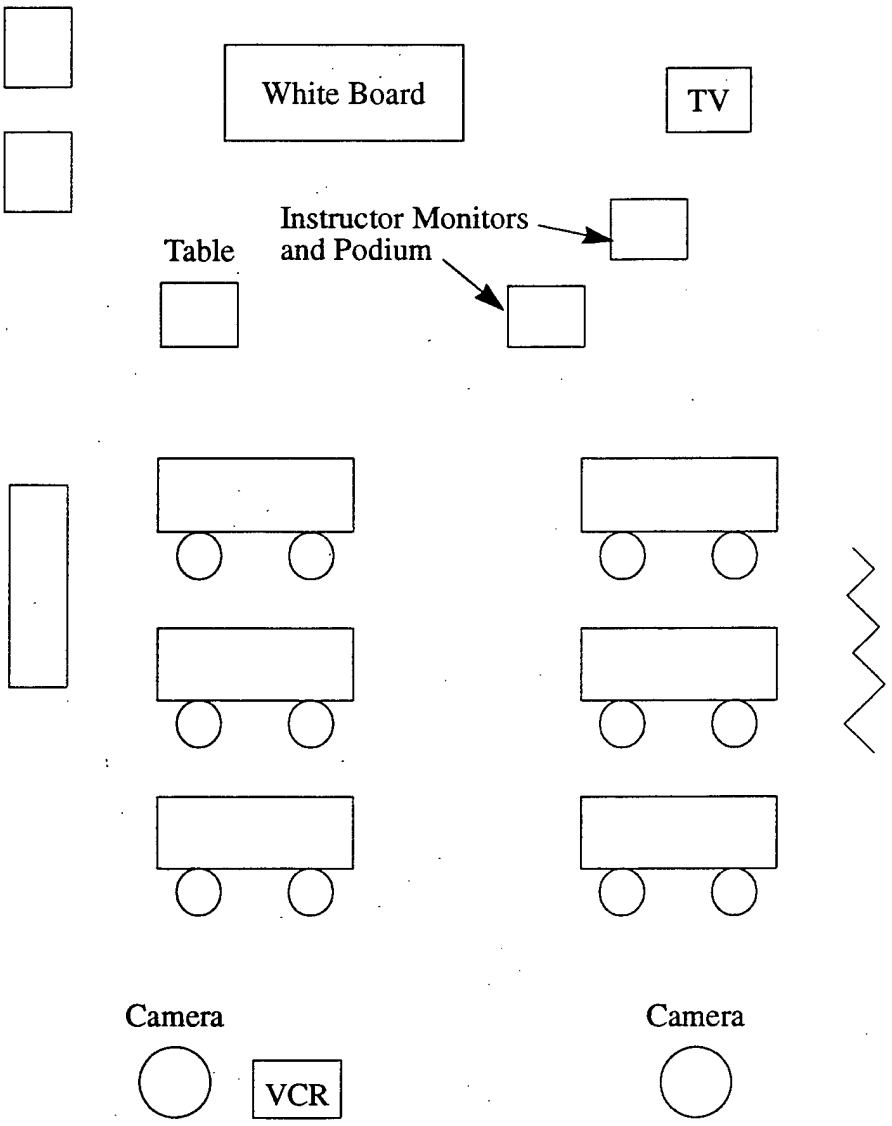

Figure 3. Phase II--Fully automated instruction classroom layout.

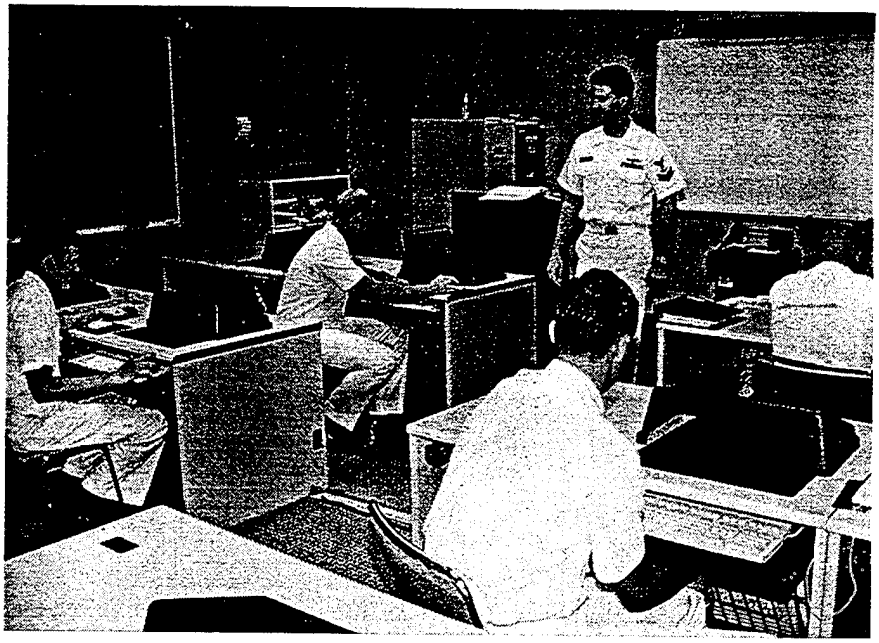

Figure 4. Phase II--Wide view of fully automated instruction student workstation design.

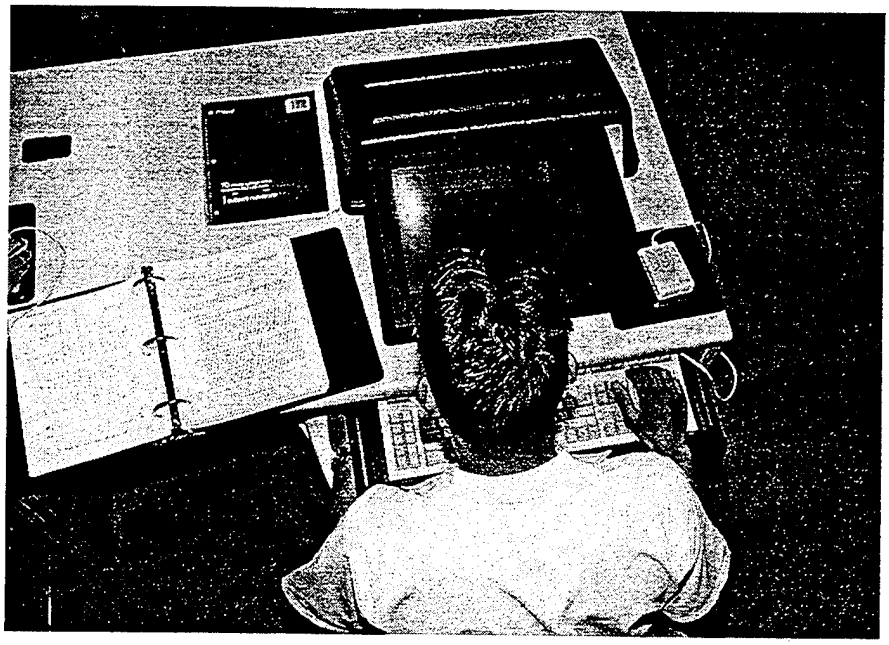

Figure 5. Phase II--Fully automated instruction student workstation design.

The instructor provided system training for the students during the course indoctrination. This was not Navy standardized instruction; it was an informal training session to familiarize students with the workstation and software. Students were excited about using the new system and rapidly learned how to scroll through the text, search for keywords, size and zoom graphics, size windows, use the TOC and on-line calculator. One student had no prior computer experience and quickly learned how to use the various features. The students liked the new workstations and the capability to view the graphics from their monitor.

A few problems with the graphics and text were noted. There were some typos, cases of inconsistent line thickness and length, different type fonts being used for text within a graphic, and some graphics needlessly large. Appendix E provides examples of the IG, TG, and graphics.

Classroom Interaction: The instructor was an enlisted member of the military. He was very experienced with this course and was most comfortable using the system. His enthusiasm for the course and use of the system was very apparent. The instructor interacted well with students and readily responded to their questions. Students felt at ease with each other and the instructor. Most of the students had just attended their first level of training at "A" school and did not have fleet experience. Several students knew each other from a previous course. They shared experiences and were enthused about their future careers.

Course Activities: The evaluator was present during the entire course. The course was conducted during normal duty hours the first week. During the second week, the course was conducted from noon into the evening. The first three days included indoctrination to the base and the training center, a topic about safety, and time to take care of personal business. Lecture began on the fourth day.

The same topics were covered as those taught in the Fundamentals course observed during Phase I of this study. The testing procedures were the same as those used during the earlier classes observed during Phase I.

Survey

Instructors were asked to respond to a system evaluation survey and a personalization survey. Survey results are presented below.

Instructor: To summarize results of the system evaluation survey (Appendix C, Table C-4), the instructor had previous use with computers but had not used them in a classroom setting. He had five years experience with computers and had been teaching for several years. The instructor supported the use of new media in the classroom and did not think the flow of information was adversely affected during his lecture. He also felt confident using the computer and agreed there were few problems with the hardware and software. While he supported the use of electronic aids for personalizing his lecture and for delivering classroom training, he did not think the course could be taught in less time. The instructor felt strongly that the use of this system will be useful for life cycle management of the course.

There was a section for additional comments at the end of the survey. The instructor suggested the capability to display graphics to a wall or large monitor be included with the system. He wanted

to see a better/easier way to make a "bookmark" in the on-line materials. A bookmark is a place holder noted by an icon displayed next to associated text on the computer screen. This is useful when wishing to return to a specific topic or location in the course at a later time. He suggested organizing the IG topics into separate electronic books so it would be easier to judge the time required to complete a topic during lecture. The instructor really enjoyed being able to interact better with the students. Being able to insert notes or personalization into the TGs for students was mentioned as something very useful for review and summary. He could quickly display graphics as he reviewed. The instructor thought the equipment worked fine, but suggested an additional monitor be placed at the back of the room. He liked to walk among the students as he lectured. He would then be able to glance at another monitor as he roamed the classroom.

What he liked least was that students tended to look down into the embedded monitor as he was lecturing. Because of that, he found it difficult to maintain eye contact with them. The problem could be solved by an overhead display. Another comment was that sometimes the system was a little slow to display a graphic. The instructor set a time for the student to read the material before class because they were not given printed materials to take away for study. It was his opinion that students got lazy about reading the material because they thought the computer (keyword search function) would find the answer for them on test day. Overall, he thought the Paperless Classroom system was a great product and said it "could be fantastic with overhead display."

Instructor (Personalization Survey): Seven instructors were surveyed about the time they spent personalizing the Fundamentals IG. These instructors were qualified to teach the Fundamentals course, but only two were teaching at the time of our study. Some of the questions were not answered by all seven instructors because they were not applicable. It was important, however, to gather information from all of them concerning the use of the Paperless Classroom system as a tool for entering personalization. The survey instrument is included in Appendix D. Instructors were asked to estimate the time spent personalizing an IG in two formats; paper-based and electronic. Within these two formats, instructors responded to questions about time spent personalizing and later updating the IG. Not all of the instructors had experience with personalizing or updating both the paper-based and electronic IG.

As reported by instructors, time spent to personalize the paper-based or the electronic Fundamentals IG varied greatly. Since the electronic IG was completed in May 1994, instructors had not been required to update their personalization. Therefore, there were no data to report about "updating" the Electronic IG.

We were also interested in what other computer systems the instructors had used prior to using the Paperless Classroom system. Four instructors had experience with IBM/PC computers, one instructor had experience with Commodores, and one had experience with Apple/Mac computers. Five instructors responded when asked to designate a category (beginner, novice, intermediate, accomplished, advanced) that best described their experience with the Paperless Classroom system. The experience levels were varied among the instructors: Beginner = 1; Novice = 1; Intermediate = 2; Accomplished = 1.

Student: Nine students responded to the system evaluation survey. Eight of the students had previous experience using computers and five had previously used a computer in a classroom setting. When asked how long they had used computers, the range was from 0-12 years. The survey

used during Phase I was changed to find out what computer systems students had used in the past. The majority of students had over a year of computer experience and seven of nine were familiar with IBM/PC computers and five reported experience with PC "Windows" environment. Responses made concerning system functionality were favorable (see Appendix C, Table C-5). Students were very supportive of using new media in the classroom and they thought the use of a computer made the course more interesting. They did not think that using computers in the class were detrimental to their learning or the flow of information. Four students were "undecided" about problems with the software and time lost during lecture as a result of system problems. When asked how they navigated through the TG, all students responded. Four students reported using the TOC, two used both the Search feature and TOC, and three used all available methods.

To gain an overall opinion about the learning environment, students were given various categories and asked **"What do you like *MOST* about the course?"** Their responses are summarized below.

Classroom Interaction: Comments from six students revealed they thought computers greatly improved classroom interaction and made the course more interesting for everyone. Students thought there was more class participation because of the system. They praised the instructor's genuine interest in the course material and his capability to teach from the system and readily respond to their questions.

Instructional Strategies: Six students commented about this category. Two students liked the tracking capability the instructor had so he could control where they were in the TG and also send graphics to their monitors. Another two students thought the use of windows for graphic display was helpful. Two students felt they could navigate through the text very quickly and thought the course material was easy to follow and understand.

Equipment Used: All seven students who commented about the classroom equipment considered the computers "great," very easy to use, quick for retrieval of information. They mentioned that the workstations were particularly nice because of the embedded monitor and no-clutter appearance with an unobstructed view of the classroom. Two students commented they liked the system capability for displaying multiple graphics and overlaying on an instruction sheet; this made it easier for comparisons of tables or figures and promoted better understanding of concepts.

Subject Matter/Curriculum: Three students commented they found it easier to find things using the system search feature when compared with "paper tabs" in printed course materials. They thought the course was well organized and flowed nicely.

Instructor: To quote a student, "He [instructor] enjoyed the computers as much as we did, so we didn't get a boring monotone instructor." Six students commented they thought the instructor was very informative, had a great sense of humor (even when problems occurred), kept the class at ease and assisted with all questions about equipment or material. Only one thought he needed more training.

Facilities: Five students stated that the facilities were "clean and very sharp looking, neat, small enough to have a personable environment, yet comfortable."

Students were asked **"What do you like *LEAST* about the course?"** with respect to the following categories. Their comments have been summarized below.

Classroom Interaction: Three students made comments about this category. One student commented he thought the class was held up by someone misusing the computer and getting sidetracked. While using the Paperless Classroom system, the instructor had control of what was displayed on student computers. One student commented that if a student was taking notes about something displayed, the instructor might choose to move to another section in the TG before the student had completed his note taking. This is a control issue that can be resolved by the instructor asking if students are finished reading or taking notes before moving on to another topic.

Instructional Strategies: Four students made comments about this category. One remarked that "Sometimes jumping around made it difficult to absorb material. We should be able to hold onto a window if reading it." One student thought that without overhead transparency use, it was a bit harder for him to follow along. He said, "Instructor did his best by drawing diagrams and following through that way, but took a little more time in doing so." Another student said, "A lot of text is skipped with no way to make it up unless you come in after hours." One stated, "Trying to break the habit of having a book to take home and review. No serious problems." One student suggested that more real life examples be added to the discussion.

Equipment Used: One student said he couldn't enter his notes on the computer. (At this time, there is no capability for entering text on the student's computer.) One student stated that, "Not being able to take diagrams out of text while in the search path makes it slower to search through the reading." This is related to graphics that are part of the TG. There is a delay in the program while the diagrams are drawn. One students felt there needed to be more room to maneuver with the mouse; the mouse cord got caught in keyboard holder when stored. One commented about heat flow problems; too much heat generated (from the computer) toward the user.

Subject Matter/Curriculum: One student remarked, "A lot of material, little time." Another one said, "The subject matter was way too in-depth for a 1-1/2 week course." Even though this does not seem to have direct relevance to an evaluation of the system in use, the fact that the subject matter is very in-depth may be of use for future course revisions. A major revision of the course would impact the contents and structure of the present "electronic book" presented by the Paperless Classroom system.

Instructor: One student commented, "just needs more training."

Facilities: No comments.

When asked **"Do you have suggestions for improving the use of this technology in the classroom?"** all nine students replied. One student commented he would like to see the system used more often, prefers it over books, and thought the advantages outweighed the disadvantages. One student felt strongly that an electronic overhead display should be added to the Paperless Classroom system. This would allow images displayed on the computer to be projected to a screen or white board in the front of the room, much as instructors have done with transparencies displayed with an overhead projector. This would be particularly useful when an instructor traces a schematic drawing by hand during a discussion. The overhead display would provide the

schematic to all students at once with an increase in visibility. Another student suggested that actual pictures from equipment onboard ship be included with the graphics. Six students commented about enhancements they would like to see: a personal on-screen note pad or highlighting markers for text, stationary mouse pad, a printer so notes could be taken home for study, color, and a bookmark function. Another stated he would like more time to learn about system features.

Interviews: One instructor, who was teaching the Fully Automated class during the field test of the Paperless Classroom system, was interviewed. The instructor was very confident with the material and enjoyed teaching from the electronic IG/TG. He liked the tracking capability the system provided. This allowed him to track where the students were in their TG, and as he lectured he could display associated graphics. The instructor quickly found it beneficial to display multiple graphics overlaid with a problem sheet. He stated learning was accomplished in much less time. There were a few minor software problems but no lengthy delays occurred.

Test scores: A review of the test scores for the Fully Automated class ($N = 9$) revealed a range of 80-100%, with a class mean = 91.67. Quiz scores were all reported to be 100%. The cumulative course mean = 92.50. This mean included quiz scores. Test scores of the Fully Automated class were compared to those in the Electronic IG class. The results of an analysis of variance (ANOVA) found no significant differences between the Fully Automated and Electronic IG classes, $F(1,29) = .1558$, $p > .05$. Table 4 presents the test scores for both classes.

Table 4

Phase II--Student Test Scores

	Class Average (%)		
Type of Instruction	Quiz	Exam	Cum. Course
Fully Automated ($N = 9$)	100	92	93
Electronic ($N = 22$)	81	90	89

Course critiques: Course critiques were not available during Phase II of this study.

Discussion and Conclusions

Current training methods are rapidly changing due to advances in technology. With the expanded availability of computers, communications networks, and peripheral equipment, electronic instruction will become more prevalent in classrooms everywhere. As we develop systems and evaluate the use of this technology in the classroom, we should use an holistic approach. By this, we mean that in addition to solving an identified training problem, consideration must be given to the needs of instructors and students, the ergonomic design of the electronic classroom, the social environment, overall impact on the educational and information processes, and impact on the organization (Bell & Elmquist, 1992; Bruce, 1989; Eisner & Carter, 1989; Roweton, Wess, & Motley, 1988).

We have identified a need for more efficiently delivering technical information in the classroom. Paperless Classroom addressed this problem by building an interface to this information and providing the instructor a tool to facilitate delivery of electronic training materials. One result that instructors had to adapt to a new delivery method in a short amount of time.

In a study on instructors using multimedia, Sammons (1994) found that faculty members were somewhat hesitant to integrate new technology into the instructional process. He suggested making equipment readily available so the instructors can become familiar with it and have a chance to develop their materials in a convenient location. A survey of college instructors revealed that they were reluctant to use multimedia in the classroom because of a lack of equipment, lack of time, and lack of knowledge. These same factors had an impact on use of the Paperless Classroom system. The instructors we interviewed were faced with time constraints, little experience with the system, and lack of technical support. In spite of these constraints, they supported our research and gave our system designers excellent feedback.

Results of the interviews, observations, and opinion surveys revealed that the prototype system was well received and was not detrimental to the learning environment. It was found that the students and instructors surveyed were very computer literate. Students in the Fully Automated class had no problems learning to use the system, search for key words, scale graphics, and size windows. Within a short amount of time, students were very comfortable with the new media in the classroom. Instructors were generally enthusiastic about using new media, but were a little reluctant to change from a paper-based to an automated course. With their already busy teaching schedules and other military duties, this new system required additional effort on their part to prepare their lessons and to lecture from the computer.

Instructors found the system to be beneficial as they prepared to lecture by personalizing the IG, but some were not convinced this was a time-saver. The variability in the time spent completing personalization could be attributed to the instructor's teaching experience, knowledge of the course, computer expertise, availability of computers, and whether the notes were original or borrowed from another instructor. Because of these factors, we can only conclude that instructors will become more comfortable with the system and learn ways to enhance their lectures, realizing the system's full potential. Electronic personalization will be saved between course revisions since the notes are linked to the discussion points by the software. There is no need to copy everything over again as with printed materials.

Test scores for two paper-based classes conducted during September 1993 were obtained to compare with the other two groups under study. Since the course was restructured in January 1994, test scores for two Fully Automated classes and seven Electronic IG classes have been compared. The course was not rewritten, just sequenced better with the text, IG, TG, all transparencies, tables, and figures in electronic form. A comparison of these test scores revealed that for those surveyed, students attending the Fully Automated course performed as well as those students attending either the Electronic IG or the paper-based courses. However, the number of students attending the Fully Automated Course was very low. We had expected the Fully Automated class to score higher on the final exam than the other two class formats. The fact that scores were only comparable might be attributed to the fact that students in the Fully Automated class did not have paper-based study materials for use after hours. Also, students were not provided with the capabilty to print any of

the training materials. The Paperless Classroom system was available for an hour before class each day, but few students came to study.

Even though this evaluation is limited -- it was tested on only one course, the Paperless Classroom system was successful. The system was a useful tool for instructors, was reliable, and was easy to use. There was no negative impact on learning. With the information we have now, we can say we did not make training worse by automating the curriculum.

As the use of electronic aids for classroom training increases, we expect more efficient use of resources. The use of notebook computers for after hour study, links to laboratory exercises and remote training sites, and structured training for instructors and students on the use of these resources will become prevalent. It is anticipated that personnel requirements, technical change management, and curricula distribution costs will be reduced. Electronic delivery will lead to reductions in publishing costs since substantial amounts of training materials will no longer have to be printed.

Recommendations

It is recommended that AEGIS Training Center automate additional courses; as more technical manuals become available in electronic form. Instructors and students should be given more on-site training on the use of Paperless Classroom system. Navy Instructor Training courses should include delivery of electronic curriculum. Consideration should be given to linking the Paperless Classroom system to laboratory systems.

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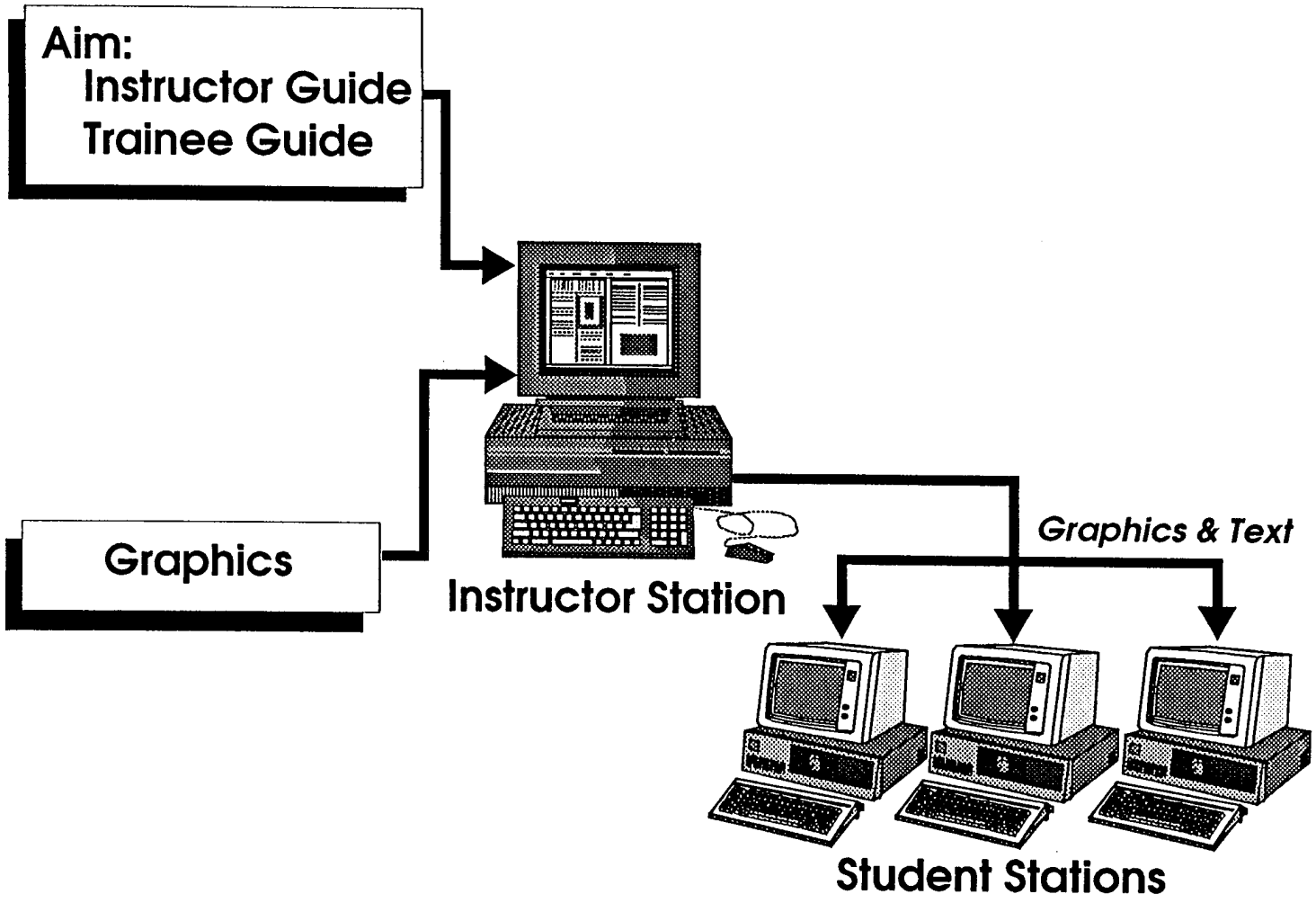
Appendix A

Phase II
Hardware Configuration

Hardware Configuration



Appendix B

Phase I
Survey Results
Electronic Instruction

Table B-1
Phase I Instructor Survey Results
Electronic Instruction

A. BACKGROUND INFORMATION

1. Rating: FC Rank: E-5
2. Previous computer use? Yes
3. Previous use of computer in a classroom? no response
4. How long have you used computers? 4 yrs
5. Years of teaching experience? 3 yrs

B. FUNCTIONALITY EVALUATION

Responses made by instructor based on the following scale.

SA	A	U	D	SD
strongly agree	agree	undecided	disagree	strongly disagree

	SA	A	U	D	SD
1. Use of the computer did not adversely affect the flow of information in the course.		X			
2. Use of the computer made the course more interesting.			X		
3. I like to see new media used in the classroom.	X				
4. I felt confident when using the computer.	X				
5. There were few problems with the hardware.	X				
6. There were few problems with the software.			X		
7. Little class time was lost because of program failures.	X				
8. The computer should be used in other classrooms to enhance training.	X				
9. Use of the computer enhanced student learning.			X		
10. I could personalize the Instructor Guide (IG)	X				
10. I could personalize the Instructor Guide (IG) with ease.	X				
11. Development time to prepare the IG can be reduced by using this system.	X				
12. Training on using the computer was adequate.	X				
13. Training on using the software was adequate.		X			
14. I will be able to cover the course material in less time by using this system.		X			
15. The use of this system will be useful for the life cycle management of the course.	X				
16. Use of this system reduced the amount of time needed for personalizing training materials.			X		
17. I prefer the use of an electronic IG when compared to a paper IG.			X		
18. The User Manual was adequate.	X				

Table B-2
Phase I Student Survey Results
Electronic Instruction (N=19)

A. BACKGROUND INFORMATION

1. Previous computer use? Yes=13 No=6
2. Previous use of computer in a classroom? Yes=3 No=16
3. How long have you used computers? (yrs)
   0 = 7
   1-4 = 8
   6-12 = 4

B. FUNCTIONALITY EVALUATION

Number of student responses based on the following scale.

SA	A	U	D	SD
strongly agree	agree	undecided	disagree	strongly disagree

	SA	A	U*	D	SD
1. Use of the computer did not adversely affect the flow of information in the course.		15	2	2	
2. Use of the computer made the course more interesting.	2	5	9	2	
3. I like to see new media used in the classroom.	9	8	1		
4. The instructor seemed confident when using the computer.	5	10	4		
5. There were few problems with the hardware.	3	7	6	1	
6. There were few problems with the software.	2	8	8		
7. Little class time was lost because of program failures.	4	11	3		
8. The computer should be used in other classrooms to enhance training.	5	9	4		
9. Teaching from the electronic IG did not adversely affect my learning the course material.	4	12	2	1	

*Some felt "undecided" because they could not view the Electronic Instructor Guide.

Appendix C

Phase II
Classes Conducted and Survey Results

Table C-1

Phase II
AEGIS Fundamentals Classes Conducted
August 1993-July 1994

Class No.	Conv-Grad Dates	Type Instruction	Students	Final Exam Average
93170	23 Aug-7 Sep 93	Paper-based	10	91%
93180	7 Sep-21 Sep 93	Paper-based	17	90%
94065	18 Jan 94-1 Feb 94	Electronic IG	23	94%
94090	22 Feb 94-8 Mar 94	Electronic IG	12	94%
94100	22 Feb 94-8 Mar 94	Electronic IG	20	94%
94130	19 Mar 94-2 Apr 94	Electronic IG	20	93%
94150	11 Apr 94-22 Apr 94	Electronic IG	22	93%
94180	23 May 94-3 Jun 94	Electronic IG	22	91%
94190	31 May 94-14 Jun 94	Fully Automated	9	92%
94200	13 Jun 94-24 Jul 94	Fully Automated	10	82%
94210	27 Jun 94-12 Jul 94	Electronic IG	24	88%

Table C-3
Phase II Student Survey Results
Electronic IG (N=22)

A. BACKGROUND INFORMATION

1. Previous computer use? Yes=17 No=5
2. Previous use of computer in a classroom? Yes=8 No=14
3. How long have you used computers? (yrs)

0 = 5
1-4 = 7
6-12 = 10

B. FUNCTIONALITY EVALUATION

Number of student responses based on the following scale.

SA	A	U	D	SD
strongly agree	agree	undecided	disagree	strongly disagree

	SA	A	U*	D	SD
1. Use of the computer did not adversely affect the flow of information in the course.	5	12	3	2	
2. Use of the computer made the course more interesting.	3	8	9	1	
3. I like to see new media used in the classroom.	10	11			
4. The instructor seemed confident when using the computer.	7	13	1		
5. There were few problems with the hardware.	7	11	3		
6. There were few problems with the software.	8	10	3		
7. Little class time was lost because of program failures.	12	7	1	1	
8. The computer should be used in other classrooms to enhance training.	8	10	3		
9. Teaching from the electronic IG did not adversely affect my learning the course material.	6	13	3		

*Some felt "undecided" because they could not view the Electronic Instructor Guide.

Table C-4
Phase II, Instructor Survey Results
Fully Automated (N=1)

A. BACKGROUND INFORMATION

1. Rating: FCC Rank: E-7
2. Previous computer use? Yes
3. Previous use of computer in a classroom? No
4. How long have you used computers? 5 yrs
5. Years of teaching experience? 2-5 yrs
6. What computer systems have you used? PC, Windows

B. FUNCTIONALITY EVALUATION

Responses made by instructor based on the following scale.

SA	A	U	D	SD
strongly agree	agree	undecided	disagree	strongly disagree

	SA	A	U	D	SD
1. Use of the computer did not adversely affect the flow of information in the course.		X			
2. Use of the computer made the course more interesting.	X				
3. I like to see new media used in the classroom.	X				
4. I felt confident when using the computer.		X			
5. There were few problems with the hardware.		X			
6. There were few problems with the software.		X			
7. Little class time was lost because of program failures.		X			
8. The computer should be used in other classrooms to enhance training.	X				
9. Use of the computer enhanced student learning.		X			
10. I could personalize the Instructor Guide (IG) with ease.		X			
11. Development time to prepare the IG can be reduced by using this system.				X	
12. Training on using the computer was adequate.	X				
13. Training on using the software was adequate.	X				
14. I will be able to cover the course material in less time by using this system.				X	
15. The use of this system will be useful for the life cycle management of the course.	X				
16. Use of this system reduced the amount of time needed for personalizing training materials.		X			
17. I prefer the use of an electronic IG when compared to a paper IG.		X			
18. The User Manual was adequate.			X		

Table C-5
Phase II Student Survey Results
Fully Automated (N=9)

A. BACKGROUND INFORMATION

1. Previous computer use? Yes=8 No=1
2. Previous use of computer in a classroom? Yes=5 No=4
3. How long have you used computers? (yrs)
   0 = 2
   1-4 = 3
   6-12 = 4

What systems have you used? PC = 7 Apple/Mac = 4 Commodore = 1 Windows = 5 Vax Unix = 1

B. FUNCTIONALITY EVALUATION

Number of student responses based on the following scale.

SA	A	U	D	SD
strongly agree	agree	undecided	disagree	strongly disagree

	SA	A	U	D	SD
1. Use of the computer did not adversely affect the flow of information in the course.	4	4	1		
2. Use of the computer made the course more interesting.	7	2			
3. I like to see new media used in the classroom.	8	1			
4. The instructor seemed confident when using the computer.	3	5	1		
5. There were few problems with the hardware.	1	6	2		
6. There were few problems with the software.		4	4	1	
7. Little class time was lost because of program failures.		2	4	3	
8. The computer should be used in other classrooms to enhance training.	3	6			
9. Teaching from the electronic IG did not adversely affect my learning the course material.	1	6	2		

Appendix D

Survey Instruments

PAPERLESS CLASSROOM SURVEY
(Instructor)

A. BACKGROUND INFORMATION

1. Rating/Rank: _____

2. Previous computer use? Yes____ No____

3. Previous use of computers in a classroom? Yes____ No____

4. How long have you used computers? _____

5. Years of teaching experience? _____

6. What computer systems have you used? MAC___ Apple___ PC___ Vax/Unix___ Windows___ Other___

B. FUNCTIONALITY EVALUATION

Circle the response that best describes how you feel about each statement.

SA	A	U	D	SD
strongly agree	agree	undecided	disagree	strongly disagree

1. Use of the computer did not adversely affect the flow of information.	SA	A	U	D	SD
2. Use of the computer made the course more interesting.	SA	A	U	D	SD
3. I like to see new media used in the classroom.	SA	A	U	D	SD
4. I felt confident when using the computer.	SA	A	U	D	SD
5. There were few problems with the hardware.	SA	A	U	D	SD
6. There were few problems with the software.	SA	A	U	D	SD
7. Little class time was lost because of program failures.	SA	A	U	D	SD
8. The computer should be used in other courses to enhance training.	SA	A	U	D	SD
9. Use of the computer enhanced student learning.	SA	A	U	D	SD

Version 2 (May 94)

10. I could personalize the Instructor Guide (IG) with ease.	SA	A	U	D	SD
11. Development time to prepare the IG can be reduced by using this system.	SA	A	U	D	SD
12. Training on using the computer was adequate.	SA	A	U	D	SD
13. Training on using the software was adequate.	SA	A	U	D	SD
14. I will be able to cover the course material in less time by using this system.	SA	A	U	D	SD
15. The use of this system will be useful for the life cycle management of the course.	SA	A	U	D	SD
16. Use of this system reduced the amount of time needed for personalizing training materials.	SA	A	U	D	SD
17. I prefer the use of an electronic IG when compared to a paper IG.	SA	A	U	D	SD
18. The User Manual was adequate.	SA	A	U	D	SD

19. Do you have suggestions for improving the use of this technology in the classroom?

_____

_____

_____

_____

In reference to the topics below, what do you like **MOST** about the course and why?

20. Classroom Interaction

_____

_____

_____

_____

21. Instructional Strategies

22. Equipment Used

23. Subject Matter/Curriculum

24. Instructor

25. Facilities

In reference to the topics below, what do you like **LEAST** about the course and why?

26. Classroom Interaction

27. Instructional Strategies

28. Equipment Used

29. Subject Matter/Curriculum

30. Instructor

31. Facilities

32. Other comments:

PAPERLESS CLASSROOM SURVEY
(Student)

A. BACKGROUND INFORMATION

1. Rating/Rank:_____

2. Previous computer use? Yes____ No____

3. Previous use of computers in a classroom? Yes____ No____

4. How long have you used computers? _____

5. What systems have you used? MAC___ PC___ Apple___ Vax/Unix___ Windows___ Other___

B. FUNCTIONALITY EVALUATION

Circle the response that best describes how you feel about each statement.

SA	A	U	D	SD
strongly agree	agree	undecided	disagree	strongly disagree

1. Use of the computer did not adversely affect the flow of information in the course.	SA	A	U	D	SD
2. Use of the computer made the course more interesting.	SA	A	U	D	SD
3. I like to see new media used in the classroom.	SA	A	U	D	SD
4. The instructor seemed confident when using the computer.	SA	A	U	D	SD
5. There were few problems with the hardware.	SA	A	U	D	SD
6. There were few problems with the software.	SA	A	U	D	SD
7. Little class time was lost because of program failures.	SA	A	U	D	SD
8. The computer should be used in other classrooms to enhance training.	SA	A	U	D	SD
9. Teaching from the electronic IG did not adversely affect my learning the course material.	SA	A	U	D	SD

Version 2 (May 94)

10. Do you have suggestions for improving the use of this technology in the classroom?

In reference to the topics below, what do you like **MOST** about the course and why?

11. Classroom Interaction

12. Instructional Strategies

13. Equipment Used

14. Subject Matter/Curriculum

15. Instructor

16. Facilities

In reference to the topics below, what do you like **LEAST** about the course and why?

17. Classroom Interaction

18. Instructional Strategies

19. Equipment Used

20. Subject Matter/Curriculum

21. Instructor

22. Facilities

23. Other comments:

Questionnaire on Time to Personalize Instructor Guide (IG)

Todays Date:_____ Command/School:_____

Name/Rank:_____

Course Name/CIN:_____

INSTRUCTIONS

(1) **Only answer as many of the sections below as apply to you for *THIS* course.** Fully complete the questions *within the sections that are applicable to you* (i.e., Personalizing a Paper-based IG in Part 1; Personalizing an Electronic IG in Part 2; or both Parts 1 and 2 if you did both of these).

(2) **If You Updated an IG More Than Once:** If you received changes to an IG that caused you to update your previous personalization and you did this **more than once,** please use another one of these forms or xerox that section and write a note on it to indicate that it was the 2nd, 3rd, etc. time you did this work.

(3) **Accurately Estimating the Number of Hours:** To arrive at an accurate estimate of your work on an IG, please take a moment to consider such things as how many hours you work a day, what portion of the day you worked on an IG, and then how many days you worked on the IG. Then total the number of hours.

(4) **Accurately Estimating the Percentage of a Document that Changed:** To arrive at an accurate estimate, think of the number of lines or pages that were changed in a document and then divide that by the total number of lines or pages in the document.

(5) **Comments:** Please add any relevant additional information or explanations of your answers on the form, e.g., descriptions of the kind of changes found in an updated IG.

Part 1 : Personalizing a Paper-based IG

A. Paper-based IG: Initial First-Time Personalization

Complete this section for the circumstance where you initially personalized a Paper-based IG (e.g., when you first taught the course using paper materials).

1. Approximate Date when work was performed:_____
2. Number of pages in Paper-based IG: _____
3. Number of hours required to enter your personalization notes into the *Paper IG*: _____
4. Hours to add subsequent minor changes after original personalization:_____
5. 5a. ☐-Yes ☐-No : Was the information you entered in the *Paper IG* developed by you from scratch?

   5b. ☐-Yes ☐-No : Did you use a previous instructor's notes as an aid to develop you own personalization notes in the *Paper-based IG* ?

   5c. Percentage of total time devoted to developing your own personalization notes:_____%.

   5d. Percentage of total time devoted to using someone elses IG notes:_____%.

B. Paper to Paper IG Update:

Complete this section for the circumstance where a new version of a Paper-based IG was received and you had to convert or transcribe your personalization from the old version of the IG to the new version.

1. Approximate Date when work was performed:_____
2. Number of pages in Paper-based IG: _____
3. Number of hours required to transcribe your personalization notes from a previous *paper-based* IG into a new *paper-based* version of a IG: _____
4. Estimate the percentage of the total document which was changed between the previous and new version of the IG: _____% (i.e., what percentage of *the document* changed irrespective of how much personalization the change provoked)
5. Hours to add subsequent minor changes (after original update):_____

C. Paper IG Users: Background Information

1. What is the average Prep-time you spend before each lecture (i.e., preparing, rehearsing, or reviewing the IG or TG)? _____hours
2. When you personalized your IG, what percentage of that time was involved with consulting the Trainee Guide (TG): _____% (put NA if there is no TG for course)

Part 2 : Personalizing an Electronic IG

A. Electronic IG: Initial First-Time Personalization

Complete this section for the circumstance where you initially entered your personalization in the Electronic IG for the first time.

1. Approximate Date when work was performed:_____
2. Number of pages in IG in its paper form: _____
3. Number of hours required to enter your personalization notes into the electronic IG: _____
4. Hours to add subsequent minor changes after original personalization:_____
5. 5a. ☐-Yes ☐-No : Was the information you entered in the Electronic IG developed by you from scratch?

   5b. ☐-Yes ☐-No : Did you use a previous instructor's *Paper-based IG* personalization notes as an aid in developing your Electronic IG personalization?

   5c. ☐-Yes ☐-No : Did you use, consult, or copy a previous instructor's *Electronic IG* personalization in developing your Electronic IG personalization?

   5d. Percentage of total time devoted to developing your own personalization notes:_____%.

   5e. Percentage of total time devoted to using someone elses IG notes:_____%.
6. At the time you performed this work, what was your level of experience with the system:

   ☐-Beginner ☐-Novice ☐-Intermediate ☐-Accomplished ☐-Advanced

B. Electronic to Electronic IG Update:

Complete this section for the circumstance where a new updated version of the IG was received and you had to repersonalize the IG because it had changed.

1. Approximate Date when work was performed:_____
2. Number of pages in IG in its paper form: _____
3. Number of hours required to change your electronic IG personalization in order to update it to accommodate the new electronic version of the IG: _____
4. Estimate the percentage of the total document which was changed between the previous and new version of the IG: _____% (i.e., what percentage of *the document* changed irrespective of how much personalization the change provoked)
5. Hours to add subsequent minor changes (after original update):_____
6. At the time you performed this work, what was your level of experience with the system:

   ☐-Beginner ☐-Novice ☐-Intermediate ☐-Accomplished ☐-Advanced

C. Electronic IG Users: Background Information

Complete this general background information if you used the Electronic IG.

Amount of experience with the *Electronic IG* system:

1. How long have you used the Electronic IG system? _____days _____months
2. How frequently do you use this system?

   ☐-daily ☐-a few times a week ☐-once a week ☐-a few times a month ☐-monthly or less
3. How long did it take you to learn to use the system? _____days _____months
4. What is your current level of experience with the system:

   ☐-Beginner ☐-Novice ☐-Intermediate ☐-Accomplished ☐-Advanced
5. How long did it take you to reach that level of experience ? _____days _____months

Computer and typing experience:

1. What is your level of keyboarding-typing skill?

   ☐-Hunt-and-Peck ☐-Novice ☐-Intermediate ☐-Advanced
2. How many *words-per-minute* do you type: _____
3. How long have you used computers prior to using this system? _____months _____years
4. What other computer systems have you used in addition to this system?

   ☐-Apple/Mac ☐-UNIX ☐-IBM/PC ☐-Other ☐-None

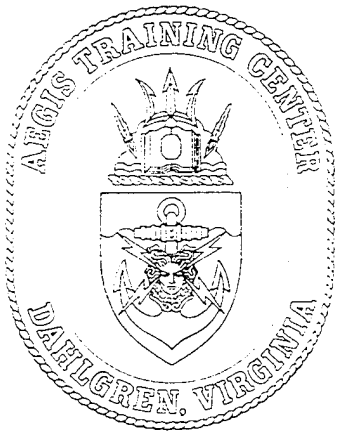
Prep-Time & TG Use:

1. What is the average Prep-time you spend before each lecture (i.e., preparing, rehearsing, or reviewing the IG or TG)?
   _____hours
2. When you personalized your IG, what percentage of that time was involved with consulting the Trainee Guide (TG): _____% (put NA if there is no TG for course)

STUDENT CRITIQUE SHEET
COURSE - INSTRUCTOR

IMPORTANT

- USE NO. 2 PENCIL ONLY
- EXAMPLE: ○A ○B ● ○D ○E
- ERASE ***COMPLETELY*** TO CHANGE



CDP CODE		○0 ○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9
		○0 ○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9
		○0 ○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9
		○A ○B ○C ○D ○E ○F ○G ○H ○J ○K
		○L ○M ○N ○P ○Q ○R ○S ○T ○U ○V
		○W ○X ○Y ○Z

CLASS NO.		○8 ○9
		○0 ○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9
		○0 ○1 ○2 ○3 ○4 ○5 ○6
		○0 ○1 ○2 ○3 ○4 ○5 ○6

UNIT		○0 ○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9

Comments from the below categories will be used to improve course effectiveness. Using the rating scale provided, blacken the box that best expresses your critique of the unit of instruction just completed. Specific comments are requested for items marked "O" or "U".

NAME _____ RATE/RANK _____

INSTRUCTOR(S) _____

_____ _____

RATING SCALE

O = Outstanding
G = Good
M = Marginal
U = Unsatisfactory
N = Not applicable

ENVIRONMENT					
1. Classroom space	○O	○G	○M	○U	○N
2. Classroom lighting and ventilation	○O	○G	○M	○U	○N
3. Desk/table and chair	○O	○G	○M	○U	○N
TRAINING MATERIAL					
4. Quality of publications/manuals/prints/charts	○O	○G	○M	○U	○N
5. Quality of transparencies/slides/films/video tapes	○O	○G	○M	○U	○N
6. Quality of instruction sheets (job/info/problem/etc)	○O	○G	○M	○U	○N
EQUIPMENT					
7. Condition of training aid equipment	○O	○G	○M	○U	○N
8. Condition of laboratory equipment/special tools	○O	○G	○M	○U	○N
INSTRUCTION					
9. Stress placed on usage of publications	○O	○G	○M	○U	○N
10. Stress placed on safety precautions	○O	○G	○M	○U	○N
11. Adequacy of break time	○O	○G	○M	○U	○N
12. Logical arrangement of subject matter	○O	○G	○M	○U	○N
13. Time allotted for classroom instruction	○O	○G	○M	○U	○N
14. Time allotted for laboratory instruction	○O	○G	○M	○U	○N
15. Availability of individual assistance/extra study	○O	○G	○M	○U	○N
16. Adequacy of assistance provided	○O	○G	○M	○U	○N

INSTRUCTOR					
17. Explanation and reinforcement of learning objectives	O	G	M	U	N
18. Presentation of and enthusiasm for subject matter	O	G	M	U	N
19. Poise/confidence and smoothness of delivery	O	G	M	U	N
20. Knowledge of and ability to explain the subject matter	O	G	M	U	N
21. Use of proper terminology	O	G	M	U	N
22. Ability to maintain student interest	O	G	M	U	N
23. Ability to maintain class control	O	G	M	U	N
24. Ability to ask and answer questions	O	G	M	U	N
25. Ability to stimulate class discussions	O	G	M	U	N
26. Concern for student progress	O	G	M	U	N
27. Assistance and supervision in the laboratory	O	G	M	U	N
28. Use of available class time	O	G	M	U	N
29. Preparedness	O	G	M	U	N
30. Overall quality of instructor	O	G	M	U	N

TESTING					
31. Explanation of grading policy	O	G	M	U	N
32. Fairness of grading policy	O	G	M	U	N

WRITTEN TEST					
33. Adequacy of time allotted	O	G	M	U	N
34. Accuracy in measuring presentation	O	G	M	U	N
35. Clarity of test items	O	G	M	U	N
36. Clarity of test directions	O	G	M	U	N
37. Test review (critique/debrief)	O	G	M	U	N

PERFORMANCE TEST					
38. Adequacy of time allotted	O	G	M	U	N
39. Clarity of test directions	O	G	M	U	N
40. Test review (critique/debrief)	O	G	M	U	N

NO. SPECIFIC COMMENTS

STUDENT CRITIQUE SHEET
COMMAND

IMPORTANT

USE NO. 2 PENCIL ONLY

- EXAMPLE: ○A ○B ● ○D ○E
- ERASE ***COMPLETELY*** TO CHANGE

CDP CODE		○0 ○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9
		○0 ○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9
		○0 ○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9
		○A ○B ○C ○D ○E ○F ○G ○H ○J ○K
		○L ○M ○N ○P ○Q ○R ○S ○T ○U ○V
		○W ○X ○Y ○Z

CLASS NO.		○8 ○9
		○0 ○1 ○2 ○3 ○4 ○5 ○6 ○7 ○8 ○9
		○0 ○1 ○2 ○3 ○4 ○5 ○6
		○0 ○1 ○2 ○3 ○4 ○5 ○6

Complete this command critique prior to graduation or as the need arises. Using the rating scale provided, blacken the box that best expresses your critique of the command. Specific comments are requested for items marked "O" or "U".

NAME _____ RATE/RANK _____

RATING SCALE

O = Outstanding
G = Good
M = Marginal
U = Unsatisfactory
N = Not applicable

GENERAL					
1. Ease of transportation to ATC	○O	○G	○M	○U	○N
2. Check-in procedures	○O	○G	○M	○U	○N
3. Command indoctrination	○O	○G	○M	○U	○N
4. Drug and Alcohol Abuse Program	○O	○G	○M	○U	○N
5. Special request chit processing	○O	○G	○M	○U	○N
6. Duty section organization	○O	○G	○M	○U	○N
7. Duty section training	○O	○G	○M	○U	○N

SERVICES PROVIDED					
8. PSD	○O	○G	○M	○U	○N
9. Disbursing	○O	○G	○M	○U	○N
10. Command Career Counselor	○O	○G	○M	○U	○N
11. Mail Room	○O	○G	○M	○U	○N
12. Special Services	○O	○G	○M	○U	○N
13. Exchange	○O	○G	○M	○U	○N

BEQ/BOQ					
14. Room size, privacy, etc.	○O	○G	○M	○U	○N
15. Ability to study	○O	○G	○M	○U	○N
16. Condition of heads/showers	○O	○G	○M	○U	○N
17. Condition of laundry room	○O	○G	○M	○U	○N
18. Condition of common areas	○O	○G	○M	○U	○N
19. Availability of cleaning gear	○O	○G	○M	○U	○N

MESSING FACILITY					
20. Operating hours	○O	○G	○M	○U	○N
21. Condition and cleanliness	○O	○G	○M	○U	○N
22. Quantity and quality of food	○O	○G	○M	○U	○N

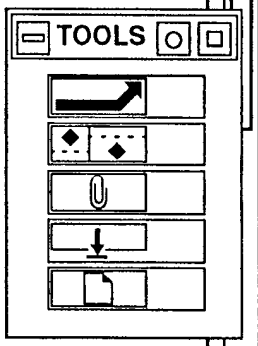
Appendix E

Phase II
Sample Instructor Guide, Trainee Guide, and Graphics

File Edit View Search Annotations

- S-150-0240 AEGIS Fundamental
  - + Front Matter
  - + A002 Basic Electricity
  - + T0007 Digital Systems
  - + T0010 AEGIS Combat System
  - + Back Matter

DISCUSSION POINT	RELATED INSTRUCTION ACTIVITY
2. Digital Circuit Components	
a. Gate Functions	a. Refer to Information T0007-1-1-2, paragraph 1.0.
(1) Inverter	
This is an example of inline	
(2) AND	(2) Refer trainee to Information Sheet T0007-1-1-2, figure 1-2.



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INFORMATION SHEET T0007-1-4-1

RANDOM ACCESS MEMORY (RAM)

A. INTRODUCTION

The purpose of this information sheet is to provide you with required information on random access memory.

B. REFERENCES

1. Mano, M. Morris, Computer System Architecture

C. INFORMATION

1.0 RANDOM-ACCESS MEMORIES (RAM)

1.0.1 A memory unit is a collection of storage registers, together with the associated circuits needed to transfer information in and out of the registers. Memory registers can be accessed for information transfer as required and hence the name random-access memory, abbreviated RAM.

1.0.2 A memory unit stores binary information in groups of bits called words. Each word is stored in one memory register. A word in memory is an entity of n bits that move in and out of the memory unit. A word of eight bits is sometimes called a byte.

1.0.3 A memory word is a group of 0's and 1's and may represent a number, an instruction code, alphanumeric characters, or any other binary-coded information.

1.0.4 The communication between a memory unit and its environment is achieved through control lines, address selection lines, and data input and output lines. The control signals specify the direction of transfer required. That is, whether a word is to be stored in a memory register or whether a word previously stored is to be transferred out of a memory register. The address lines specify the particular word chosen out of hundreds or thousands available. The input lines provide the information to be stored in memory and the output lines supply the information coming out of memory. A block diagram of a memory unit is shown in Figure 1-1.

Figure 1-1 Block diagram of a memory unit.

1.0.5 A memory unit is specified by the number of words it contains and the number of bits in each word. The address selection lines select one particular memory word out of the m words available.

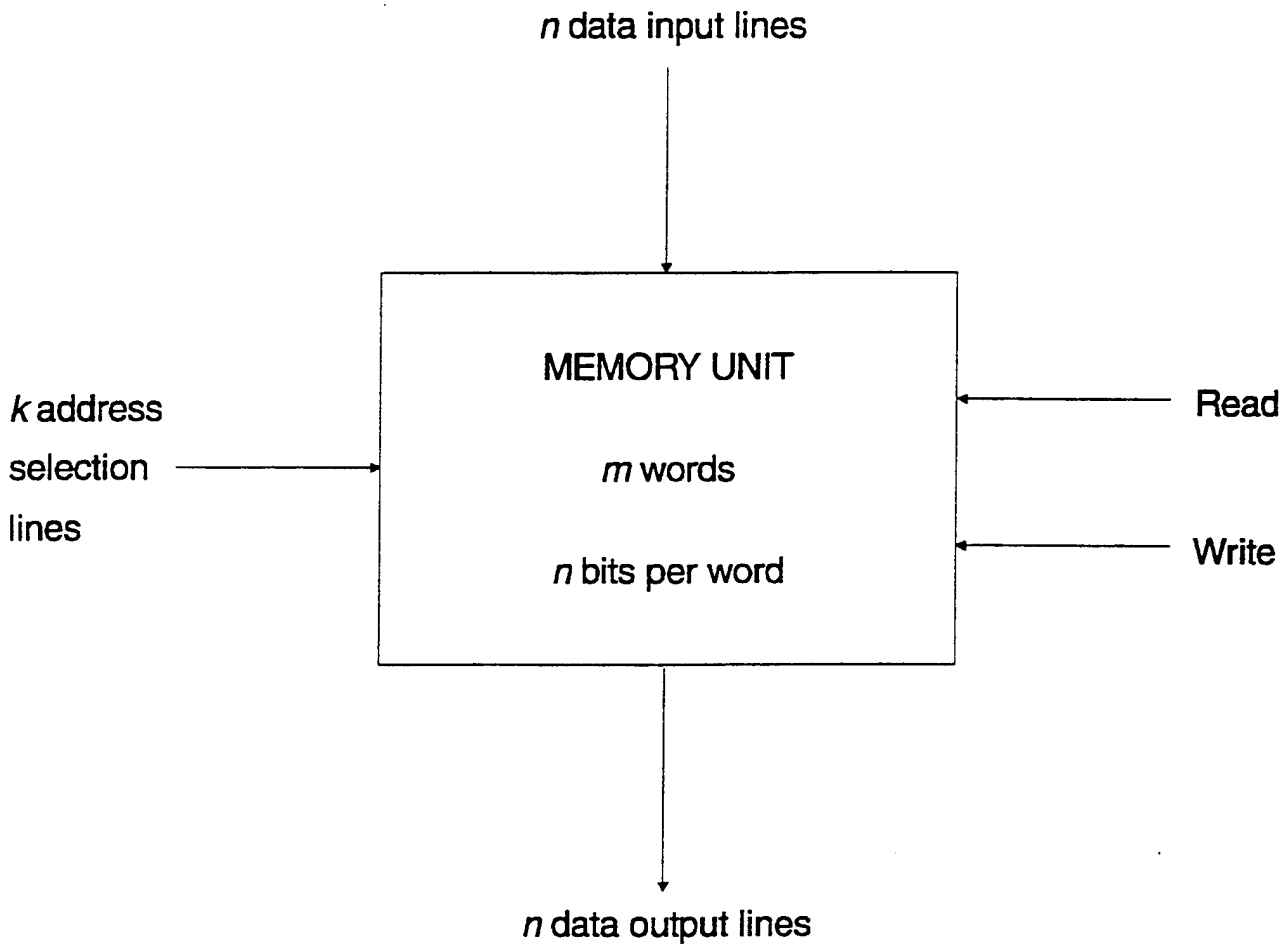

Figure 1-1 Block diagram of a memory unit.

Each word in a memory is assigned an identification number, called an address, starting from 0 and continuing with 1, 2, 3, and up to m-1. The selection of a specific word inside the memory is done by inserting its binary address value into the selection lines. A decoder inside the memory unit accepts this address and opens the paths needed to select the word specified. Thus, k address bits can select any one of 2k = m words. Computer memories may range from 1024 words, requiring an address of 10 bits, to 1,048,576 = 2^{20} words, requiring 20 address bits. It is customary to refer to the number of words in a memory unit with the unit K. K refers to 1024 = 2^{10} words: thus 1K = 1024 words, 4K = 4096 words, and 64K = 2^{16} words.

1.0.6 The two control signals are called "read" and "write". A write signal specifies a transfer in operation; a read signal specifies a transfer-out operation. On accepting one of the control signals, the internal control circuits inside the memory unit provide the desired function. When the memory unit receives a write control signal, the internal control transfers the n data input bits into the word specified by the address lines. With a read control signal, the word selected by the address lines appears in the n data output lines.

2.0 IC RAM

2.0.1 Integrated circuit memories sometimes have a single line for the read/write control. One binary state, say 1, specifies a read operation and the other binary state specifies a write operation. In addition, one or more enable lines may be included in each IC package to provide means for expanding several packages into a memory unit with a larger number of words.

2.0.2 The internal construction of a random-access memory of m words with n bits per word consists of m x n binary storage cells and the associated logic needed to select a word for writing or reading. The binary storage cell is the basic building block of a memory unit. The logic diagram of a binary cell that stores one bit of information is shown in Figure 2-1. Although the cell is shown to include five gates and a flip-flop, internally it is constructed with a two-transistor flip-flop having multiple inputs. The binary cell of a memory unit must be very small in order to be able to pack as many cells as possible in the semiconductor area available in the chip. The binary cell is shown to have three input lines and one output line. The purpose of the select input is to select one cell out of the many available. With the select line at 1, a 1 in the read/write terminal forms a path from the output of the flip-flop to the output terminal. With the read write terminal at 0, the bit in the input line is transferred into the flip-flop. Both the input and output are disabled when the select line is 0. Note that the flip-flop operates without a clock pulse and that its purpose is to store the information bit in the binary cell.

Figure 2-1 Memory cell.

2.0.3 The configuration of a 4 by 3 RAM is shown in Figure 2-2. It consists of four words of three bits each for a total of 12 binary storage cells. Each small box labeled BC in the diagram includes within it the circuit of a binary cell. The four lines included with each BC box designate the three

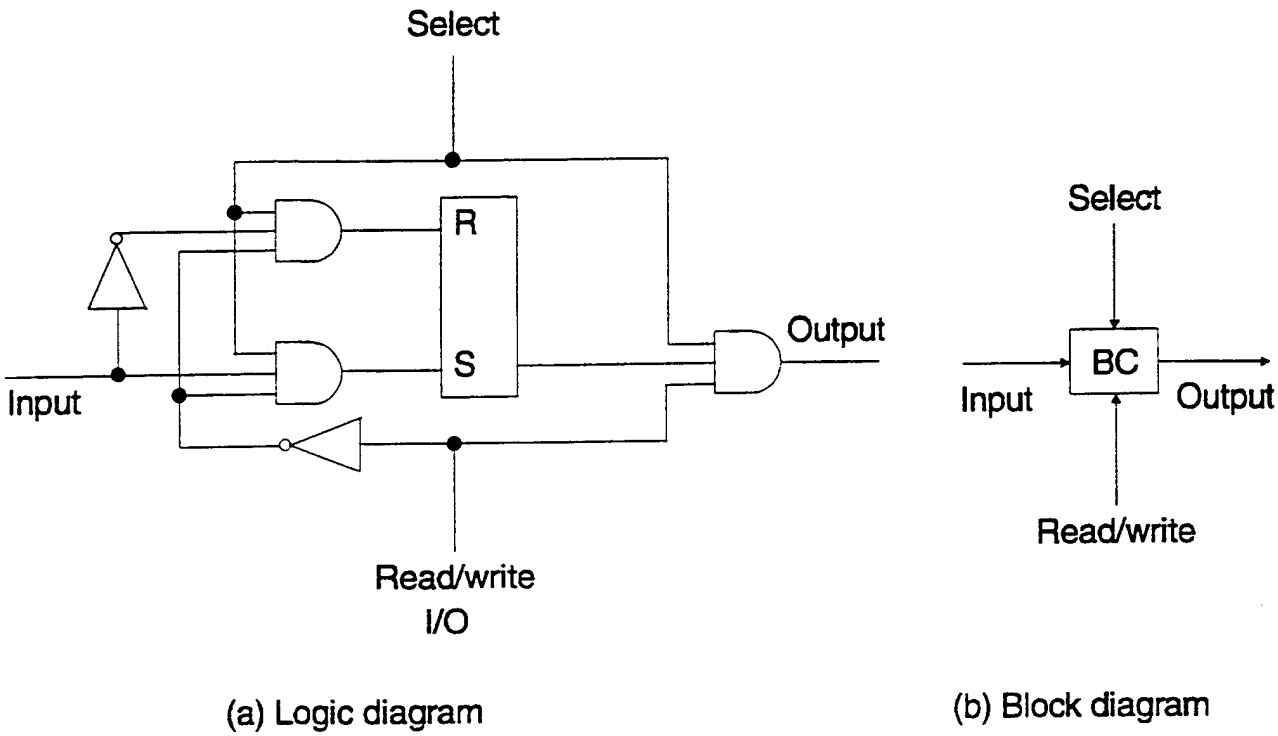

Figure 2-1 Memory cell.

inputs and one output as specified in the diagram of Figure 2-1.

2.0.4 The two address lines go through a 2 by 4 decoder with an enable input. When the memory enable is 0, all the outputs of the decoder are 0 and none of the memory words are selected. With the memory enable input at 1, one of the four words is selected, depending on the bit combination of the two address lines. Now, with the read/write control at 1, the bits of the selected word go through the three OR gates to the output terminals. The non-selected binary cells produce 0's in the inputs of the OR gate and have no effect on the outputs. With the read/write control at 0, the information available in the input lines is transferred into the flip-flops of the selected word. The non-selected binary cells in the other words are disabled by their selection line so their previous values remain unchanged. Thus, with the memory enable at 1, the read/write control initiates the required read and write operations for the memory unit. An inhibit operation is obtained by maintaining the memory enable at 0. This condition leaves the contents of all words in memory as they were, irrespective of the value of the read write control.

Figure 2-2 4 by 3 IC RAM (BC is the binary cell of figure 2-1).

2.0.5 IC RAMs sometimes employ binary cells whose outputs can be tied to form a wire-OR or a wire-AND function. Other IC RAMs provide tri-state outputs. These outputs are convenient when two or more ICs are connected to form a memory unit with a larger number of words since they eliminate the need for external OR gates that would otherwise be needed.

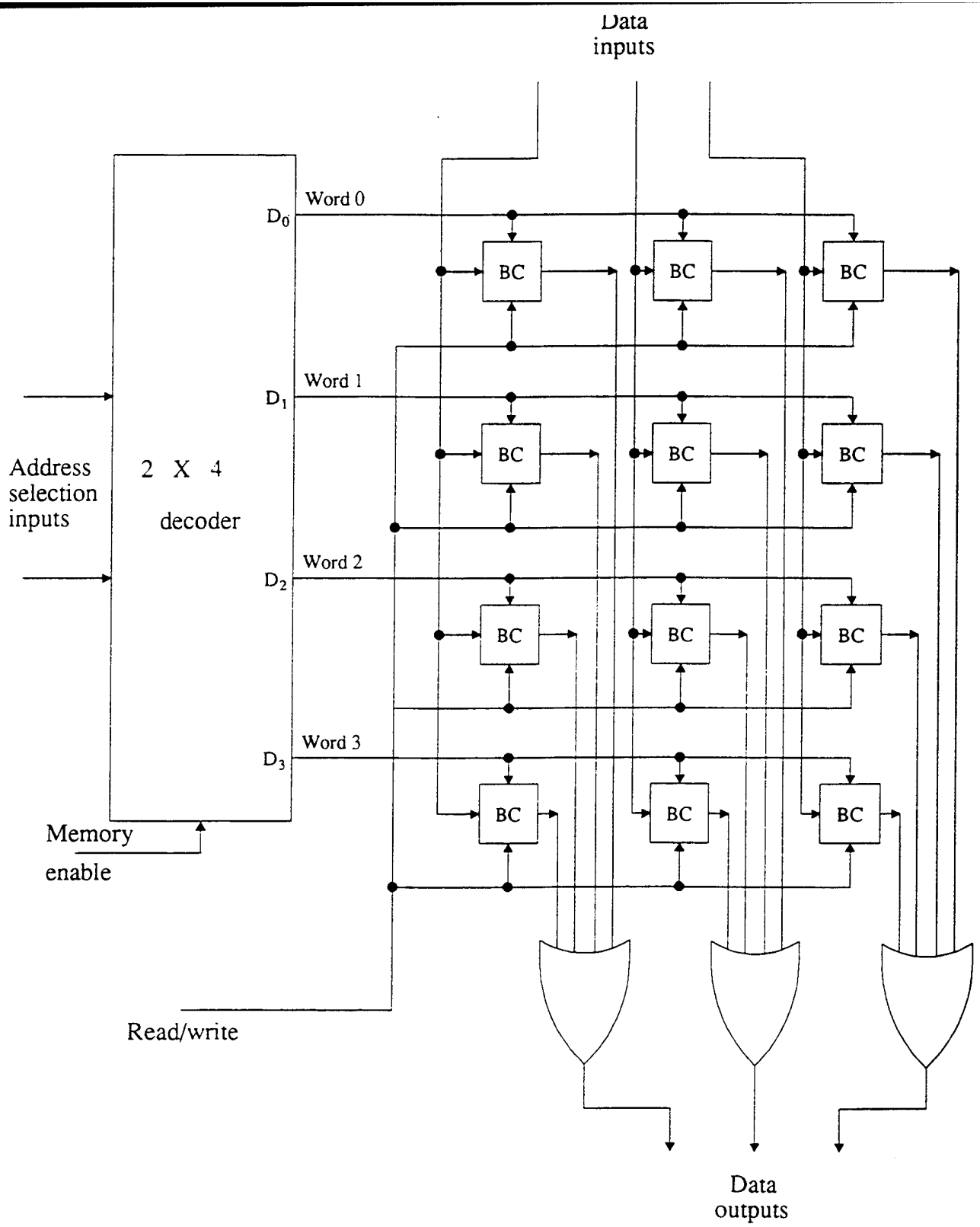

Figure 2-2 4 X 3 IC RAM (BC is the binary cell of figure 2-1).

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