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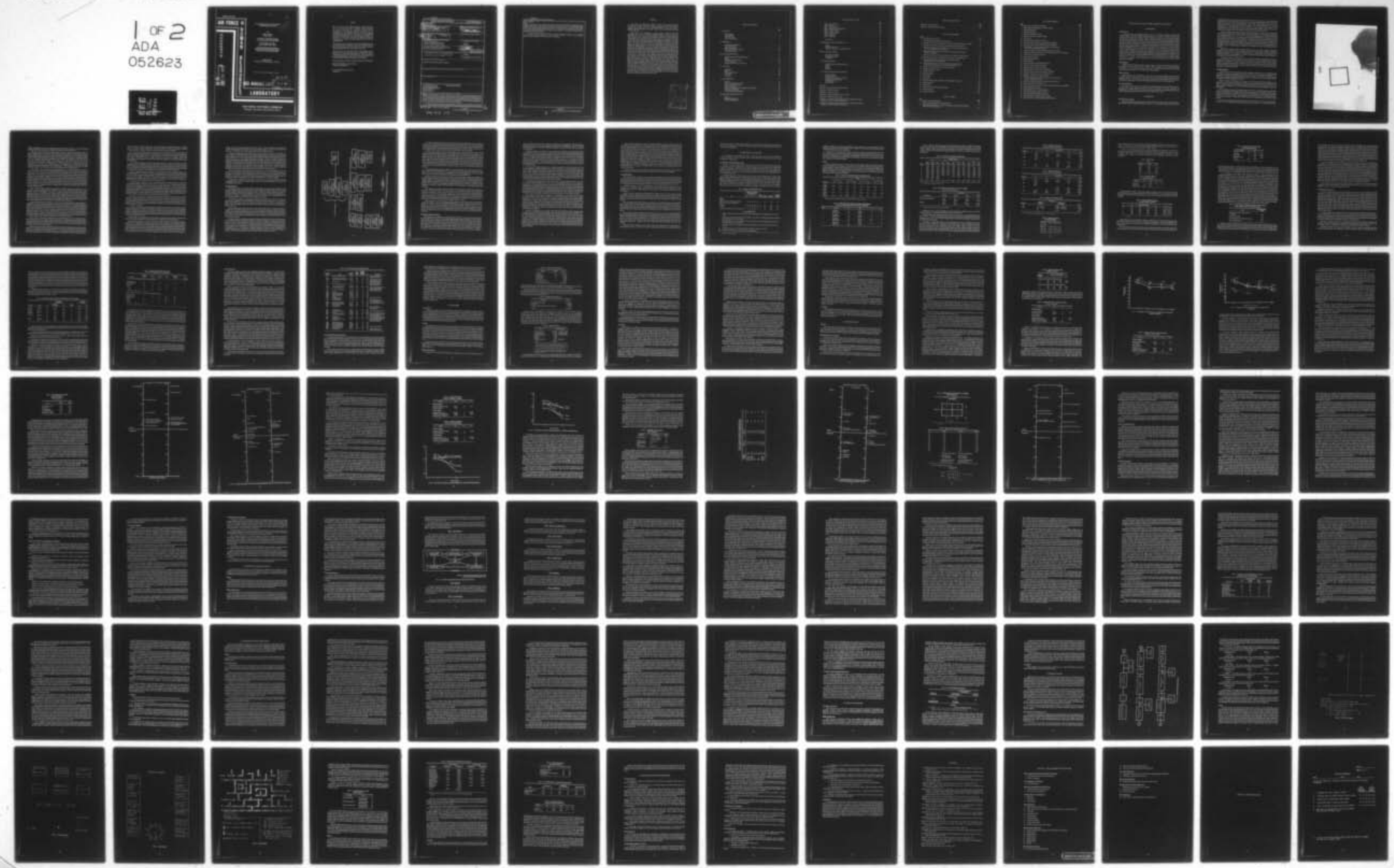

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AIR FORCE HUMAN RESOURCES LABORATORY

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EVALUATION OF PLATO IV IN VEHICLE MAINTENANCE TRAINING

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Final Report for Period August 1972 – June 1976

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NOTICE

This final report was submitted by Technical Training Division, Air Force Human Resources Laboratory, Lowry Air Force Base, Colorado 80230, under project 1121, with HQ Air Force Human Resources Laboratory (AFSC), Brooks Air Force Base, Texas 78235.

This technical report has been reviewed and is approved for publication.

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→ This study documented an Air Force service test of the PLATO IV Computer-based Educational System at Chanute Technical Training Center, Chanute AFB, Illinois. As a part of an instructional systems development effort for four Special Purpose Vehicle Repairman's courses, thirty-five computer-assisted instruction (CAI) lessons were prepared, covering approximately 20 hours of instruction. The evaluation addressed six major areas. In the first area, instructional effectiveness, the PLATO based version was the most efficient of the four versions compared (but the efficiency increase directly attributable to PLATO IV was not determinable).

A cost analysis demonstrated that the Chanute application of PLATO was not cost-effective, but the potential exists for enhanced benefits by selectively applying PLATO and increasing student usage of terminals. A study of

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instructional impact showed student and instructor attitudes to be, respectively, favorable and acceptable. No major adversive impacts relative to the conduct of training were experienced. The fourth area, instructional material development, found the development process with its reliance on a team approach to be effective, but the lessons did not exploit the full potential of PLATO. The study of the remaining two areas, management and human factors considerations, revealed that relatively minor adjustments were necessary to accommodate PLATO within the military technical training environment.

The authors concluded that PLATO IV could be a viable tool for military technical training once it is learned how to exploit the system's capability, and increase production efficiency of courseware and management applications. Recommendations were provided for this effort.

B

PREFACE

This study was conducted in support of project 1121, Technical Training Development, Dr. Marty R. Rockway, project scientist; task 1121-02, Dr. Joseph Y. Yasutake, task scientist; work unit 1121-02-06, PLATO IV Service Test, Brian E. Dallman, principal investigator. This report covers research conducted between August 1972 and June 1976.

This report is the culmination of a 4-year effort to examine PLATO IV's assimilation into an Air Force technical training environment. Over the years many individuals performed at their limit under difficult conditions. It is these people who make a project a success, and this report is dedicated to them. The authors would like to acknowledge everyone associated with the project, however, it is practical to cite those closest to the effort and those who assisted in the preparation of this report. The original eight PLATO authors were MSgt Carl Dennis, Sgts Mel Marcus, Dennis Mitts, and Roger Pelkey, Ms. Janice Dallman, Mr. Bruce Iehl, Mr. William Kennedy and Mr. John Predmore. Joining the project later were Mr. Ken Burkhardt, Mr. Paul Aschenbrenner, Mr. Bob Blocker, Sgt Richard Bourne, A1C Jerry Lynch, Ms. Georgia Rodetis, and Ms. Kathy Wigton. Instructional Systems Development personnel who designed the curriculum and prepared course materials other than PLATO lessons included TSgt Keith Bloomer, Mr. Don Brown, SSgt James Farren, MSgt Edward Siedlemen, MSgt Owen Smith and TSgt Thomas Smith. The individual who integrated the efforts of the ISD and PLATO personnel into a unified project was Mr. Robert Gissing. Various individuals assisted in the performance of the evaluation: TSgt Ralph Bush, Sgt Frank Gaston, Sgt David Gerts, SSgt Ernie Goenag, Lt Joseph Green, SSgt Vance Lennon, Sgt James Mitchell, TSgt Henry O'Neil, Sgt Sherwood Schoff, SSgt Michael Stoll and Lt Harold Trask. It is expected that the University of Illinois Computer-Based Education Research Laboratory personnel will be acknowledged in their reports, but a special thanks should be extended to Mr. Lynn Misselt and Ms. Kikumi Tatsuoka for their efforts in data analysis and Mr. Joseph Klecka for his detailed study of the PLATO lessons. Likewise, the assistance of Dr. Jerry Deignan, Amn Eric Duncan and Amn Karen Kozlowski's data analysis assistance at the Air Force Human Resources Laboratory (AFHRL) was appreciated. The authors would also like to thank Major Brian K. Waters (AFHRL) for his extensive technical review and substantive comments, and Mrs. Virginia Bahnsen for the numerous hours expended in typing and proofreading the draft report.

TABLE OF CONTENTS

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Table of Contents (*Continued*)

Table of Contents (*Continued*)

LIST OF ILLUSTRATIONS

LIST OF TABLES

List of Tables (*Continued*)

EVALUATION OF PLATO IV IN VEHICLE MAINTENANCE TRAINING

I. INTRODUCTION

Project Genesis

During the 1960s, technological advances made at the University of Illinois' Computer-based Education Research Laboratory (CERL) provided substance to the dream of computer-based education which someday may become cost-effective. This new technology became the heart of a fourth generation teaching system called PLATO IV (Alpert & Bitzer, 1970). The acronym stands for *P*rogrammed *L*ogic for *A*utomated *T*eaching *O*perations. Interest in the computer-assisted instruction (CAI) capabilities of PLATO grew along with the evolving system. Monitoring this evolution for potential applications within military technical training environments were a number of government agencies, among them the Defense Advanced Research Projects Agency (ARPA), the Technical Training Division of the Air Force Human Resources Laboratory (AFHRL), and the Air Training Command (ATC). In 1971 ARPA agreed to fund a tri-service test of the PLATO system. The Air Force test commenced in 1972 at the Chanute Technical Training Center, Chanute AFB, Illinois. Proximity to the University and the continuing interest expressed by the Training Research Applications Branch (TRAB) at Chanute were important factors in the decision to use Chanute as a field test site. The ensuing ARPA/AFHRL/ATC research agreement stated that the project's objective was "to conduct a small scale service test of the PLATO IV system in a technical training environment to determine its cost effectiveness, acceptance, incorporability (into ongoing technical training), and reliability."

Responsibilities

ARPA furnished the necessary hardware, and by means of a contract with CERL, provided training and assistance to the Chanute test site. AFHRL's primary obligations were to provide direction, consultation, perform monitorship and liaison roles, and, in conjunction with the TRAB, to evaluate and document the project outcomes. ATC provided manpower and facilities.

Project Personnel

Project manning varied considerably over the service test's run. Since changes in manpower were extremely important to the outcome of the service test, a detailed discussion is included in the section covering site history. The primary project personnel consisted of an on-site AFHRL project monitor, two TRAB members, eight authors from the Vehicle Maintenance Branch, and a computer programmer.

Scope of Development

The project involved the four Special Purpose Vehicle Repairman courses. PLATO was used in connection with a major redesign of a portion of these courses shared in common. This effort was performed by the 3340th Technical Training Group's Instructional Systems Development (ISD) team with PLATO designated the delivery system for 35 lessons in 29 subject matter areas.

II. BACKGROUND

PLATO System Description

During the service test's operational phase, the PLATO system (Alpert & Bitzer, 1970) consisted of approximately 1,000 time-shared terminals connected to a Control Data Corporation Cyber 73-24 dual-processing computer via microwave and telephone lines. Most were centered at various educational facilities within or near the university campus; however, terminals were distributed throughout the United States and some were located in foreign countries. Though many hardware features were important, a significant feature–one that allowed hundreds of lessons to be used simultaneously with an average response latency of 125 milliseconds–was the Extended Core Storage (ECS) unit. This electronic memory permitted the two processors rapid access to the CAI lesson coding, keeping response latency low; i.e., students viewed changes to the lesson display as virtually simultaneous with their actions.

Another innovative feature was the plasma panel terminal (Figure 1) which should be distinguished from the cathode ray tube (i.e., television) variety. The panel consisted of a grid of conductors, sandwiched by two glass sheets (8.5" by 8.5" by .5"), with a neon gas mixture filling the space between grid and glass. When voltage was applied to any combination of the more than 250,000 conductor intersections, the neon mixture provided an orange glow. Thus, the display of alphanumeric characters and graphics was possible by illuminating adjacent intersections. Projection of a microfiche image on this panel was possible due to the transparent nature of the panel. Students interacted with the terminal via a typewriter keyboard or by physically touching the dispaly screen. This touch-panel detected the screen location a student pointed to; for instance, when he was instructed to identify one automotive part on an image depicting several alternatives.

PLATO lesson authors prepared material through the use of a special simplified programming language known as TUTOR. For simple displays and instructional programming strategies, TUTOR was effectively employed by site authors. Programming lessons, collecting data, and managing student instructional sequences were facilitated by a variety of generalized programming routines developed by CERL personnel or other PLATO system users.

At Chanute, twenty-nine terminals were used for training students and authoring lessons, while one terminal was dedicated to special functions such as monitoring a student's interaction with a lesson, diagnosis and remediation of spurious coding difficulties, and communication with CERL personnel. Student terminals were located in a 25- by 50-foot room–each terminal in its own carrel. A microware link was used to transmit data from CERL to Chanute, while a telephone line returned information from site terminals to the computer mainframe.

Historical Perspective

The PLATO IV service test was characterized by three distinct phases. Phase I was a prolonged period of hardware acquisition and planning in which the definition of project goals and philosophy, and development of an effective management scheme were the two major events. During this phase, personnel selection and training, equipment acquisition, and lesson development were also accomplished. Phase I commenced in July 1972 and ended in June 1974.

Phase II marked the transition of the project to an operational mode with emphasis on the development of CAI materials in association with the redesign of the Special Purpose Vehicle Repairman courses. In seven months, the courseware was ready for the first class tryout (14 January 1975). It took approximately one additional year to validate all PLATO-mediated materials and obtain the bulk of the evalution data.

Phase III began in October 1975 and concluded in June 1976. The original agreement with ARPA called for a 30 September 1975 termination date; however, additional time was required for evaluation data collection. ARPA granted the extension, with the provision that additional development goals be specified and these new efforts be evaluated. These consisted of the development of seven experimental lessons investigating several different research areas, selected additional CAI applications, and an expanded testing program.

Phase I. A memorandum of understanding between ARPA, AFHRL, ATC, and the Chanute TRAB, drawn in June 1972, established the general orientation of the service test. As a result, it became the

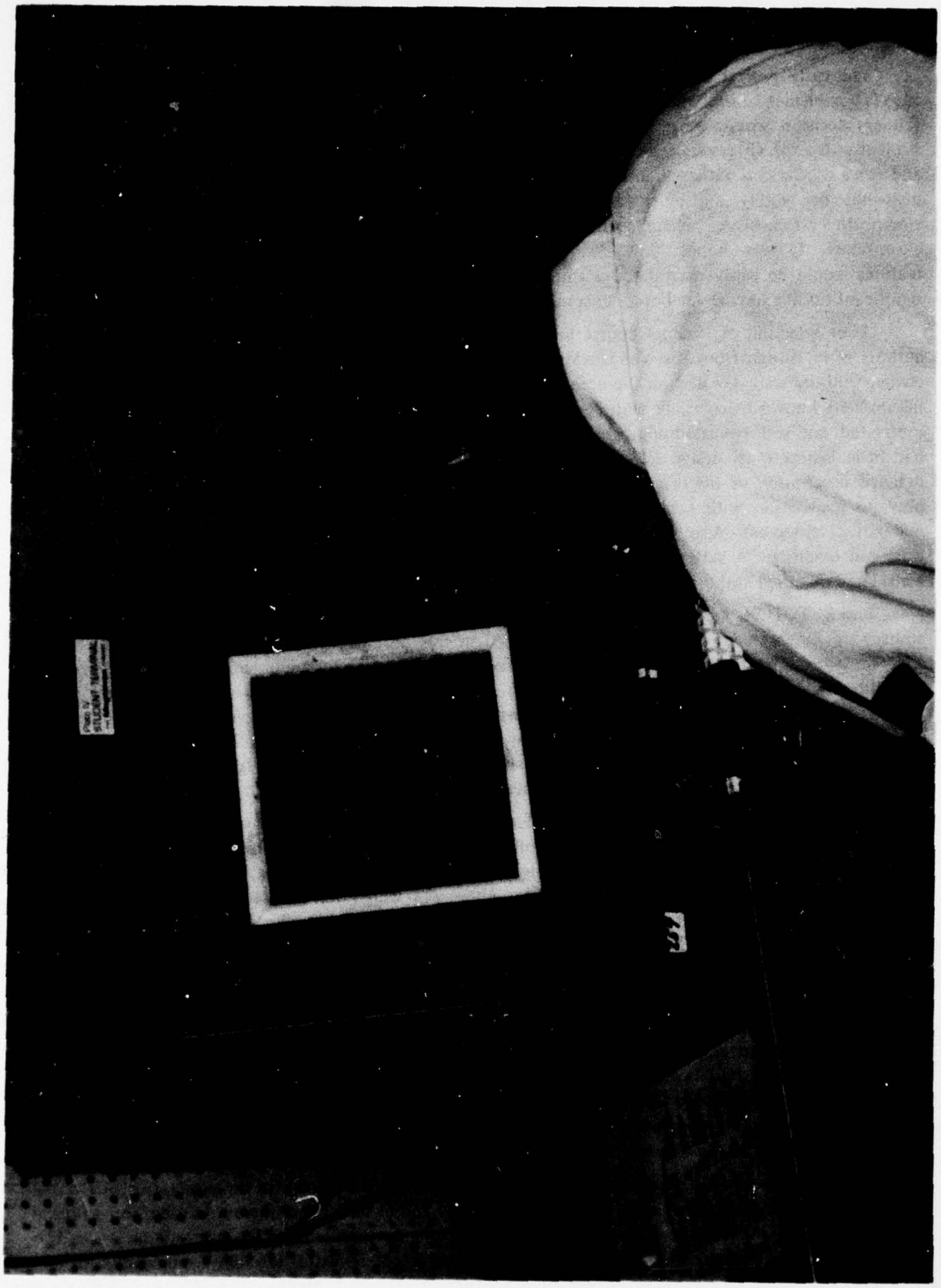

Figure 1. **PLATO IV student terminal.**

TRAB's responsibility to develop a research agreement between these agencies, to commence detailed planning activities in conjunction with AFHRL, and to gather the necessary resources.

The early project documentation indicated that a variety of courses were considered as targets for PLATO implementation, with the final selection being the General Purpose Vehicle Repairman course. Primary decision criteria were: (a) a non-controversial nature (important at the time because of university student attitudes), (b) generalizability of results to other training environments such as community colleges, and (c) a mechanical rather than electrical/electronics orientation. The significance of the third criterion may not be readily apparent. Much of the previous work with CAI systems had been in the electrical/electronics area where cognitive skills are emphasized, and where the caliber of students was exceptional. It was hoped that PLATO–owing to its simplified lesson development and usage features–could be easily assimilated within the mechanical training environment. This would be a highly significant finding for the Air Force, since much ATC training has a mechanical orientation.

After selection of a target course and following agreement on a general approach, PLATO lesson authors were chosen from the Vehicle Maintenance Branch instructor personnel. Four military and four civilian authors were selected on the basis of education and productivity, as no criteria of a more specific nature were known to correlate with performance as CAI authors. In general, the author group was young, motivated, and well educated compared to the other vehicle maintenance instructors. However, the group had little instructional design experience and six selectees were relatively inexperienced as instructors. A detailed description of the original eight authors is available in Green (1973). None of the eight had any previous association with CAI or computer programming. Only two had some experience with lesson material development. Also, this group's classroom instruction experience and subject matter familiarity were not extensive. A substantial amount of training time was invested in this group before they were considered qualified authors.

Initial TUTOR language training was presented by CERL representatives. Though some CAI courseware development discussions were included in this program, CERL had anticipated that author selectees would be knowledgeable in the area of curriculum development and would merely require specialized training on CAI techniques. CERL provided supplementary informal lesson development training through periodic site visits from representatives. In addition, authors were required to read two CAI-related articles per week. This cultivation of the author group's skills was a long and tedious process due to the amount to be learned, the lack of proven guidelines, the trainer's and trainees' inexperience with CAI, and the changeability of the PLATO IV system during its early development.

Lesson preparation efforts during Phase I were directed at producing innovative materials, taxing the capabilities of system and authors alike. Each author became an investigator in his own right, attempting to duplicate eye-catching instructional strategies and incorporate his own ideas. Yet, individual capabilities and interests soon sorted authors into specialized roles. Those who were not interested or talented in developing lesson content centered their efforts on computer programming. Those who didn't have the interest or aptitude to struggle with the complex coding (needed for the more innovative lessons) attended to instructional design or curriculum development. One author spent most of his time on hardware-related activities. These first experiences were quite valuable in determining the future operational structure, when the project's original research orientation changed to one of operational efficiency.

System hardware and software modifications were frequent during the first years. Along with several other recurring problems, these changes tended to inhibit author training and lesson preparation activities. Prolonged equipment delivery slippages, ECS memory shortages, and system unreliability, reduced terminal availability for authoring and precluded student tryout of the new courseware. Such circumstances were extremely frustrating to the Chanute authors.

Attrition of personnel greatly limited productivity during the first stage of the project. Despite verbal agreements, two military authors left the service before the end of their commitment. In their year with the project, each had demonstrated considerable talent in the development of lessons, and their loss was unfortunate, especially since the acquisition and training of a replacement often took from six months to a year. To increase work force stability, and to provide computer programming assistance to remaining authors, a civilian computer programmer was hired in February 1974. This acquisition facilitated courseware production, since the tedious and complex coding was done more efficiently.

By late 1973, an adequate service test plan was yet to be prepared. Service test conditions had stabilized; consequently, the potential for successful execution was great, yet some major deficiencies were apparent, and ARPA, AFHRL, and ATC representatives convened to address the problems. It was decided that project management required strength, experience, and above all, adequate support. The representatives recommended that the project become the responsibility of the 3340th Technical Training Group's ISD team.

The important outcomes of a May 1974 project review were a clear, new definition of project orientation, and an organizational structure with sufficient support to achieve the new goals. The earlier research orientation was gone; PLATO was considered to be an operational training tool, part of an arsenal of devices employed by the ISD team. Management was centralized and the ISD team was made responsible for all development functions. A manifold increase in project interest was evident at all levels.

Phase II. Changing the project's orientation to an operational setting was consistent with the service test's primary goals. Yet, by the project's end, it was recognized that research to determine CAI application had been sacrificed. Detailed planning prepared by the ISD team, during June 1974, called for the new course tryout to commence in January 1975. PLATO would serve as the principal medium for 33 knowledge-oriented objectives. Hence, in six months, 16 new lessons were prepared, and 17 existing lessons were transformed to coincide with the objectives of the new system.

In the ISD team's management plan, a principal objective was to "Make maximum use of PLATO's CAI and CMI capabilities." As used at Chanute, the term CAI (*C*omputer-*A*ssisted *I*nstruction) referred to materials which presented information to the student for learning purposes; i.e., student lesson materials. This should be distinguished from CMI (*C*omputer-*M*anaged *I*nstruction) which can include student evaluation administrative functions, adaptive lesson sequencing for individual or group needs, and extensive data collection. CAI efforts were directed at the 33 lessons, subject matter being the underlying facts and principles necessary to perform special vehicle maintenance tasks. CMI uses included test administration, student curriculum routing, automated data collection, and clerical functions.

To prepare CAI courseware, the ISD team provided the PLATO authors with lesson objectives, objective tests, and teaching points. ISD personnel closely monitored author activities, since none of them were fully qualified in all three facets of a CAI author's role (i.e., computer coder, subject matter expert, and instructional programmer). Thus, the lessons were developed using a quasi-team approach. After an adjustment period, this procedure worked reasonably well, and on 15 January 1975 the first class tryout of all new courseware commenced.

A variety of PLATO system characteristics retarded lesson development and validation progress. Preparing microfiche for PLATO's slide projection capability proved to be a complex, time-consuming process. ECS limitations–imposed on each PLATO site when memory approached capacity–limited the number of authors that could simultaneously program materials. The instructor/author found that the more intricate CAI lesson strategies required sophisticated programming skills. Many of the authors never did attain the required proficiency level.

Overall, Phase II was regarded as the most productive and valuable period, and much of the acquired experience should be applicable to future CAI endeavors in a military technical training context.

Phase III. Phase III started on 1 October 1975 and concluded 30 June 1976, although some Phase II activities (lesson validation) were ongoing until January 1976. In addition, some Phase III activities continued into the ATC funded extension of the service test. During Phase III, the three basic objectives of a revised management plan were to be accomplished, along with continuing evaluation of the PLATO-based vehicle maintenance courses. The first objective was to investigate CAI applications through three successive levels of studies. Seven priority A studies described in the plan, sought to derive basic techniques which would have applications to technical training. In general, B- and C-level studies were for the purpose of refining the more promising techniques noted in the A studies. The second objective was an expanded use of CMI, predominantly in the testing area. A third objective sought to identify and implement CAI applications for the latter portion of each Special Purpose Vehicle Repairman course.

During the planning stage, these objectives did not seem unrealistic. By the end of the service test, however, only one of the seven studies was completed, CMI applications were partially accomplished, and further application of CAI was not attempted. ISD and PLATO personnel losses devastated this part of the project, since only one of the original eight authors remained by March 1976. Until their departure, experienced authors were used primarily to finish Phase II activities such as lesson validation and microfiche preparation. The operationally oriented ISD team felt comfortable with plans of their own design; they did not approve of exploratory research planned by others. As a result, departures from the original plans were numerous and the priority for completion became secondary. As in Phase I objectives, planning, management, authority, and responsbility were not clearly defined. In the face of a heavy workload and uncertainty over the project's future, achieving the planned objectives became impossible.

What was completed during Phase III owed its existence to a 3 March 1976 program review. The purpose of the review was to consider preliminary evaluation data and to formulate future directions for the project. It was apparent to the technical school and ATC managers that two additional cost-related studies were warranted. As a result, ATC funded a short extension. The high level interest in the cost studies carried over to the ARPA goals, and was the principal factor in their partial completion.

The elementary consideration in the service test was to describe, document, and evaluate PLATO's incorporability into Air Force technical training. In spite of numerous difficulties, the test site did accomplish this basic mission.

Instructional Setting

Describing the features of the Special Purpose Vehicle Repairman courses (before and after the ISD curriculum modifications) will assist the reader in understanding the evaluation design. The four courses and their respective content areas are depicted in Figure 2. Each of the courses was termed a "shred-out" and varied in length according to the complexity, or number of vehicles, within a shred classification. For example, the "A Shred" or Crash/Fire Vehicles, had a 16-week duration in its "conventional" form. The term conventional will be used in reference to the pre-ISD course version.

All conventional courses were divided into instructional units called blocks. The first four blocks of each course were identical; that is, the information and laboratory skills were common to the four shreds. Blocks, which followed the common core segment, presented information unique to a specific class of vehicles. Since all students received instruction in the common segment, student flow was highest here, about ten per week.

Students received instruction 6 hours a day, 5 days a week, during the 6 a.m. to noon time period. On a typical day, the instructor might lecture for 4 hours covering; for example, principles of carburetor operation; then students would spend the remaining 2 hours performing carburetor maintenance tasks in the laboratory. This knowledge to performance ratio was 60 percent to 40 percent in the conventional courses. The courses were lock-step, meaning that the instructor adhered to a time schedule specified in the course control documents.

Student evaluation was derived from instructor observation and block tests. Every day, the instructor made a qualitative decision concerning an individual's composite performance. A student could fail a lesson test, but do well in class and laboratory activities, and receive a satisfactory performance rating. This procedure was one of the determinants for assigning specialized individual assistance (SIA) to the students, as were absenteeism and performance on comprehensive block tests. End-of-block tests generally consisted of approximately 30 to 40 multiple-choice questions. Students who failed were either "washed-back" to the following class, given a probationary continuation (allowed to continue with their class pending the results of a retest) or eliminated from the course if several successive failures had occurred.

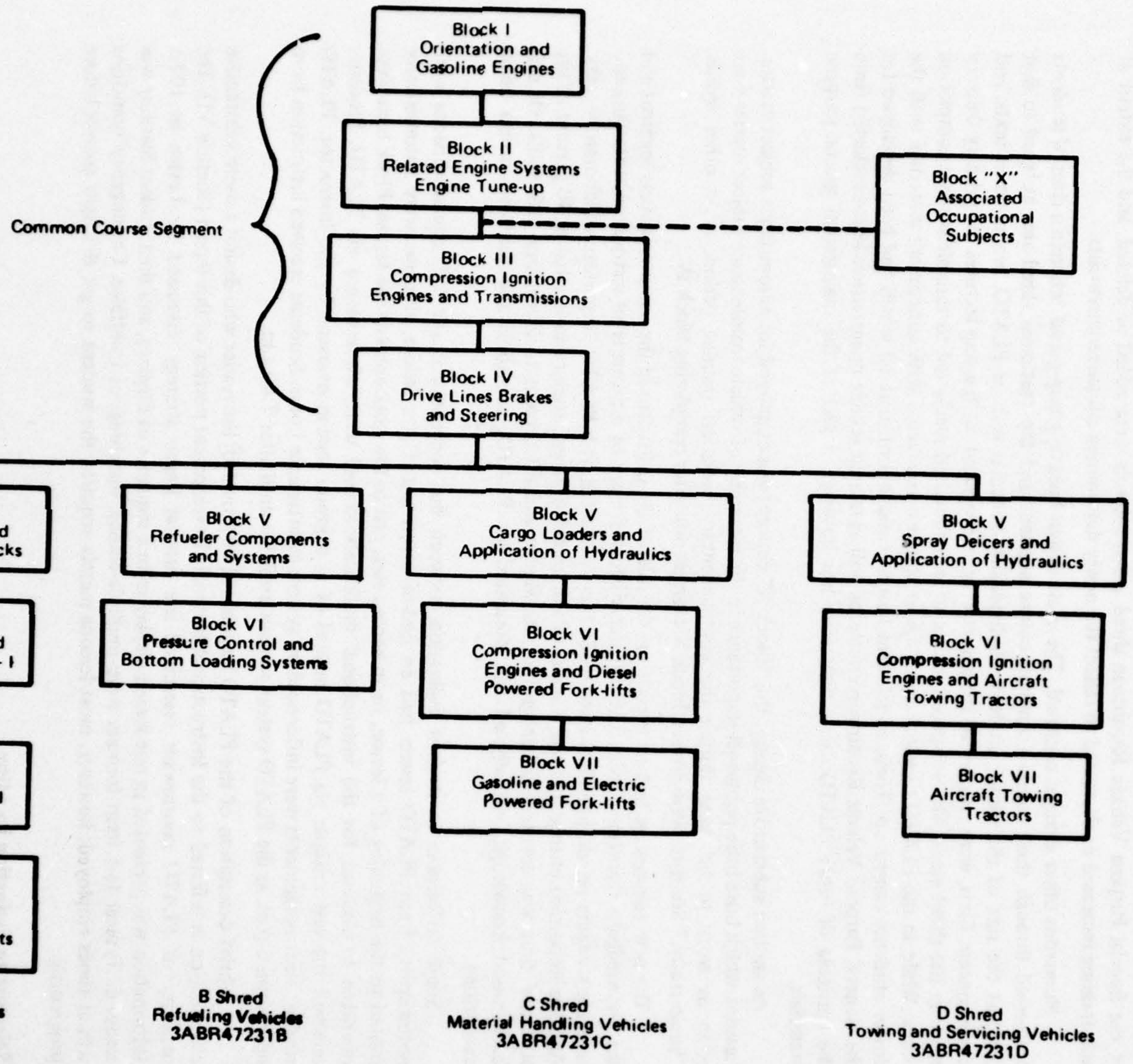

Figure 2. **The Special Purpose Vehicle Repairman courses.**

The ISD team substantially changed the Special Purpose Vehicle Repairman courses. In refining an existing course, an ISD team applied a specific procedural model (AFP 50-58, 1974). Scope and depth of training received emphasis to insure that the end product was relevant to field needs and efficient. In each of the Special Purpose Vehicle Repairman shred areas, subjects were added or deleted, and the extent of task training increased or decreased to reflect the newly determined course requirements.

Numerous other changes occurred. The basic design became group-paced, wherein a class of students progressed through their course (common course segment and the particular shred area assigned to that class) at the rate of the slower students. Individualized media; such as PLATO, programmed texts, and single concept films, were created for the common course segment, with group lectures the primary delivery mode in the shred areas. The self-paced nature of individualized media led to variable student completion times. While in the PLATO terminal room, faster students interacted with enrichment materials until the slower students caught up. These enrichment lessons consisted of material which had been developed for the General Purpose Vehicle Repairman course, as well as related vehicle maintenance lessons selected from the curricula of other PLATO users; they were not however, a part of the mainstream special purpose materials.

As another substantive change, the "Block X" concept was employed for autonomous subject matter. Lessons which bore little positional importance in the hierarchy of vehicle maintenance subject matter were given as work to be done during the complementary technical training period, or in other words, "home-study." Students were given a Block X examination after completing Block IV.

The new courseware had an impact on the role of the instructor in the common course segment and the knowledge/performance ratio. The instructor became more of a manager of instruction, observing and assisting students on an individual basis while they interacted with PLATO, or performed laboratory tasks. Another important change was the reversal of the knowledge/performance ratio; that is, 40 percent of the students' time was devoted to background knowledge and 60 percent to laboratory task skills. Of this background knowledge, virtually all was presented via PLATO; handtools and technical orders being exceptions.

Some differences in student evaluation between the conventional and ISD course versions were noteworthy. Each PLATO lesson had an end-of-lesson test. Upon failure, students were automatically routed to the beginning of a lesson, or in some cases, just to the weak areas of the lesson. Block tests were rewritten to account for the instructional modifications and were administered via PLATO. Students received the test critique via PLATO instead of in a group session overseen by the instructor. PLATO student shift assignments were influenced by system maintenance hours. Students received instruction from noon until 6 p.m. as the PLATO system was not available until after 7:40 a.m.

A brief description of the PLATO lessons will be provided; the reader who desires a more substantive examination is referred to the Instructional Materials Development portion of this report (Section VI). The majority of PLATO courseware resembled the tutorial lesson strategy discussed by Levien in 1972. Information was presented in one screen display or in a sequence of displays, and then student learning was assessed. Typical test item formats were multiple-choice, matching, or true/false. Contingency branching was at times employed; however, most lessons merely required the student to get the right answer before progressing.

Selecting an Evaluation Paradigm

When planning for an evaluation, it is essential that the evaluators consider the needs of the audience and the purpose of the evaluation. An appropriate perspective and evaluation design may then be selected. For the present study, a survey was sent to ATC, ARPA, AFHRL, CERL, and other military PLATO sites. The survey requested these agencies to rank-order six basic evaluation areas and likewise order questions within each area. The criteria for ranking were the importance of the area or question to that agency's needs. This exercise confirmed the notion that different needs and project expectations would be found. For example, the project evaluation might provide decision makers with information, or establish a repository for CAI research and experience. However, a decision to continue or not continue involvement with the PLATO system was ATC's paramount consideration and responsibility. The final evaluation planning mirrored the ATC priorities, stressing the accumulation of information on which to base future PLATO-related decisions at Chanute. Systematic investigation of various CAI realms was not a major goal of this evaluation.

Evalution activities concentrated on cost, instructional effectiveness, and instructional impact (attitudes) because of their importance as indicated by the survey. Instructional materials development, management, and human factors considerations were important, but had a lower priority. With regard to cost, expenses dealing with equipment, personnel, operational and communication were examined in relation to savings. Instructional effectiveness included the study of key course and PLATO medium-associated variables that provided a picture of student performance, course efficiency, PLATO's performance contribution, *et cetera*. Instructional impact looked at student and instructor attitudes, training capabilities, and organizational features which may have been affected by PLATO's incorporation into technical training.

Two program evaluation paradigms were considered applicable to the PLATO service test. The absolute suggested by Cronbach (1963) involves the formal study of a well-defined student sample with respect to goal attainment and side effects. This model does resolve several of the internal validity issues present when a comparative field design is employed; i.e., the problem of equating control and treatment groups. It also avoids the curriculum evaluation enigma Cronbach refers to as equivocal results. When comparing separate curricula, it frequently happens that the effectiveness of about half the modules in each curriculum will be greater than their counterparts. When this occurs, no superiority for either curriculum can be demonstrated, and the results of the evaluation are equivocal.

Comparative design limitations have been noted by many evaluation theorists (Glass, 1972, p. 105), but as Scriven (1967) pointed out, in terms of the decision-making purpose of most evaluations, comparisons are often unavoidable. When an evaluation serves as the basis for selecting one program over a competing one, comparing the attributes of each is a necessity. From ATC's perspective, many instructional system versions would allow students to attain training goals; however, only the most efficient, economical version was desirable. Efficiency had to be underscored because of its direct relationship to training costs. Determining the relative efficiency of conventional and PLATO-based course versions was a high priority ATC need. Hence, the comparative paradigm was chosen to examine most of the evaluation questions.

The comparative design had to maximize the interpretability of the findings. If the primary performance outcomes of the before-and after-course versions were compared, the conclusions reached would pertain to the course as a whole, not to a particular medium. Statements concerning the specific contribution of a medium, design technique, or any particular curriculum change would not be justified by comparing block examination scores, completion times, and failure rates because many features of the courses had changed. Since the present evaluation was chiefly interested in PLATO's contribution to the instructional environment, the evaluation method had to attend to the problem of multiple changes. Furthermore, it was important that media comparisons involve similar classes of media under varying types of instructional circumstances.

A number of investigators have attempted to ascertain CAI's contribution compared to other media. In separate reviews of CAI projects and studies, Taylor (1974) and Jamison, Suppes, and Welles, (1974) cited results indicating that CAI-based curriculum students performed as well as or better than students in the non-CAI (control) curriculum. Time savings were typically present in favor of CAI, but several questions remained unanswered. What was CAI's direct contribution? Were other changes present that could account for the greater efficiency? The comparison groups in almost every study were conventional classroom–lecture settings. Comparing almost any self-paced or group-paced setting with a group lock-step situation would yield these results, since the first two make use of individualized media and the latter, group instruction. Therefore, interpretation of relative instructional efficiency findings was limited in those projects and studies.

Other studies have attempted to control for contaminating influences, thus increasing the precision of the results. In one study (KPR 73-118, 1974) at the USAF School of Applied Aerospace Sciences, Keesler Air Force Base, Mississippi, programmed test (PT) versions of lessons developed for the Lincoln Terminal System (LTS) were prepared by the authors of the original lessons. Care was taken to change only those aspects of the lessons necessary to prepare an off-line version. The PT lessons were then administered to a sample of student from the same electronics course as the LTS project. Result indicated that achievement scores were significantly greater, but completion times of the LTS students were significantly longer than those of the PT students. The investigators concluded that though achievement scores were better, the LTS instruction was less efficient. In another study a comparison was made at the lesson level between student groups in an Army machinist training course (Dept of the Army, 1975). The course was self-paced using individualized media such as single-concept films, programmed texts, and sound-on-slide presentations. PLATO lessons were prepared concurrently for some of the instructional objectives. Students were randomly assigned to a PLATO or an alternative medium lesson condition, so that most students received several PLATO lessons. In general, the PLATO versions were as effective as the alternative versions, and produced time savings.

It can be seen that many factors influence the clarity of evaluation findings. The present evaluation was structured to be responsive to these factors by being flexible in its choice of methodologies.

Overall Methodology

The current evaluation concentrated on three areas–instructional effectiveness, instructional impact, and cost. The method was comparative and primarily directed at variables which would reveal course and medium differences. Some methodology was common to the three areas, but the design used in each area was dependent upon the nature of the area, available resources, and the limitations placed on the evaluation team. This section presents those evaluation methods common to the examination of the three areas.

Conditions. The first of the four conditions was termed baseline (BL). The purpose of the BL condition was to determine major course parameters before ISD interaction changed the course. Administrative records for a 9-month period prior to 14 January 1975 were reviewed and relevant course data extracted.

Similar to the BL condition, the non-PLATO (NP) condition served as a control group. It existed concurrently with the remaining PLATO conditions, but consisted only of A-shred students. Students within this conventional setting knew of PLATO's existence and that evaluation data were being collected. Evaluation instruments prepared during the BL condition data collection period were administered to NP students.

The conventional PLATO (CP) condition was composed of C- and D-shred students who used PLATO lessons in lieu of instructor presentations. Since these lessons reflected the modifications imposed by the ISD training analysis, and most remained unvalidated throughout the duration of the CP condition, instructors filled in any gaps they perceived with supplemental or reinforcing instruction. The amount of PLATO material used in this condition was variable, ranging from about 70- to 90-percent of the new CAI lessons.

The remaining condition consisted of the four ISD course versions and was termed PLATO-based (PB). In this condition, students interacted with all new courseware in the context of an updated Special Purpose Vehicle Repairman course curriculum. The individual shred tryouts were staggered because of the necessity to match the shred area instruction to the common course segment. As soon as a shred area revision was complete, the students in that course would receive the new materials. Thus, the tryout commencement dates were: 15 January 1975 (B), 13 March 1975 (D), 22 May 1975 (C), and 13 June 1975(A).

Student Population. Included in this study were 426 students assigned to the four Special Purpose Vehicle Repairman courses for training. The number of students in each condition was: 200 for BL, 23 for

NP, 46 for CP, and 157 for PB. Condition sample size was a function of the staggered tryout schedule for the NP and CP conditions. In most cases, deviations in sample sizes found in the following tables were the result of missing observations.

III. INSTRUCTIONAL EFFECTIVENESS

The evaluation of instructional effectiveness focused upon three areas: the course, PLATO as a medium, and PLATO courseware. Procedures, results, and discussion will be discussed for each area. Overall conclusions are presented later.

Special Purpose Vehicle Repairman Course

Special Purpose Vehicle Repairman Course Procedures. Primary indices of instructional effectiveness at the course level were student block examination grades, course completion times, eliminations, washbacks, probationary continuations, and special individualized assistance time. The evaluation team members extracted these data from course records of students who received instruction during the 9-month period prior to 15 January 1975 (BL condition) and from 15 January 1975 to 30 September 1975 (NP, CP, and PB conditions).

Additional data were provided through a field follow-up survey. Supervisors of technical school graduates were periodically surveyed by the Technical Training Evaluation (TTE) Division, Chanute AFB, Illinois to determine if the quality of those graduates was meeting Air Force needs. Special Purpose Vehicle Repairman (SPVR) graduates, from classes participating in the PLATO service test, were surveyed in March 1976. These individuals were from classes graduating between March 1975 and October 1975. Types of data collected from this field evaluation are presented in Table 1. Thirty-three tasks (in this particular functional area) were common to all four shreds. These tasks, listed in Appendix A, were the only ones

Table 1. **Sample of Field Evaluation Data**

	Frequency of Graduates Performing at Level									
		Level								
Task	NP	0	1	2	3	4	STS[a] Code Level	Percent Qualified	Percent Performing	STS Survey Qualified Average
Engines										
Determine proper operation of engines	1	0	10	51	41	13	2	91	99	2.5
Engine systems and components:										
Repair	2	0	10	52	41	11	2	91	98	2.4
Service	2	0	3	37	58	14	2	97	98	2.7
Test and adjust engine system components	0	1	12	37	43	8	2	87	100	2.4

Level Interpretation

4	Highly Proficient. Can do the complete task quickly and adequately. Can tell others how to do the task.
3	Competent. Can do all parts of the task. Needs only a spot check of completed work. Meets minimum local demands for speed and accuracy.
2	Partially Proficient. Can do most parts of the task. Needs help only on hardest parts. May not meet local demands for speed or accuracy.
1	Extremely Limited. Can do simple parts of the task. Needs to be told or shown how to do most of the task.
0	Incapable. Can do no part of the task without being told or shown how to do it.
NP	Not Performed. Has not performed task in current assignment.

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[a] Specialty training standard.

analyzed. In addition to data from the graduates of 1975, data from an earlier evaluation of course graduates conducted in 1973 were available for use as a baseline. These data were examined to determine if changes had occurred in the student population.

Comparison of overall performance ratings was made for five groups of graduates. Those from CP, NP, and PB conditions constituted three groups. Graduates who had participated in PLATO training after all classes had transitioned to the experimental system (designated Late PLATO or LP) made up the fourth group, and the 1973 graduates constituted the fifth, baseline (BL 73) group. (Note: These baseline students were not the BL Group of earlier analyses.)

Results

Block Examination Scores. The mean common course segment block examination scores and standard deviations for each condition are presented in Table 2. BL, NP, and CP scores were analyzed by a one-way analysis of variance (ANOVA) design for each of the common course segment blocks (Table 3). No significant differences between group performance were found. PB scores were not included in the ANOVA design—even though they were apparently greater than those within other conditions—because of the aforementioned block examination differences.

Table 2. **Common Course Segment Block Examination Data**

	Block							
	1		2		3		4	
Conditon	M	SD	M	SD	M	SD	M	SD
BL (N=190)	79.0	10.9	76.2	10.3	75.2	12.4	74.0	9.8
NP (N=23)	76.5	10.3	77.1	9.6	78.7	10.7	76.7	9.2
CP (N=46)	76.6	11.2	78.1	9.5	78.4	12.3	76.6	10.5
PB[a] (N=156)	91.0	7.8	80.9	11.2	83.3	11.3	86.3	9.7

[a] The block examinations for this condition are different than the other conditions.

Table 3. **ANOVA Summary Tables for Common Course Segment Block Examination Scores (BL, NP, and CP Conditions)**

Block	Source	df	MS	F	p
1	Condition	2	84.62	.71	.49
	Within Cells	253	118.86		
2	Condition	2	38.16	.37	.69
	Within Cells	253	102.12		
3	Condition	2	157.78	1.05	.35
	Within Cells	251	149.89		
4	Condition	2	98.05	1.01	.37
	Within Cells	246	97.50		

Course Compeletion Time. Mean course completion time data are presented in Table 4. Time savings, resulting from the group-paced PB condition, were computed by determining the difference between PB and BL conditions. Table 5 shows that the time savings for the common course segment was about 28.5 percent. An estimate of additional time savings attributable to PLATO as a self-paced medium will be provided later.

Table 4. **Mean Course Completion Times (Hours)**

	Shred/Conditions										
	A			B		C			D		
Block	BL N = 38	NP N = 23	PB N = 13	BL N = 35	PB N = 37	BL N = 57	CP N = 30	PB N = 21	BL N = 50	CP N = 14	PB N = 41
1	57.6	59.0	42.6	57.3	51.1	58.8	57.7	53.3	56.8	57.1	54.7
2	58.2	59.7	43.7	56.8	45.7	59.3	56.3	49.1	51.5	58.4	52.5
3	60.6	60.0	36.8	60.9	43.9	58.7	61.9	46.1	59.7	60.5	42.8
4	59.8	60.7	21.4	57.9	25.3	59.5	56.8	24.4	58.6	58.0	24.0
5	59.4	64.5	68.7	59.6	45.4	57.1	59.4	65.5	59.1	60.0	61.4
6	59.0	62.7	57.7	60.4	67.7	57.4	59.6	59.9	60.1	60.6	31.8
7	58.3	61.4	60.0	–	–	57.7	59.9	a–	59.6	61.2	61.6
8	58.2	56.7	24.0	–	–	–	–	–	–	–	–
Total	471.1	484.7	354.9	352.9	279.1	408.5	411.6	298.3	405.4	415.8	328.8

[a] C-shred course was shortened one block.

Table 5. **Mean PB Time Savings Relative to the BL Condition**
(Hours and Percent Reduced)

	Shred Course			
Instruction	A (N = 13)[a]	B (N = 37)	C (N = 21)	D (N = 41)
Common Course Segment	22.9	16.8	15.8	14.7
	38.8%	28.8%	26.8%	23.2%
Overall	126.2	68.5	104.2	81.6
	26.7%	19.6%	25.8%	19.8%

[a] Sample of PB students used to estimate time savings.

Eliminations. Three academic eliminations occurred during the evaluation period, all in the BL condition. Therefore, no analysis of elimination frequencies was performed.

Washbacks. PB and BL washback frequencies (Table 6) were found not to be significantly different, $X^2(1) = .04$, $p = .84$ as was the comparison of the composite PLATO-using conditions with the BL and NP conditions, $X^2(1) = .25$, $p = .62$. No other comparisons were attempted, since observation frequencies were low in the NP and CP conditions.

Absenteeism. Absentee data (Table 7) were analyzed using a two-way classification table. This procedure tested for independence of absenteeism and condition as the example in Table 8 demonstrates. For each condition used in the classification table. mean number of days not absent–for all four shreds–was computed to account for course length differences. These variable completion times were a function of the shred, and the course design (Table 4). The results of the important condition comparisons are presented in Table 9. Both the PB and NP conditions had significantly greater absentee frequencies

Table 6. Washback Frequencies
(Observations/Students and Percentage)

	Shred Course				
Condition	**A**	**B**	**C**	**D**	**Total**
BL	2/41 4.8%	3/39 7.7%	4/58 6.9%	5/52 9.6%	14/190 7.4%
NP	1/26 3.8%	–	– –	– –	1/26 3.8%
CP	– –	– –	1/34 2.9%	0/13 0	1/47 2.1%
PB	0/25 0	1/46 2.2%	0/21 0	9/68 13.2%	10/160 6.3%

Table 7. Absentee Frequencies
(Observations/Students and Percentage)

	Shred Course				
Condition	**A**	**B**	**C**	**D**	**Total**
BL	12/41 29.3%	17/39 43.6%	18/58 31.0%	11/52 21.2%	58/190 30.5%
NP	21/26 80.8%	– –	– –	– –	21/26 80.8%
CP	– –	– –	12/34 35.3%	7/13 53.8%	19/47 40.4%
PB	10/25 40.0%	23/46 50%	12/21 57.1%	35/68 51.5%	80/160 50%

Table 8. Example of Classification Table

	Absenteeism		
Condition	**Number of Absences**	**Number of Non-Absences**	**Total**
BL	58 (83.8)[a]	12,906 (12,880.2)[a]	12,964
PB	80 (54.2)[a]	8,309 (8,334.8)[a]	8,389
	138	21,215	21,353

[a] Expected number if independent results: $\chi^2 = 19.5, p < .05$.

Table 9. Absentee Frequency Comparison Results

PB vs. BL: $\chi^2\ (1) = 19.5; p < .05$

BL + NP vs.
PB + CP: $\chi^2\ (1) = 10.1; p < .05$

NP vs. BL: $\chi^2\ (1) = 15.2; p < .05$

CP vs. BL: $\chi^2\ (1) = .01; p > .05$

when compared to the BL frequency. However, the hypothesis that the BL and CP conditions differed with respect to absenteeism was not rejected. The combined PLATO conditions had a greater frequency of absenteeism when compared to the combined NP and BL conditions.

In view of the relationship between the evaluation conditions and absenteeism, an ANOVA was performed on actual number of hours absent within conditions. Mean hours absent and the ANOVA results are shown in Tables 10 and 11, respectively. Though the frequency of absenteeism was higher for several conditions when compared to the BL data, the amount of time students were absent did not differ significantly.

Table 10. **Time Absent**
(Hours)

Condition	Mean	SD
BL	2.45	7.91
NP	5.17	5.91
CP	3.61	6.2
PB	2.33	4.89

Table 11. **Results of Absentee Analysis of Variance**

Source	df	MS	F	P
Condition	3	69.89	1.6	.18
Within Cells	404	43.6		

Special Individual Assistance. An extended median test (Siegel, 1956, p. 179) was used to determine if SIA time differences were significantly different between conditions. For each block, the results (Table 12) showed a trend for the CP condition students to have had more assistance than students in the other conditions.

Table 12. **Special Individual Assistance Extended Median Test Results**

Block	Condition Medians				Chi Square Value
	BL	NP	CP	PB	
1	.105	.091	.833	.072	$\chi^2(3) = 236.49$*
2	.169	.042	.300	.112	$\chi^2(3) = 172.61$*
3	.183	.196	.389	.152	$\chi^2(3) = 138.52$*
4	.188	.313	.357	.168	$\chi^2(3) = 112.72$*

* $p < .001$.

Field Evaluation. The field evaluation resulted in a graduate survey with the following sample sizes: PB = 42, NP = 28, CP = 32, LP = 45, BL = 73. Among these 220 graduates, 138 were at the apprentice duty level, 73 at the mechanic duty level, eight were holding other assignments, and duty level information was missing for one.

The first analysis was performed to determine if overall field performance was different for graduates of the five groups. To account for variance due to differences in duty level, a two-day factorial ANOVA was

Table 13. **Analysis of Variance of Overall Field Performance Ratings**

Source of Variance	df	MS	F
Condition	4	.480	1.017
Duty Level	1	2.057	2.901*
Condition X Duty	4	.634	.894
Residual	201	.709	

*p < .10.

performed with five levels of condition and two levels of duty (Table 13). The results showed that there were no significant differences in overall performance between each of the conditions, although duty level appeared to be related to overall performance as expected. The overall mean for graduates in mechanic duties was slightly, but not significantly, higher than the overall mean for graduates at the apprentice level.

As a cross-check on the validity of the performance measure, a second analysis was done by standardizing ratings on each of the 33 tasks, summing them, and performing another ANOVA on this variable. Specific task data from the BL group could not be used in this analysis, because the task format was not compatible with that of the four groups sampled in the survey. Consequently, all analyses concerned with summed performance of the 33 tasks listed in Appendix A relate only to conditions PB, LP, CP, and NP. It was found that there were no significant performance differences among graduates of the four conditions, F (3, 145) = 1.271, $p > .25$. To determine if certain tasks were related to overall performance and if those specific tasks were differentially influenced by PLATO and non-PLATO training, two additional analyses were performed. The first of these analyses involved a multiple regression design, in which the dependent variable was the overall field performance rating of students at the apprentice level, and the independent variables were 12 tasks which had the highest rating variances. Four of these tasks were significantly related to the overall rating. The four tasks were of significantly different difficulty. The task dealing with tools and safety received the highest mean rating of all tasks (2.9) indicating it was perhaps the easiest to perform. The remaining three tasks received approximately the same mean score, 2.235, 2.285, 2.229, for technical orders, data collection forms, and power steering, respectively, indicating approximately equal difficulty. These four tasks produced a multiple R of .743 and are presented in Table 14. The second analysis was a 4 X 4 ANOVA (four levels of tasks and four levels of conditions). Again, it was found that condition was not a factor in the ability of a student to perform these tasks.

Table 14. **Tasks Related to Overall Performance Rating of Special Purpose Vehicle Repairman Training Graduates**

Task	Mean Performance Rating
Apply safety practices with tools and equipment	2.97
Use technical orders	2.17
Use maintenance data collection of forms	2.28
Power steering system	2.23

Discussion of Course Effectiveness. Almost all the common course segment instructional effectiveness indicators showed the ISD versions to be more instructionally efficient. Moreover, PLATO course versions were at least as effective as versions employing alternative media. The block examination findings showed the PB condition students' performance to be satisfactory–in a purely numerical sense, even better than the other conditions. This latter case could be the result of lower test difficulty and a policy of teaching towards the test items. Student eliminations, washbacks, and SIA time differences between the BL and PB conditions were not significant. The higher absentee frequency for the PB students could have been a function of factors not related to the PB instructional environment since the same increase was noted for other concurrent conditions (NP, CP). Field evaluation findings also provided evidence for the contention that the PB condition was at least as effective. Field supervisors did not report an appreciable change in the quality of the courses' graduates. In fact, this graduate evauation study was unusual in that every item was at least satisfactory. More often, graduate evaluation shows at least one and typically several deficiencies. It seemed evident that the new version was instructionally effective, and because of the 28 percent time reduction, it was considered as instructionally more efficient than the preceding versions.

It can be concluded that both PLATO-using versions were effective. In addition to the previous line of reasoning for the PB condition, the CP condition block examination scores were not significantly different from the NP and BL condition scores. This finding was somewhat confounded by the fact that CP students had the greatest amount of additional assistance. Interviews with instructor personnel indicated that the CP instructors were concerned about the unvalidated PLATO lessons' effectiveness. Also, due to the depth of instruction changes, instructors found it necessary to review and present additional material after their students had interacted with PLATO. In most areas, this occurred immediately during the normal 6-hour day. But it was periodically necessary to use SIA time for this augmentation. The impact on the block examination scores could only be surmised; yet, this increased SIA time was not considered to be substantial. Also, the additional assistance might not have been necessary, since review of the PLATO lessons was probably a function of initial concern for their effectiveness. Other indices of system effectiveness showed the CP condition to be at least as effective as the BL and NP conditions.

All in all, the ISD version was instructionally efficient, and PLATO was an integral and effective component of that instructional system. Similarly, PLATO worked well in the course before the changes, through the lessons were not really designed for use there.

PLATO System Effectiveness

The most perplexing problem faced by the evaluation team was the creation of a design to determine if PLATO IV–as used by the project personnel at Chanute–was more or less instructionally efficient than other presently available media. To determine this relative media efficiency without developing numerous alternative lessons was the basic constraint. Thus, the problem was to ascertain if lesson achievement and completion time differences that existed between conditions were related to a class of medium; i.e., CAI or non-CAI. The ideal design would control for the effects of ISD influences, subject matter differences, and the nature of the medium. ISD influences were chiefly changes to the scope and depth-of-instruction, and lesson strategies. Subject matter characteristics (e.g., lesson complexity) directly influenced student performance. Also, since PLATO was an individualized medium, efficiency comparison had to be made within that general class of medium. The results might clearly indicate that within the context of PLATO's application at Chanute, PLATO lesson efficiency was less than, greater than, or about the same as other media of a similar nature.

No single design within the constraints laid on the evaluation team could simultaneously control for the key variables. Hence, two methods were used to examine the relative efficiency of PLATO. First, a topical test was employed in determining achievement differences between conditions while controlling for some ISD procedural influences. Second, a small scale programmed text versus PLATO lesson comparison controlled for subject matter, lesson design, and nature of media differences.

Procedures. A 50-item topical test was prepared to assess achievement differences between each condition (excepting BL). Development constraints precluded trying out and revising the instrument. The test reliability was low, consequently the methods and results will not be included in this report.

Determining whether time savings were attributable to PLATO required comparisons with other self-paced media; therefore, four programmed texts were prepared to replace four PLATO lessons. The lessons were selected from those lessons which used computer graphics (rather than microfiche slides) to present illustrations, so that all screen displays could be electrostatically copied using a printer designed for the PLATO system. The off-line versions paralleled the on-line wherever possible, the major differences being: (a) response feedback was provided at the top of the next page, (b) feedback was not as varied, (c) no animations were possible, and (d) any departure from the programmed sequence was at the discretion of the student. Between 40 and 70 students received either version of the lesson during the last 4 months of 1975. Lesson completion times, end-of-lesson test scores, and student responses to two attitude items were collected. Attitude items asked the student for his preference for PLATO as opposed to programmed texts, and asked which medium he found easier to use. Attitude data were not collected from the PLATO lesson control group.

Results. Descriptive statistics for the measures taken to compare the PLATO and programmed text lesson versions are reported in Table 15. *T*-tests were performed on the score means, the results being not significant for any lesson pair. It should be noted that each PLATO version of the lesson had a higher mean score, the probability of this event being p = .0625.

Table 15. **Performance Data for PLATO and Programmed Text Comparison**

			Achievement (% Correct)			Time (Minutes)	
Lesson	**Type**	**N**	**M Lesson Test Score**	**SD**	**Test Failure**	**M**	**SD**
Cooling	PLATO	70	95.9	13.2	5	40.8	15.3
System	PT	44	93.8	14.8	7	32.3	10.9
Warning	PLATO	58	91.6	11.5	7	13.7	7.9
Systems	PT	41	87.3	18.0	9	14.4	4.1
Clutches	PLATO	56	91.2	15.8	8	24.5	12.4
	PT	42	88.0	15.9	6	26.0	10.8
Brakes	PLATO	51	95.8	7.5	0	46.0	18.5
	PT	46	93.0	13.1	4	41.7	11.2

Lesson completion times were analyzed in a similar fashion as lesson scores. The cooling system lesson pair was found to have significantly different completion times, $t(112) = 3.46$, $p < .01$. No other comparison attained significance.

A four-way classification table was used to determine if lesson failure was independent of media. The results indicated that programmed texts had a significantly higher failure rate, $\chi^2 (1) = 3.6$, $p > .05$.

Attitude item response frequencies are depicted in Table 16. Most students preferred PLATO to programmed tests, and found the CAI lessons easier to use.

In summary, the results of the comparison of PLATO lessons with a comparable lesson version using the programmed text medium found little difference in terms of lesson completion times and lesson text scores. Programmed text versions had a substantially greater failure rate and were less desirable to students.

Discussion of Comparison Findings. The results of comparing PLATO lessons with an off-line programmed text version demonstrated that the PLATO lessons were more instructionally effective: end-of-lesson test scores were consistently higher, and fewer failures were observed. The higher programmed text failure rate may have been the result of the loss of the forced review feature–students were required to repeat a lesson segment if they did not reach the author's standards for within-lesson testing–when the lessons were adapted for off-line use. Often, the fact that students did not review a portion of a programmed text when they made mistakes may have been a factor. Also, many students tended to look at answers on the next page of a programmed text before answering the questions. It is likely that the higher failure rate was attributable to a combination of these two circumstances.

Table 16. **Attitude Item Response Frequencies for PLATO-Programmed Text Comparison**

Lesson	Definitely Disagree 1	Disagree 2	Undecided 3	Agree 4	Definitely Agree 5	No Response
Item 1: I like programmed texts more than PLATO.						
Cooling System	16	9	13	3	3	
Warning System	21	9	5	3	3	
Clutches	19	11	5	3	3	1
Brakes	18	9	11	2	6	
Total	74	38	34	11	15	1
M = 2.16; SD = 1.29; N = 173						
Item 2: PLATO is easier to work with than programmed texts.						
Cooling System	4	5	6	13	16	
Warning System	5	4	6	9	17	
Clutches	3	1	9	10	19	
Brakes	9	2	6	14	15	
Total	21	12	27	46	67	
M = 3.73; SD = 1.36; N - 173.						

If the effort had been made to validate the off-line lesson versions prior to data collection, the resultant programmed texts would probably have required more time to complete. Basically, the lessons were technically accurate and the presentation of material by the instructional strategies employed was acceptable. Hence, revision would be of the form most commonly used in this situation; additional within-lesson practice in areas related to the end-of-lesson test. Additional practice would undoubtedly have brought about a corresponding increase in lesson time. Thus, the net effect would be the same as was indicated earlier; the programmed text versions would require more time, making them less instructionally efficient than the PLATO versions.

As it was, the intention of this comparison to investigate the effectiveness of the Chanute author's PLATO lessons relative to an off-line version of the same lessons, the results should not be considered as generalizable outside of that environment. It is possible that given a different target population and subject matter area, programmed texts may be more efficient. Even generalizing to the entire vehicle maintenance lesson population requires qualification. The lessons were selected from those which did not use the microfiche capability and a case could be made that the microfiche use was related to the more sophisticated lessons. For example, one lesson used microfiche in a randomized matching routine, which required students to identify ignition system components without error before progressing. Though not probable, it may be that lessons like this one would not be as instructionally efficient as a carefully prepared programmed text. All in all, the Chanute PLATO lessons were somewhat more efficient and preferred by students.

It may be possible to extrapolate cost savings from these tenuous indications; however, the merit of such an activity might be questioned. It will be evident from the cost analysis that potential savings had to be sizable for Chanute's style of CAI lesson to be cost-effective. To achieve a cost-effective operation with lessons which are slightly more efficient requires large numbers of lessons and a high degree of student use. Typically this situation is not possible in a military training environment.

PLATO Courseware

Procedures. Evaluation resources and circumstances rendered comparisons at the lesson level impractical; consequently, absolute measures of lesson effectiveness were desirable; i.e., each lesson should be assessed on the basis of goal attainment. The goal in this case was the lesson validation criterion employed by the ISD team. A lesson was said to be validated when 90 percent of a 30-student sample achieved the stated standard on their first attempt at the lesson. Once the validation criterion was met, lesson improvement activities were no longer mandatory. The validation data collection was retained during a lesson's post-validation period for a longitudinal study of goal attainment. Student scores, completion times, and number of lesson repeats were collected on each lesson, so that data collection lasted until February 1976 for some of the latest validating lessons.

Results. The primary indicators of lesson performance are presented in Table 17. The 10 percent maximum allowable failure rate selected by the ISD team for lesson validation purposes was used as a basis to judge the longitudinal performance of a lesson. If the failure rate was less than 10 percent after the lesson achieved its validated status, it was considered instructionally stable, requiring only periodic monitoring of the performance indicators to insure that changes in the target population or instructional setting did not decrease its effectiveness. If the failure rate was greater than 15 percent, performance data for the 40 students who received the lesson prior to 20 January 1976 were reviewed and the updated rate cited in the comments section. A failure rate falling in and/or remaining in the 10- to 20-percent range indicated that the lesson should be monitored, then revised if deemed necessary by the course administration. Revision was considered mandatory with a failure rate greater than 20 percent. Of the 35 instructional units prepared, four were in need of revision and eight required monitoring as of January 1976.

The self-paced nature of the CAI courseware could result in additional time savings if the group-paced Special Purpose Vehicle Repairman course went to a self-paced design. An estimate of additional common course segment time savings can be found by subtracting mean lesson time (20 hours) and estimates of block examination time (3 hours) and on-line remedial instruction (1 hour) from the total on-line time for the four blocks (30 hours). The residual 6 hours is the mean time that students spent on enrichment material over the four common blocks while waiting for the slower students to complete lessons. The common segment could be shortened by this amount if the loss of enrichment material did not impair attainment of objectives.

Discussion of Lesson Performance Results. The courseware performance indices signified that the lessons, as a group, were instructionally effective. With some additional revision, it is apparent that failure rates can be kept at approximately 10 percent per lesson. From a longitudinal standpoint, the PLATO courseware retained its effectiveness despite changes in the target population. The entering ability of the PB condition students increased over the 12-month data collection period. Higher ability students should perform well on the end-of-lesson tests. However, it is unknown whether these lessons would have retained their effectiveness had the entering ability of the target population declined. It is possible that increase in ability may be related to an attitudinal decline. Later PB students did not like PLATO lessons as well as early students, and one explanation is that the higher ability students found the lessons to be too easy. Though the longitudinal data indicated courseware effectiveness to be stable, there is reason to believe that changes in student entering ability may have produced undesirable changes in performance and attitude.

A further qualification upon the interpretation of student performance arises from a particularly frustrating student behavior. A number of students attempted to "beat the system" by finding ways of circumventing lessons. A favorite tactic was to page quickly through the lesson, learning just enough to satisfactorily respond to the periodic interaction. Then, upon taking the end-of-lesson test, the student familiarized himself with the items so that he could key upon the subject matter related to these items. Such a tactic arbitrarily inflated failure rates.

PLATO courseware is discussed extensively in the instructional materials development section. Many of the topics pertain to the effectiveness of these lessons; consequently, the interested reader is referred to this section.

Table 17. PLATO Courseware Performance Data

Instructional Unit	Title	Validation Date	Mean Lesson Time	Failure Rate (%) (Before October)	N	Comments
103	Gasoline Engine Principles	10 Jun	:30	11	63	Recommend Monitoring Student Performance
104a	Identification of Engine Parts	14 Apr	:34	6	114	
104b	Identification of Engine Parts	14 Apr	:34	14	113	Recommend Monitoring Student Performance
105	Cooling System	14 Apr	:44	12	102	Recommend Monitoring Student Performance
106	Engine Lubrication System	19 Jun	:15	18	33	Recommend Monitoring Student Performance
201a	Air and Exhaust System	28 May	:20	10	99	
201b	Air and Exhaust System	23 May	:38	28	109	22% Last 40 Cases (20 Jan 76) Revision Recommended
202a	Electrical Fundamentals	18 Aug	:148	18	33	Recommend Monitoring Student Performance
202b	Batteries	28 May	:15	2	99	
203a	Electrical Schematics	28 May	:28	3	33	
203b	Electrical Schematics	13 Jun	:28	6	33	
203c	Electrical Schematics	18 Aug	:28	9	33	
204	Starters	18 Aug	:48	6	33	
205a	DC Generators and Charging System	15 Jan 76	:60	21	33	Recommend Revision
205b	AC Charging System	15 Jan 76	:37	18	33	Recommend Monitoring Student Performance
206a	Battery Ignition System	13 Jun	:43	18	90	7% Last 40 Cases (20 Jan 75)
206b	Battery Ignition System	25 Jun	:23	18	65	5% Last 40 Cases (20 Jan 75)
206c	Battery Ignition System	11 Apr	:51	5	118	
207	Emission System	15 Aug	:32	9	33	
301	Diesel Engines	25 Jun	:31	21	109	12% Last 40 Cases Monitoring Performance Recommended
303	Lighting System	2 May	:13	10	109	
304	Vehicle Warning System	25 Jun	:11	18	65	10% Last 40 Cases (20 Jan 75)
305	Clutches	18 May	:25	4	109	
307	Principles of Hydraulics	14 Apr	:32	19	130	10% Last 40 Cases (20 Jan 75)
308	Automatic Transmissions	18 May	:48	37	109	35% Last 40 Cases (20 Jan 75) Recommend Revision
401	Propeller Shaft	17 Apr	:20	17	142	5% Last 40 Cases (20 Jan 75)
402	Differentials	8 Jul	:78	21	65	10% Last 40 Cases (20 Jan 75)
403	Transfer Cases and Power Take-Offs	30 Jun	:10	21	65	15% Last 40 Cases (20 Jan 75) Recommend Monitoring Student Performance
404	Suspension Systems	2 Sep	:13	0	33	
405a	Power-Assisted Brakes	26 Aug	:42	0	33	
405b	Power-Assisted Brakes	26 Aug	:10	9	33	
405c	Power-Assisted Brakes	26 Aug	:25	6	33	
405d	Power Assisted Brakes	2 Sep	:29	27	33	Revision Recommended
406	Mechanical Steering	30 Jun	:32	5	65	
407	Power Steering	2 Sep	:26	12	33	Recommend Monitoring Student Performance

Instructional Effectiveness Conclusions

The instructional effectiveness of the Special Purpose Vehicle Repairman course and its principal instructional medium, PLATO were assessed. The procedure was to compare key instructional effectiveness indices to determine the relative efficiency of the new course and the PLATO medium. Like most evaluative field research, site conditions distorted somewhat the clarity of individual findings. However, as in the situation where one views a newspaper photograph from a distance and sees a meaningful picture rather than a collection of dots, the individual findings do portray the effectiveness issue when viewed as a composite.

Course performance indices showed the new Special Purpose Vehicle Repairman courses to be highly efficient. Data analysis revealed no major group differences between the evaluation conditions except for reduced student completion time for the PB condition. The 28 percent time reduction in the common course segment was attributable to the use of individualized, self-paced media, group-paced instructional design, and adherence to the ISD philosophy of preparing lean, but effective and relevant, instruction.

Student achievement in the new course was similar to that of prior versions with and without the use of PLATO. Consequently, PLATO lessons can be said to have produced comparable learning outcomes. It is evident that the Chanute PLATO authors were able to develop effective lessons for presenting factual and conceptual information. Moreover, there was some indication that these CAI lessons may have been more efficient than a programmed text counterpart. Student performance did not fluctuate due to instructor differences because of the standardized characteristic of the CAI lessons. PLATO (as a technical training tool) and the consolidated ISD and PLATO development team lessons were instructional effective.

The quantitative evaluation findings supported the observations of instructor, project, and evaluation team personnel. Another way of conveying the point that PLATO and the new course were performing their role is to compare student behavior in different environments. Instructors in the PLATO laboratory seldom cautioned students to remain alert, even if their students had experienced the majority of their PLATO lessons. Instructors, management, and evaluation team personnel had noted that this was not the case when student–in some situations even the same students–were interacting with programmed texts and workbooks. This type of CAI system captured and retained student attention for the same reasons that laboratory tasks do so. The student interacted with and manipulated his learning environment. Since this situation was more prevalent in the new course with its PLATO lessons and its greater emphasis on laboratory activity, it is reasonable to propose that this student activity had a direct bearing on the efficiency of instruction.

IV. COST FACTORS

Introduction

This section examines the costs and benefits associated with the PLATO systems as used at Chanute. Since no competing system which had the same goals and outcomes was available for comparison purposes, a true cost-effectiveness study was not possible. Where possible, comparative information will be given. For example, when discussing costs, the developmental and operational expenditures can be compared with a similar system which would not rely on PLATO. Moreover, PLATO-related benefits will be presented as actual and potential savings, and those tangible benefits upon which it is difficult to place a dollar value: student attitudes, improved methods, and enhanced safety.

Method

PLATO-related cost and benefit data were collected during the first 9 months of 1976. Collection procedures primarily involved interviews with personnel directly associated with the design, development, and operation of the PLATO instructional program. Applicable records and reports, available from CERL and Chanute activities, were also used as data sources. Cost figure details varied considerably, because a breakdown of costs was not kept. The level of detail was influenced by the conditions of the service test. For example, the attempt to appraise the total lesson development cost was heavily contaminated by the fact that much of the material developed for the original target course was modified for the Special Purpose Vehicle Repairman course. As a result, cost comparisons between course versions must be on a very global level.

Certain assumptions are necessary to provide comparative information. It will be assumed that the Special Purpose Vehicle Repairman course without PLATO would have used programmed texts, where CAI lessons were used and conventional paper-and-pencil block examinations instead of the computer-administered tests.

Results and Discussion

Equipment Costs. Table 18 lists equipment costs during the service test. The Varian printer was a

Table 18. **Capital Cost of Equipment**

Device	Number	Cost
Terminal	30	$156,150
Touch panel	30	16,320
Varian Printer	1	7,588
Audio Unit	1	2,000
Microwave System	1	9,630
Total Capital Investment		$191,688

useful device which made an electrostatic copy of a PLATO panel display. The audio unit was never used in conjunction witht he project, since only one was available and the device had poor reliability.

Facilities Preparation Costs. Electrical outlets, and pneumatic lines and controls were installed in the PLATO terminal room. Power and air outlets were placed near each of the 30 carrels in which the terminals were placed. Each carrel had a variable-intensity light for note-taking purposes. Costs associated with facilities preparation are presented in Table 19.

Table 19. **Facilities Preparation Costs**

Facilities	Cost
Electrical and Peneumatic	$1,822.50
Carrels (3)	2,700.00
Variable-intensity light with anti-theft cable	280.00
Total	$4,802.50

Operating Costs. To maintain the operational course involved some yearly expenses directly attributed to PLATO. These expenses were classified as computer leasing, terminal maintenance, communications, facilities, and support personnel. Table 20 depicts these costs for the operational SPVR course. If PLATO had not been used in this course, recurring costs associated with programmed texts and block examinations would have been present. Ordering, storage, and handling of replacement programmed texts, tests, and answer sheet forms would have cost approximately $2,500 per year. Thus, with the 30-terminal system employed at Chanute, the operating expenses were approximately $87,500 higher than a similar system which would not use PLATO.

Table 20. **Operational Costs**

Item	Annual Expense	
Computer leasing	$45,000	(1,500/terminal)
Communications	6,120	(204/terminal)
terminal maintenance	30,000	(1,000/terminal)
Facilities[a]	1,318	
Utilities[b]	295	
Support personnel[c]	7,200	(Estimate)
Total	$89,933	

[a] Prorated costs of utilities (air conditioning, lighting, compressed air, etc.) and maintenance for the PLATO lab area, 1,600 sq. ft.

[b] Power costs to operate terminals based on a mean usage of 1,092 hours per year per terminal, and 500 watts per terminal.

[c] Based on two authors (GS-9 and GS-5 ratings) and a computer coder (GS-7—spending about 20% of their time on operational maintenance tasks.

Developmental Costs From the point where the ISD and PLATO projects merged, it cost $52,200 to adapt lessons developed for the General Purpose Vehicle Repairman course, create new courseware, program CMI routines, and develop 14 block examinations. The cost figures were based on 6,517 civilian and military man-hours. With such gross figures available, no attempt was made to use this information for comparative development costs. Yet, the following estimate of comparative costs was made. For the simple tutorial lesson produced in a quasi-team approach (see Instructional Materials Development Section), approximately 100 man-hours were required to develop one student contact hour on PLATO. It takes approximately 40 hours to develop one draft programmed text contact hour. The CAI lesson, on the other hand, was ready for validation tryouts. Using an estimated hourly wage of $7.80 which includes indirect support costs, the cost for a tryout-ready CAI lesson was about $780 dollars per contact hour. Using the same $7.80 figure and adding in typing and printing expenses, the tryout-ready programmed texts cost about $470.00 per contact hour, a difference of $310.00. Obtaining the validated lesson would narrow this price difference somewhat since a programmed text would generally be more expensive to revise. Lesson revision typically involved adding questions, improving text, and eliminating technical and grammatical errors. These activities could be accomplished more easily on PLATO because of edit capability. With programmed text, changes involved retyping pages, cutting and pasting, and reproducing enough copies for the next tryout. Moreover, obtaining a final version of a programmed text involved retyping the entire text, performing artwork, and proofreading. After a PLATO lesson was validated, it was ready immediately for use. Our best estimate was that overall the price difference was less than $155 per contact hour. ($310 difference minus $155 typing and printing costs.)

For each block examination, course authors used the same computer coding routine; hence, the basic differences in development costs were small. After the routine was duplicated into a lesson file, a clerk typed in the questions. No reproduction costs were therefore incurred. The original routine cost approximately $500.00. It is assumed that reproduction, assembly, and handling charges would balance this development cost, since eventually 60 block examinations were put on-line. Consequently, cost differences were small.

The cost to develop the routine which automatically performed the test analyses required by ATC (see Management section) could not be determined. The benefits in terms of real savings and aesthetic consideration were great and will be discussed later.

It was apparent that the PLATO version of the Special Purpose Vehicle Repairman course cost more to develop. Using a difference of $155 to develop a student contact hour and a mean number of contact hours of 20, the difference for the lessons alone was $3,100. For the additional routines of a CMI nature, one might add several thousand dollars.

Cost Savings

Real Savings. In the military environment, shortening training time produces real savings. For example, the reduction of the common course segment by 28 percent brought about a yearly savings of $180,000. This saving was attributable to all the changes brought about by the redesign of the courses. What portion of this time savings was attributable to PLATO is unknown, but an estimate can be provided. From Army experiences at Aberdeen Proving Grounds (Department of the Army, 1975) and the results from the programmed text/PLATO lesson comparison, it was reasonable to assume that the CAI lessons provided a time savings. The Aberdeen report suggests at least a 10 percent time reduction. The programmed text-CAI lesson comparison suggested that the off-line version would require additional practice or explanation in order that the failure rates would not be different. From these experiences, it was assumed that Chanute PLATO lessons saved approximately 10 percent over programmed text equivalents. The mean on-line time for mainstream lessons was 20 hours. If programmed texts were used, it would have increased training time by 2 hours per student.

Block examination administration and critiquing time was cut in half by the use of the PLATO system. A net saving of 6 hours was experienced for the four common course segment blocks. Therefore, an estimated time savings attributed to the Chanute use of PLATO IV was about 8 hours or one and one-third training days. At $48 per student per day (provided by Chanute AFB Requirements Section) and a total student flow of 375 per year for the four Special Purpose Vehicle Repairman courses, the estimated savings was approximately $23,000.

If it can be assumed that time savings for the instructor's tasks allowed him to be productive in other areas, then instructor time savings produced real savings. For example, if instructors no longer had to grade end-of-lesson tests and block examinations, and they had more time available because test analyses were automatically performed, then they could use that additional time to revise test items. Thus, instructor productivity could increase, and a method of appraising the dollar value of this productivity could be found. However, because instructor time savings were typically spread out over a long period of time rather than grouped, lesson test grading time savings occurred daily and saved small amounts of time. It is unrealistic to think that the time savings would promote productivity. All things considered, the PLATO system reduced the instructor's burden, yet the time savings associated with this reduction had no measurable dollar value savings in this environment.

Potential Savings. Within the PLATOized common course segment environment, instructors had few demanding tasks. Little student-instructor interaction was required, and the instructors felt that monitoring student progress would just disturb the students, since the interaction between student and terminal kept the student attentive. In a self-paced environment, or a group-paced design with a different management structuring, the instructor staff could be reduced. This was one area for potential savings. Even if the number of individuals required in the PLATO laboratory to assist students would not be decreased, it was apparent that the level of responsibility could. Many of the exchanges between instructors and students had no training function, thus instructor assistants could have easily performed adminstrative and management tasks.

Additional savings would result from increased terminal utilization. The 30 PLATO terminals were available from 7:40 a.m. to 10:00 p.m. during a period designated "prime time." Special Purpose Vehicle Repairman course students interacted with the terminals for approximately 25 to 30 percent of the available prime time. Through careful management of the resource (see Management section) the terminal utilization could be at least doubled, as was demonstrated late in the service best by the inclusion of General Purpose Vehicle Repairman course students in some portions of the training program, which were in common with the Special Purpose Vehicle Repairman courses.

Another area where PLATO could have provided savings was utilization of instructional resources. Training equipment requirements might be reduced by allowing students to practice tasks on the terminal and then testing on real equipment. As an example, students were required to wire simple circuits on a training device. The activity could have been done on PLATO, then tested with real devices; the more expensive complex, and fragile the equipment, the greater the potential savings. To illustrate, the student tuned up engines with an engine analyzer. If a simulation were made which allowed the student to attain a desired level of task proficiency before actually performing the real task, less hands-on time would be required and students could learn the task more quickly with less chance of damaging actual equipment.

A number of administrative applications could be performed by PLATO. Student records management could be automatically performed, reducing the instructor's responsibilities and possibly eliminating a clerical position. Course control documents might be developed and maintained on the PLATO system. This would expedite their preparation and revision. If PLATO applications were expanded to other courses, a terminal situated near the staff agencies charged with review of courseware, records, and control documents could be used for review purposes.

Other Benefits. It is difficult to place a dollar value on many of the benefits which were, or could be, associated with PLATO. For example, how much money was saved because student attitudes were higher towards PLATO than programmed texts? Did these higher attitudes promote efficiency? It was not possible to determine savings from these benefits, but they should be mentioned.

In many cases, PLATO applications improved training methods. On-line test administration and test analysis reduced the number of test-associated tasks (test security measures, visual inspection of test forms for pencil marks, annotating individual items responses for each student). Instructors were pleased about this aspect of PLATO. Updating of training materials was much easier, changes could be in effect the same day that the need became apparent. The use of simulation often decreased safety risks associated with maintenance tasks. Students who practiced reading the battery hydrometer and interpreting the results on PLATO required less practice in the laboratory. Thus, they directed more of their attention to the manual aspects of the task insuring that they did not spill battery acid.

Many applications may be derived which could improve training practices. With respect to laboratory tasks which required small groups of students to perform, it was doubtful that the student got experience with each subtask. Through the use of simulation and performance testing on PLATO, the student could attend to each subtask. Some teaching activities, such as demonstrations, could be improved; the demonstration could not always be performed under good conditions. A demonstration performed in the Crash/Rescue Vehicles course may illustrate the point. The instructor demonstrated key tasks in the operational checkout of a fire truck system to a group of 12 students. Because it was difficult for more than four or five students to view the procedure, some became distracted or restless. Consequently, the value of the demonstration was questionable. Since the development of a training aid would be a long, expensive process and a PLATO lesson with interactive displays might accomplish the intent of the learning activities in far less time with greater effect, it is desirable to try such applications.

The flexibility of the PLATO system could allow it to be used for many diversified applications which could improve instructional methods. It was noted that once instructor and management personnel accepted and became involved with the project they became more innovative; i.e., thinking of ways to improve their instructional environment through PLATO applications. Again, a dollar value cannot be assigned to this effect.

Conclusion

The PLATO-based Special Purpose Vehicle Repairman course was not as cost-effective as one that would use programmed texts and conventional testing procedures. It is believed though, that if a serious effort were undertaken to optimize system usage through systematic manipulation of real and potential benefits, a PLATO-based course operation would cost less than a non-CAI environment that had similar goals and desired outcomes.

V. INSTRUCTIONAL IMPACT

Overview

This section will examine the impact of PLATO on vehicle maintenance training conducted in the four service test courses. The specific aspects to be reported are (a) student and instructor attitudes, (b) the impact of PLATO on daily training activities, (c) changes in Air Force regulations necessary to incorporate PLATO, and (d) the effect of PLATO on potential new capabilities within vehicle maintenance training.

Student and Instructor Attitudes

Introduction. Measuring student attitudes toward training was necessary to obtain an indication of how well the instruction was matched to student capabilities. If attitudes are positive, it is more likely that a training system is operating with acceptable efficiency. But, it student attitudes are found to be negative, it is possible that something is wrong.

In like manner, instructor attitudes can be an indication of training system acceptability. If attitudes are positive, it can be expected that instructors will work with and improve an instructional system. On the other hand, if attitudes are negative, it is highly likely that the system will fall into disuse as soon as the tryout period, regardless of its outcome, is completed.

For this portion of the PLATO evaluation, a variety of attitudes were measured in order to cover a broad spectrum of student and instructor reactions to introduction of the new system. Surveys were developed to examine attitude changes over time, to detect reactions to specific features of the training sytem (both PLATO and non-PLATO), and to compare attitudes of students at Chanute with attitudes of students at other training centers who had not experienced PLATO.

Student Attitudes. Student attitudes were assessed with three instruments. The first questionnaire, designated the Short Form Survey, was designed to measure changes in attitudes toward medium of instruction as students progressed through the course. A second questionnaire, called the Long Form Survey, was developed to obtain more extensive reactions to the PLATO medium specifically. The final measure of student attitudes, the Technical Training Survey, was an instrument developed by the Personnel Research Division of AFHRL. This questionnaire was employed in the present study, primarily to compare the attitudes toward technical training of the present sample with those of the entire student population at Chanute, as well as with students at other ATC training centers.

Short Form Survey. Two different versions of the Short Form Survey were constructed, one for students who experienced PLATO training, and one for students in the non-PLATO (NP) condition. These instruments were intended to be parallel forms and consisted of five endorsement items and two open-ended items (see Appendix B). The PLATO version and the NP version differed basically with respect to two items covering medium of instruction. PLATO students saw items referring to PLATO, while non-PLATO students saw items referring either to the instructor or classroom depending upon which was more appropriate.

The five endorsement items were scored using a Likert-type format, with a scale ranging from 0 to 9. They covered five aspects of the training situation–enjoyment of training, perceived effectiveness of training, satisfaction with principal medium of instruction (instructor or PLATO), adequacy of the content of instruction, and perceptions of the extent to which training was a challenge. The open-ended items requested students to comment on what they liked best about their training and what they would like to change.

The Short Form Survey measured attitudes at a general level and was intended to permit comparisons between conditions (PB, CP, and NP) at different points in time.

Method. During the early stage of the evaluation, the Short form was given to all students four times, once in each of the four common blocks. A total of 41 students in the PB condition, 35 students in the CP condition, and 23 students in the NP condition completed all four administrations of the survey from early January 1975 until the last week of June 1975. All classes beginning after May 1975 were entered into the PB condition. At this time, administration in every block ceased, and only students completing the fourth block of instruction were given the instrument. Consequently, data were collected from 132 additional students during the May through September period of the service test as they completed the PLATO-based portion of their training.

The Short form was administered approximately 2 days before the end of each block of instruction. For students in the group-paced PB condition, this entailed completing it at 7- to 10-day intervals. Students in the lock-step CP and NP conditions received the questionnaire after regular 14-day intervals. All administrations of this form were conducted in the normal classroom.

Results. For the purpose of comparing CP and PB condition attitudes toward PLATO, the five items on the PLATO questionnaire were summed and considered to be a scale. When including the NP condition as well, only items 2, 3, and 4 seemed to logically compare media across the three conditions. That is, the substitution of instructor for "PLATO," in items 1 and 5 was viewed as keying the student to a particular medium, whereas the connotations of "class" (items 1 and 5, Appendix B) seemingly related to the entire instructional milieu. Therefore, for comparisons involving the NP condition the score was calculated by summing items 2, 3, and 4. The internal consistency reliabilities of these two scales, as estimated by Cronbach's Alpha, are reported in Table 21. These reliability estimates were found to be acceptable. Comparison of PB and CP conditions was made by summing all five responses to create a scale score for each student on each of the four administrations. To facilitate analysis, twenty students were randomly selected from each of the PB and CP conditions and their scores were analyzed using a 2 x 4 (condition by

Table 21. **Short Form Survey Alpha Reliability Estimates**

Reliability/ Number	Block of Administration			
	1	2	3	4
A. Five-Item Scale (CP and PB Conditions)				
α	.817	.856	.889	.900
n	104	104	194	198
B. Three-Item Scale (NP, CP, and PB Conditions)				
α	.705	.745	.830	.817
n	126	126	136	219

administration) ANOVA with repeated measures on the last factor. Table 22 indicates that only the administration main effect was significant. As Figure 3 shows, the mean student scale scores decreased over the four administrations of the survey. Scale scores could range from 0 to 45; thus, a value of 22.5 would be considered neutral. Though student attitudes decreased across administrations, all means showed a positive orientation toward PLATO.

Table 22. **Analysis of Variance: Short Form Survey**
(PB and CP Conditions)

Source	MS	df	F
Between Subjects			
Condition (CP, PB)	726.76	1	2.79
Sub w/conditions	260.02	38	
Within Subjects			
Administration (1-4)	406.60	3	10.86*
Condition x Administration	16.91	3	.45
Admin x Sub w/conditions	37.45	114	

*$p < .01$.

Similar to the preceding analysis, scale scores for a random selection of twenty students in all three conditions were compared. A 3 x 4 (condition by administration) repeated measures ANOVA was performed on scale scores for the three items which addressed the principal medium. The results (Table 23) were similar to the preceding analysis in that only the administration main effect attained significance, $p < .05$. Again, the decreased mean scale scores across administrations (Figure 4) appear to be responsible. Since the neutral point for this scale was 13.5, all attitude means were again in the positive range.

Examination of the open-ended items revealed spontaneous comments about the positive and negative aspects of using PLATO. On the positive side, students reported liking graphics and illustrations (particularly those involving movement), felt the programs were easy to understand, and were pleased with the review features that PLATO employed. They also frequently reported that they enjoyed the enrichment lessons and the games that were available as time buffers for fast students. Many positive comments were also related to group-pacing.

Negative comments mostly concerned the PLATO lessons. Several comments indicated that wording of questions did not match the instruction and that missed questions often required review–not only of material related to the question but of additional material which was not related. Many comments were directed at the exactness of the answers required. Close answers were often judged wrong, which was frustrating and annoying. Students reported difficulty reading microfiche images, particularly when

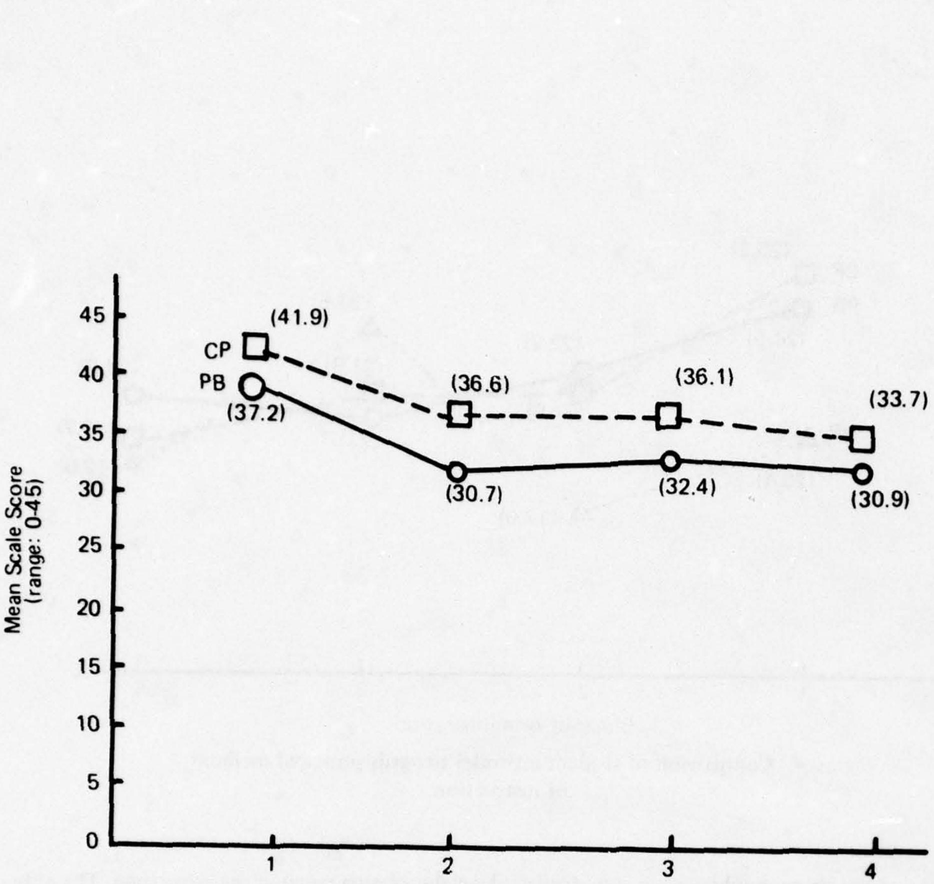


Figure 3. **Comparison of short Form Survey results for the PLATO-Using evaluation conditions.**

Table 23. **Analysis of Variance: Short Form Survey**
(PB, CP, and NP Conditions)

Source	MS	df	F
Between Subjects			
Condition (PB, NP, CP)	134.47	2	1.77
Sub w/groups	75.82	57	
Within Subjects			
Administration	142.62	3	3.24*
Condition x Administration	74.81	6	1.70
Admin x Sub w/groups	44.08	171	

*p < .05.

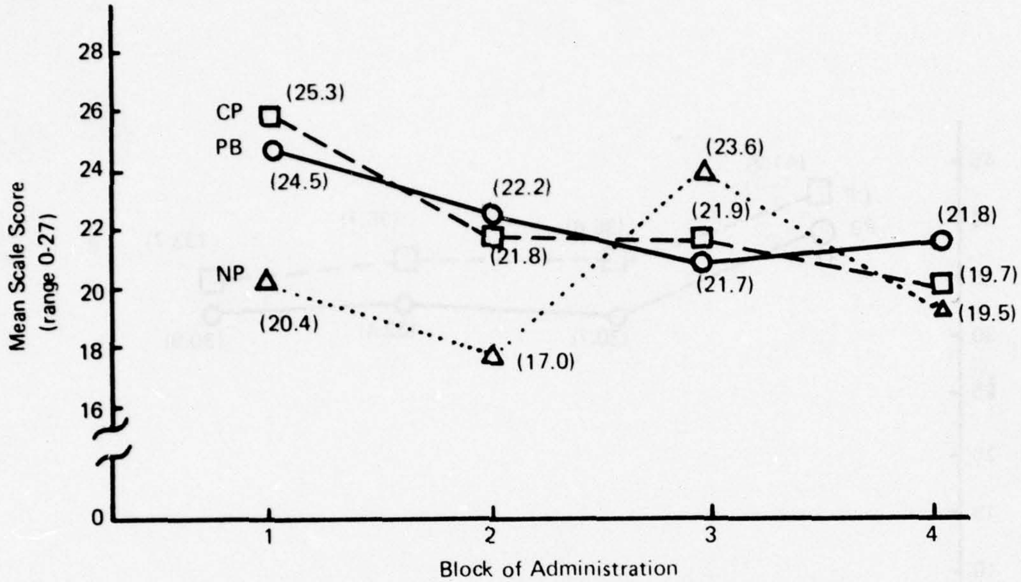


Figure 4. **Comparison of student attitudes towards principal medium of instruction.**

computer-generated words or graphics were also displayed on the plasma panel at the same time. The only negative statements, not relative to PLATO, concerned the hardness of the chairs.

Discussion. Analysis of the Short Form Surveys showed several marked consistencies among student responses toward PLATO as a training medium. First, attitudes toward PLATO remained positive throughout the 6- to 8-week exposure to the system. Students enjoyed using PLATO even after 20 or more hours of contact with it. As might be expected, the novelty diminished over time which may have accounted in part for the positive attitude reduction over the period. Another contributing factor may have been the state of the lessons during the data collection period. Most lessons had not been validated; consequently they contained technical errors and were subject to presentation difficulties. Increasing exposure to the unvalidated lessons may have lowered attitudes toward PLATO.

As Figure 3 indicates, student attitudes seemed more consistent toward PLATO across administrations than they were toward instructors. Just prior to the evaluation period, several new instructors joined the Vehicle Maintenance Branch. Since their teaching skills were not fully developed, it is logical to assume that student contact with them could have caused student attitudes to become less positive. Even though not wholly appropriate (no significant main effect was noted) two *post hoc* mean contrasts were performed. Using the Tukey procedure (Kirk, 1968, p. 268) the combined CP and PB mean was found to be significantly greater ($p < .05$) than the NP mean for each of the first two administrations. The new instructors taught the first two blocks of instruction, where these possible attitude differences between NP and combined PLATO students were found. Also, a popular instructor taught each of the NP condition classes in block 3 and a less popular instructor taught block 4. The Tukey procedure was again used to contrast the four NP condition means. A significant attitude difference was found between blocks 2 and 3, and the decline from block 3 to block 4 was also significant. Course critique information was consistent with these quantitative results.

Not surprisingly, all data indicated that in a training environment where the instructor is a principal medium, student attitudes will be substantially influenced by the characteristics of the instructor.

Content analysis of the open-ended comments indicated that while students liked many aspects of the PLATO system, there was still room for improvement in the Chanute lessons. Again, it should be remembered that these lessons were in the formative evaluation stage, and most were validated after administration of the surveys used to assess condition differences. It was determined that in each of the conditions students liked their principal medium of instruction. Also, standardized presentation media, such as PLATO, provided a consistency to student attitudes. Finally, student orientation toward a medium remained positive, but declined as the students became more familiar with the medium.

Long Form Survey. Attitudes of students toward specific features of PLATO were assessed by means of a specially constructed 66-item inventory designated the Long Form. This instrument was developed to obtain more in-depth reactions than was possible with the Short Form Survey. Forty-five of the Long Form items were adapted from a scale developed by Brown (1966) and were used to measure attitudes specifically related to working with the PLATO medium. Of the remaining items, six were directed at attitudes toward various media (movies, PLATO, programmed texts); twelve employed a modified semantic differential (e.g., PLATO is boring, exciting, fun) and two were related to perceptions of system reliability. A final item measured overall satisfaction with PLATO. All but the last three items were measured by a 10-point agree disagree scale (0 to 9). The last three items measured how much time a person had difficulty with PLATO or liked it. They used a percentage scale of 0 to 9 representing 10 to 100 percent of the time (see Appendix C).

Method. The Long Form was administered once, at the end of the fourth block of instruction to students in the PB and CP conditions. From January 1975 through September 1975, 43 students in the CP condition and 157 students in the PB condition completed this survey.

Responses of all students were combined and the questionnaire was factor analyzed to determine the attitude areas sampled. This analysis revealed five general factors. These factors, the items in each, and their loadings are presented in Appendix D.

The first factor consisted of those items related to PLATO and was labeled PLATO Training. The second factor was difficult to classify; however, the items were generally related to the annoying, frustrating aspects of working with PLATO, designated Training Frustration. Items comprising the third factor related to stressful aspects of the training environment and were therefore labeled Training Stress. The fourth factor contained references to media other than PLATO which were employed in daily training and was titled "Non-PLATO Media." The final factor was related to the humanistic aspects, or lack thereof, in a computer-based training setting. Accordingly, this fifth factor was labeled "Mechanistic Training."

Results. Based on the factor analysis, each of the five dimensions was considered to be a scale, and scale scores were calculated for each person. A person's item responses were summed yielding a raw total for each factor. In order to keep the factor scores comparable across scales, the sums of the item responses were divided by the number of items appearing on a particular scale. The means of these scale scores are presented in Table 24. On the whole, it can be seen that students tended to be positive toward PLATO instruction, did not feel frustrated or overly stressed, and did not find the training to be mechanistic. Comparison of the PB and CP conditions by *t*-test indicated that no significant differences were present for any of the factors.

Since the system was constantly improving over the course of the survey, it was hypothesized that later PLATO-Based (LPB) students would have more positive attitudes than earlier PLATO-Based (EPB) students. Additional analyses failed to uphold this hypothesis. In fact, the opposite was observed on Factor I (Attitude toward PLATO instruction), the means being 6.31, and 5.60, for the EPB and LPB conditions, respectively. Using a t-test ($t = 2.14$, $p = .03$, $df = 143$) this difference was significant. This decline may have been the result of an initial Hawthorne effect, or a reduction in instructor attitudes, which will be discussed later.

Table 24. **Mean Responses to Attitude Factors by Students**
(PB and CP Conditions, Scale = 0 to 9)

Factor	PB (N = 153)	CP (N = 42)
PLATO Instruction	5.79	5.27
Frustration	4.74	3.58
Training Stress	3.44	3.56
Non-PLATO Media	5.31	5.33
Mechanistic Training	2.75	3.17

Examining specific items relating to media preference revealed that, in the PB condition, PLATO lessons were the most preferred medium next to laboratory instruction. CP students, on the other hand, did not hold PLATO lessons in such high regard, rating them least preferred of all media. The difference between means on this item was statistically significant ($t(196) = 2.28$, $p = .02$). A graphic representation of the mean ratings of the various media is presented in Figure 5. The only other notable difference between conditions was the higher preference of the CP students for laboratory instruction ($t(196) = 2.45$, $p = .02$).

Relative differences between conditions in terms of the semantic differential items are graphically displayed in Figure 6. In general, students in the PB condition had a tendency to rate these items about the same as CP students. Treating the twelve responses as a scale, no significant differences between conditions were found. Looking at specific items, one major difference was that PB students perceived PLATO to be more frustrating ($t(196) = 2.82$, $p \leqslant .01$). This difference may be related to the fact that PB students had more interaction with PLATO. The only other significant difference was that PB students were more likely to report that PLATO made them feel proud of their accomplishments ($t(195) = 2.38$, $p \leqslant .02$). The group-pacing mode experienced by PB students may have accounted for this difference, since group-pacing gave students more immediate feedback on the results of their efforts than did lock-step course design.

To determine the relationship between system reliability and attitudes toward PLATO lessons, two items dealing with system reliability were correlated with the item, "As a student I do my best work with PLATO lessons" (item 2, section III). The first reliability item was positively worded and asked how often the system worked when attempting to use it; the second reliability item was negatively worded, asking how often system interruptions made the respondent want to stop using PLATO (items 19 and 20, section III). If attitude and system reliability were related, one should find a positive correlation between attitudes toward PLATO lessons and the first reliability item. Conversely, a negative correlation would be expected with the second reliability item.

As expected, these relationships were found to exist. Correlation between perceived reliability and attitude toward PLATO lessons was .40, significantly different from zero at the .01 level. Correlation between the negatively stated reliability item and attitude was –.42, again statistically significant. Thus, the more frequently students had trouble with PLATO hardware, the more negative their attitudes.

Discussion. The in-depth investigation of attitudes toward PLATO showed that the system was perceived as an acceptable part of the training environment. Combining PLATO with the group-paced training mode, though tending to increase frustration levels, did not reduce positive student attitudes toward their training. Moreover, the fact that CP students rated PLATO lessons as the least preferred of all media is understandable in that the lessons were not validated and the CP instructors openly expressed their concern over the effectiveness of the PLATO lessons (see discussion of course effectiveness). Finally, hardware reliability appeared to exert a major influence on how students perceived the effectiveness of the

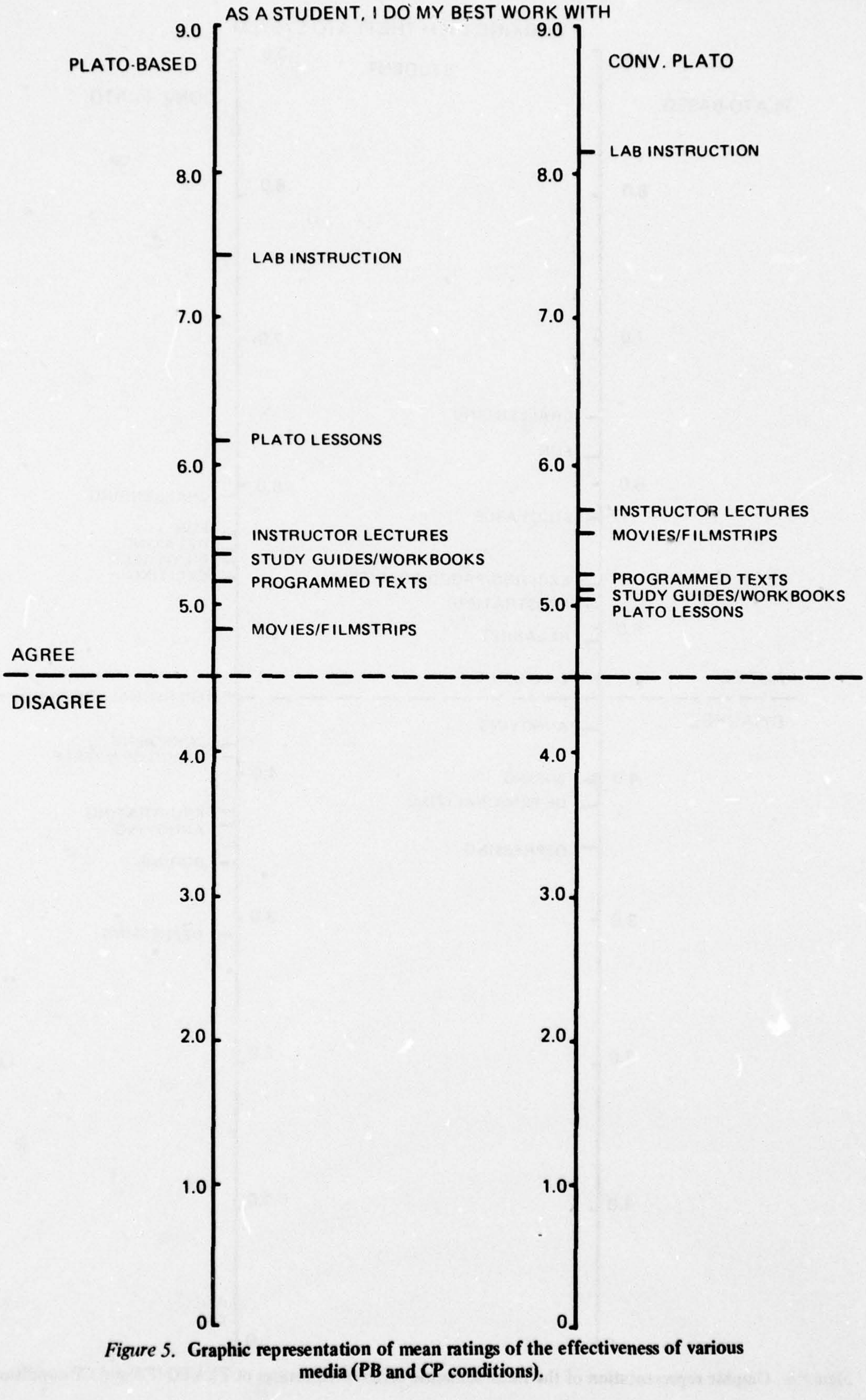


Figure 5. **Graphic representation of mean ratings of the effectiveness of various media (PB and CP conditions).**

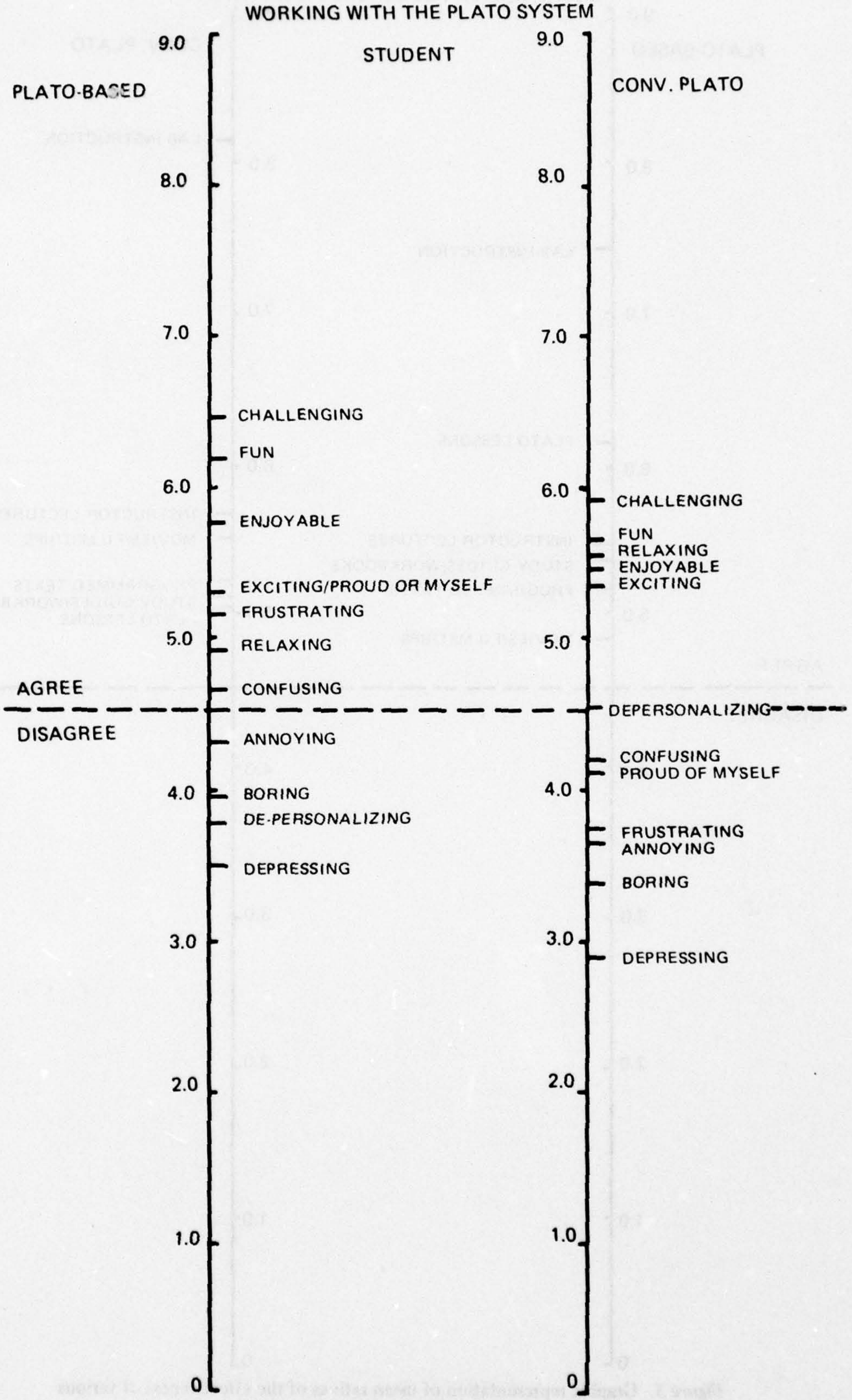


Figure 6. **Graphic representation of the mean semantic differential ratings of PLATO (PB and CP conditions).**

system, and as a result should be given close attention in all decisions concerning future use of CAI in general, or PLATO specifically.

Technical Training Survey. This instrument was developed by the Personnel Research Division of AFHRL for the purpose of uncovering attitudinal or motivational factors connected with attrition from technical training. It was administered to 12,666 students across Air Training Command in 1974 and 1975. Twelve dimensions were measured using 121 items. Factor analysis confirmed the construct validity of the scales (Vitola, personal communication). A brief description of the instrument follows; the entire survey is included as Appendix E.

The first three scales were motivational in nature, consisting of Instrumentality (the extent to which the respondent saw good performance in technical training to be instrumental in obtaining valued outcomes); Valence (the attractiveness of potential outcomes associated with good performance in technical training), and Valence of Performance (the multiplicative combination of instrumentality and Valence summed over all outcomes). These concepts come from the Expectancy-Valence formulations of Vroom (1964) and Lawler (1971). Valence of Performance can be considered a rough measure of individual motivation, since motivation is theoretically a partial function of the strength of the reward structure in a situation and the extent to which people perceive rewards as a consequence of good performance.

The next seven scales covered opinions about particular aspects of the training situation: Instructor Technical Competence (the extent to which the instructor was viewed as knowing how to present instruction); Instructor Personal Relations (the extent to which the instructor was seen as supportive and considerate); Fellow Students (the extent to which contacts with fellow students promoted a harmonious learning environment); Organization Control (perceived degree of control exerted by the organization); Training Stress (amount of pressure felt by the student); Training Materials (perceived adequacy of materials, methods, and their utilization); and Physical Setting (satisfaction with environmental factors–ventilation, heat, light, work space). Finally, two short scales covered Global Training Satisfaction and Career Choice Satisfaction. These measures provided another set of attitudinal data from which to draw inferences about the impact of PLATO training.

Method. Two administrations of the survey were made as part of the service test. These occurred during block 1 and block 4 for students in all conditions. Comparisons between conditions across administrations were possible, as well as comparisons between PLATO service test students and students across the entire Air Training Command.

Results. Eight of the 12 scale scores were analyzed by a 4 x 2 repeated measures ANOVA, condition being the first factor and administration the second. Significant differences in attitudes can be summarized as follows.

For all the motivational variables, there were significant administration effects, but no differences between conditions; i.e., means for all conditions tended to decline across administrations. This was especially noticeable for Instrumentality. A similar, but less pronounced decline, occurred for Valence. Since Valence of Performance was multiplicative combination of the preceding variables, it also dropped.

Both scales dealing with the instructor–Instructor Technical Competence and Instructor Personal Relations–showed significant interaction effects. Results of these two ANOVAs are presented in Tables 25 and 26; associated figures which depict the relationships graphically are Figures 7 and 8. In answering the questions dealing with the instructor, students in the PLATO condition were told to respond as if the PLATO system were the instructor. Hence, these results permit a comparison between attitude toward real instructors and toward the PLATO system. Post-hoc analysis by Scheffe method showed that the means for the two PLATO-using conditions, taken together, were significantly lower than for the non-PLATO conditions on Administration 2.

Attitudes toward the physical setting also declined between the two administrations, but there were no changes across time or differences between conditions on either Global Training Satisfaction or Career Choice Satisfaction. Due to an error in coding the raw data, repeated measures analyses could not be performed on four scales–Fellow Students, Organizational Control, Training Stress, and Training Materials.

Table 25. **Analysis of Variance: Instructor Technical Competence**

Source	MS	df	F
Between Subjects			
Condition (PB, CP, NP, BL)	238.14	3	2.56
Subj w/conditions	93.18	76	
Within Subjects			
Administration (1, 2)	819.02	1	22.52*
Condition x Administration	330.08	3	9.08*
Admin x Sub s/conditions	36.36	76	

*p < .01.

Table 26. **Analysis of Variance: Instructor Personal Relations**

Source	MS	df	F
Between Subjects			
Condition (PB, CP, NP, BL)	276.57	3	3.38*
Subj w/conditions	81.70	76	
Within Subjects			
Administration (1, 2)	1248.81	1	37.95*
Condition x Administration	160.66	3	4.88*
Admin x subj w/conditions	32.90	76	

*p < .01.

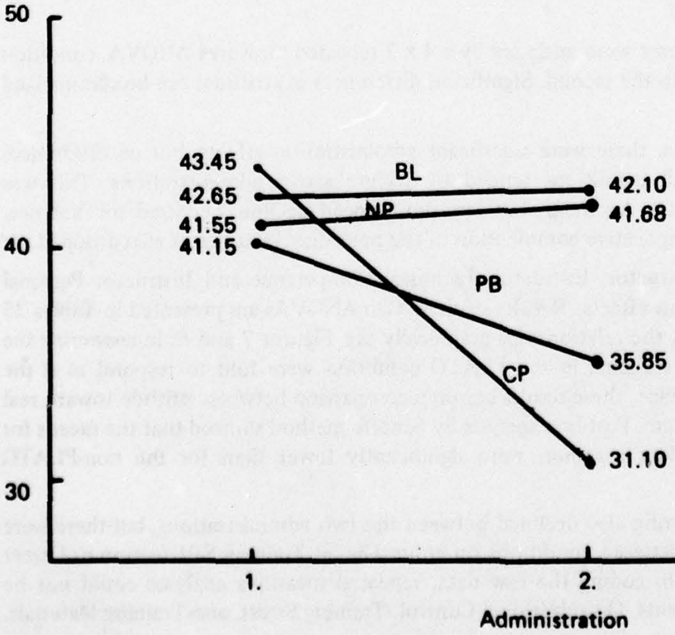


Figure 7. **Mean values of instructor technical competence by condition and administration.**

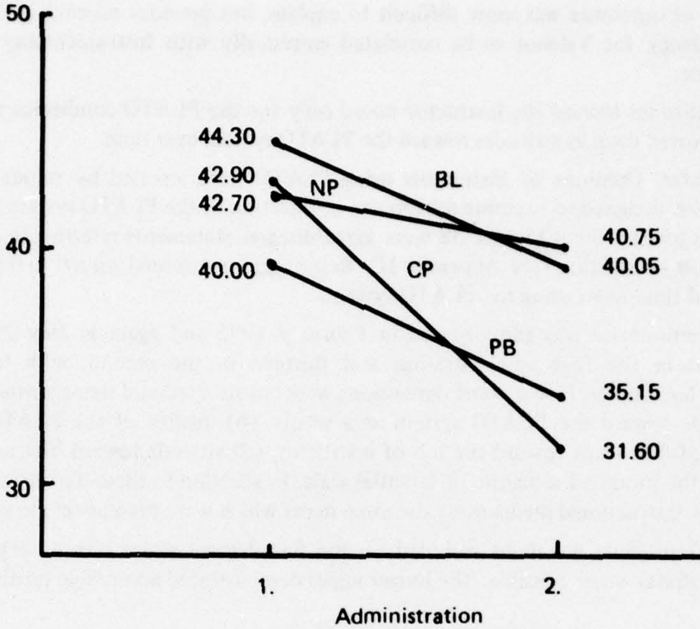


Figure 8. **Mean values of instructor personal relations by condition and administration.**

The problem of comparing attitudes of students in the present study with those of all students at Chanute and all technical training students was approached in a straightforward way through the use of confidence intervals. In the present case, there was a set of means from relatively small samples (n ranged from 20 to 158 in the four conditions) and two other sets of means coming from very large samples (n = 2,484 and n = 12,666). These latter sets may be taken as parameter values since they ostensibly included the populations of interest. Given the observed means for the four conditions of the PLATO service test, and an estimate of the population standard deviation, confidence intervals around the population parameters were constructed in order to delimit the boundaries within which samples like these could have been drawn. Then, the question became: Was the population parameter bracketed by the sample confidence interval? If parameter values failed to fall within these boundaries, an observed mean was accepted as coming from a different population and an actual difference was present, given a .05 probability of error.

Means and confidence intervals for the two administrations are given in tabular form in Appendices F and G. These data revealed some scattered differences from population parameters. One consistent tendency in the first administration was for PB students to have generally higher motivation, attitudes, and satisfaction. In the second administration of the survey, however, these tendencies reversed for the PB group with the exception of satisfaction and Instrumentality which remained higher than the Chanute or ATC mean ratings. In addition, the second administration found CP students considerably lower than Chanute and ATC norms on nearly all the dimensions.

***Discussion.* Observed differences on the dimensions covered by the Technical Training Survey tended to support, in general, the attitude findings reported earlier. Again, there was a persistent tendency for attitudes to decline, yet to remain slightly positive.**

The most plausible interpretation for the Instrumentality decline was that students tended to perceive reality more correctly after experience in the technical training environment. There were, in fact, very few real connections between valued outcomes and performance in technical training. The naive student probably failed to appreciate this fact until he had had more exposure to the realities of Air Force training.

The decline in valence of outcomes was more difficult to explain, but previous research in the motivation area has noted a tendency for Valence to be correlated empirically with Instrumentality despite their theoretical independence.

The decline in attitudes toward the instructor noted only for the PLATO conditions was consistent with the previously reported drop in attitudes toward the PLATO system over time.

Instructor Attitudes. Opinions of instructors using PLATO were assessed by means of a 40-item Likert-type questionnaire designed to examine acceptance or rejection of the PLATO system and its impact on perceptions of their job. Of the 40 items, 38 were agree/disagree statements referring to characteristics of PLATO, ISD, and job satisfaction (see Appendix H). Responses were scored on a 0 to 9 scale. The two remaining items covered time spent using the PLATO system.

Method. The questionnaire was administered in February 1975 and again in July 1975. Eighteen instructors participated in the first administration and thirteen in the second, with ten instructors completing the survey both times. Five *a priori* dimensions were constructed and items written to tap these dimensions: (a) attitude toward the PLATO system as a whole, (b) quality of the PLATO lessons as a medium of instruction, (c) attitude toward the job of instructor, (d) attitude toward ISD, and (e) PLATO affect as measured by the modified semantic differential scale. In addition to these dimensions, instructors made ratings of various instructional media using the same items which were present on the student survey.

Results. Table 27 presents the items included on the five derived scales plus an estimate of scale reliability (Cronbach's alpha) where possible. The longer scales demonstrated acceptable reliability.

Table 27. **Reliability of the Instructor Survey Subscales**

Dimension	Item Numbers	Alpha
PLATO System	3, 16, 17, 18, 20, 22, 35, 36, 39, 40	.88
PLATO Lessons	6, 19, 37, 38	.80
Job Satisfaction	1, 2	--
ISD	4	--
PLATO Affect	23 to 34	.93

Table 28 presents means and t-tests for the attitudinal data analyzed as repeated measures with correlated observations. Item responses have been averaged so that 4.5 represents a neutral response, except for the PLATO affect scale where 54 was the neutral point. A drop in attitude toward the PLATO system and PLATO lessons was observed only for the PLATO affect. Inspection of the means, however, shows that even after the highly favorable initial attitude had worn off, the general orientation of instructors was slightly better than neutral.

When the pattern of positive and negative responses to the semantic differential items was considered, a clearly significant difference was detected (Figure 9 and Table 29). A Chi-Square test was performed on the individual responses between administrations, $\chi^2(1) = 38.22$, $p < .001$. This result confirmed the fact that a major shift in feelings about the PLATO medium had occurred over the 5-month interval. To make the situation more evident, Table 30 was constructed which lists the means of the semantic differential items for both administrations and the net change between administrations. A sign test confirmed that this result was not likely to have occurred by chance, $\chi^2(1) = 12.0$, $p < .01$.

Instructor preferences for various teaching media are shown graphically in Figure 10. Little change can be noted between administrations. The only differences which approached customary statistical significance ($p < .10$) were for PLATO lessons which dropped approximately .5 scale point, and study guides and workbooks which gained about 2 points.

Table 28. **Instructor Attitudes Toward Selected Aspects of the PLATO Service Test Over a 5-Month Time Span**

Attitude Domain		Feb 75 (N = 18)	Jul 75 (N = 13)	t	P
PLATO System	*M*	5.54	5.21	.498	.62
	SD	1.49	2.19		
PLATO Lessons	*M*	5.94	5.85	.153	.88
	SD	1.56	2.02		
Job	*M*	7.11	6.69	.642	.53
	SD	1.50	2.13		
ISD	*M*	6.17	6.23	.072	.94
	SD	2.28	2.65		
PLATO Affect	*M*	72.06	52.00	2.59	.015*
	SD	17.71	25.54		

*$p < .05$.

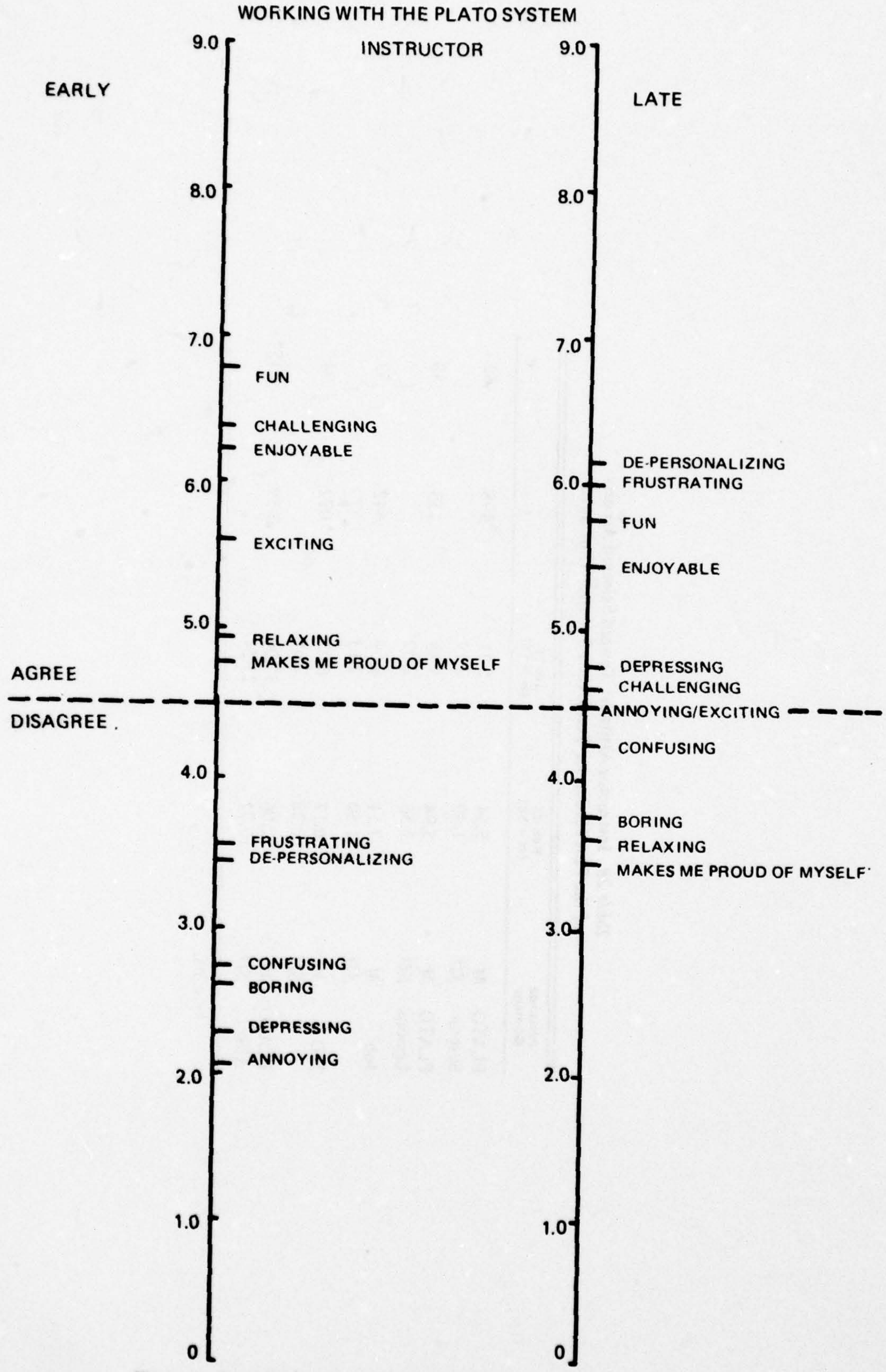


Figure 9. **Graphic representation of mean instructor responses to semantic differential items referring to PLATO.**

Table 29. Positive and Negative Responses on Semantic Differential Items

		Administration		
		1	2	
Responses	+	95	48	143
	–	25	72	97
		120	120	240

$\chi^2 = 38.22^*$

*p < .001.

Table 30. Means and Net Change for Items 23–34

Item	Admin 1	Admin 2	Change[a]
23	7.5	5.5	–2.0
24	6.0	2.7	–3.3
25	7.2	4.1	–3.1
26	6.8	4.6	–2.2
27	6.5	4.4	–2.1
28	5.5	2.8	–2.7
29	6.5	5.0	–1.5
30	5.1	3.7	–1.4
31	7.1	4.0	–3.1
32	7.0	5.0	–2.0
33	5.4	2.1	–3.3
34	6.3	4.1	–2.2
	12/12 above neutral (4.5)	4/12 above neutral (4.5)	
	100% favorable 0% unfavorable	33% favorable 67% unfavorable	
	10 more than one scale point above neutral	*none* more than one scale point above neutral	

[a] All 12 items changed in negative direction

Sign Test Results

	Responses +	Responses –	
Admin 1	12	0	12
Admin 2	4	8	12
	16	8	24

$\chi^2 = 12.0$ $p < .001$.

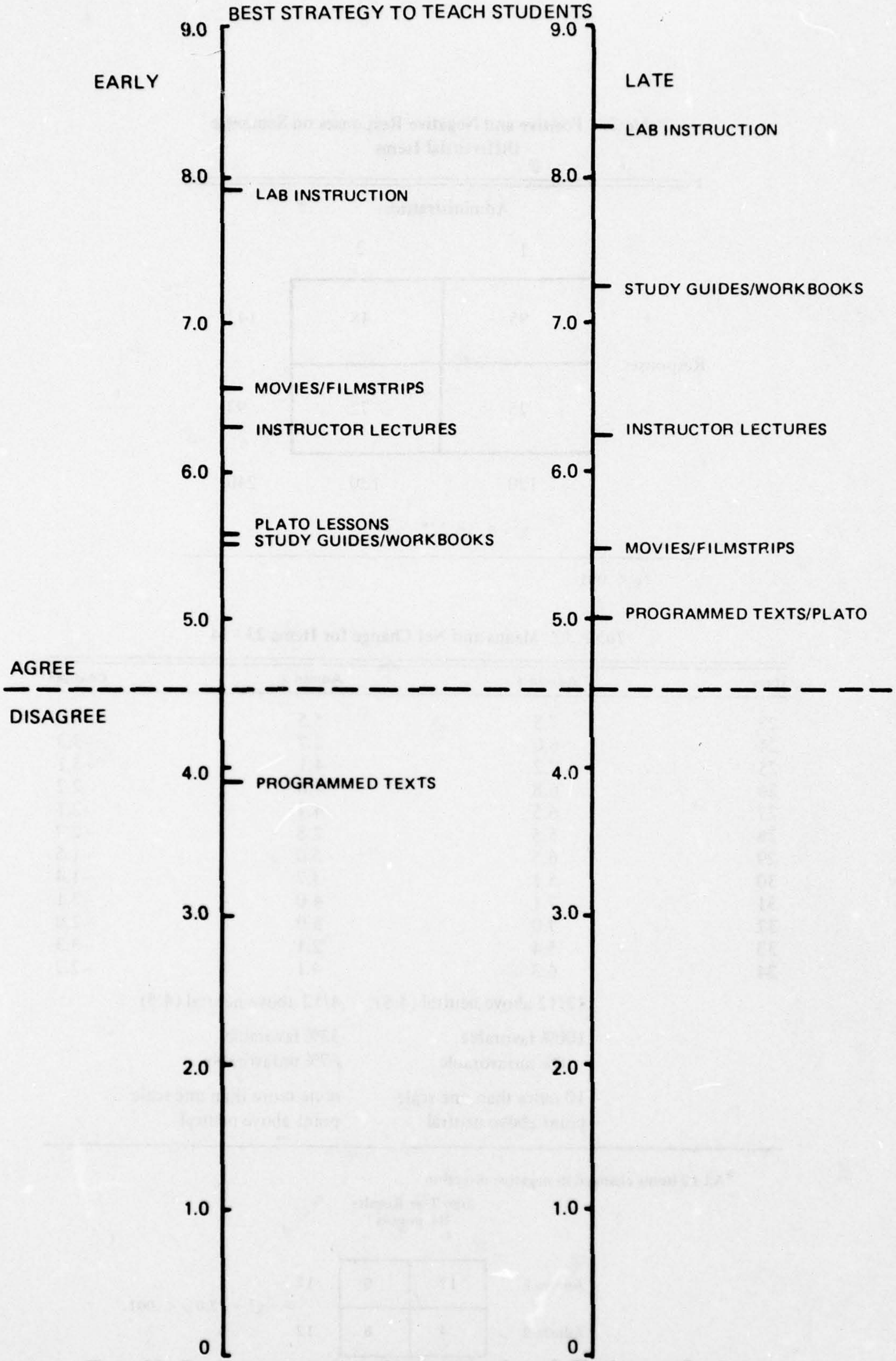


Figure 10. **Graphic representation of instructor ratings of effectiveness of various media on two administrations of the instructor attitude survey.**

Disucussion. To summarize, instructor attitudes were, in the beginning, positive toward PLATO as an instructional medium which may be attributable to initial enthusiasm. Their reappraisal after 5 months appeared to indicate a dissatisfaction with their less active role in the instructional environment. The instructor perceived PLATO as somewhat depersonalizing, a catalyst for decreased role activity, and as a suppressing agent for a sense of accomplishment and self-fulfillment.

These findings point to a need to increase instructor involvement in PLATO-based instruction. It is conceivable that reducing the total number of instructors, associated with operating PLATO, may increase their activity level and improve morale. Perhaps an arrangement, whereby a few instructors are assigned specifically to PLATO training (wherein they become experts on the lessons, routers, data collection procedures) and the remaining instructors are assigned specifically to laboratory training may be a possible solution to this problem. In any case, the complexity of operating PLATO at, or near, its potential will always require a nucleus of highly trained instructors. Further discussion of instructor utilization will be presented in evaluation of management.

The fact that a drop in instructor attitude was detected in this study should not obscure the fact that instructor attitudes were at least neutral in the most recent administration of the survey. Acceptance of the system was, in the final analysis, satisfactory, though perhaps not as strongly positive as had been anticipated.

Impact on Training Activities

Procedure. To determine the impact of PLATO on daily training, observations of classroom and laboratory activities in the Special Purpose Vehicle Repairman courses were made on a random basis. Two observers visited classrooms individually at irregular times. They were given check sheets containing alert items. In general, their guidance was to observe the instruction and note anything out of the ordinary. Most frequently, the observers made extensive notes on separate sheets of paper. The two principal observers were instructors on loan to the PLATO project for 90 days. They had extensive experience as instructors and could recognize problems where non-instructors might not. Over a period of 3 months, they spent approximately 40 hours in classroom observation.

These measures involved a certain amount of risk that observer presence would affect student behaviors, but after several sessions, the students appeared to relax and pay little attention to the observer. There still was no assurance that the act of observing the students did not influence the instruction, but since the objectives of the observations were not clear to the students or the instructors, reactivity was not considered to be of great consequence.

In general, the principal object of the observations was to obtain an insight into the way instruction was presented in a conventional classroom setting and how it might compare with instruction presented through the PLATO system. The observations were organized according to specific areas so that, when appropriate, comparisons could be made between conventional instruction and PLATO instruction. The areas were: (a) conduct of training, (b) student interaction, (c) instructional content, and (d) instructional styles.

Results and Discussion

Conduct of Training. Since PLATO, as used at Chanute, was a resource limited to 29 terminals for training, a finite amount of ECS, and operational availability from 0740 to 2200 hours, it was necessary to introduce new operating procedures to accommodate it. The major changes involved operating the PLATO portion of all four courses on B shift (1200 to 1800 hours). A schedule was posted at the entrance of the PLATO laboratory and each instructor could reserve blocks of time and terminals for his class to work on PLATO lesson material. Though unprecedented, the system appeared to have worked. Instructors, however, complained of problems in getting access to terminals and found that this procedure complicated their job.

During peak loads on the system, there would occasionally be insufficient ECS for all students in the PLATO laboratory to be in different lessons at the same time. This required PLATO instruction to be interrupted for some classes and replaced by other instruction until ECS was available. Such interruptions and substitutions were unique to use of the PLATO medium.

Problems with computer operating times and ECS limitations occurred because the PLATO system was not an Air Force resource and, as such, there was not direct control over when it operated or the priority for ECS. This feature was perhaps the single most serious drawback concerning utilization of PLATO in the current study.

Student Interaction. Student interaction was perhaps the richest area provided by the observations. For the most part, conventional classroom activities centered around instructor presentations (lectures). Student interaction with these lectures varied depending upon the kinds of students and the complexity of the subject matter being presented. At times, when student discussion was absent, many students were observed to become rather quiescent, almost to the point of falling asleep. Any interruption in the routine lecture, however, became a welcome diversion. Whenever instruction required the students to stand or move about, they seemed much more alert.

Instructor questioning of the students took two forms. The instructor either asked general questions and waited for a volunteered answer, or he asked a specific student for an answer. In the first case, if the question was difficult or the instruction was unclear, it would often be followed by an embarrassed silence. If easy, several students would attempt to answer at the same time. In either case, the instructor could only *sample* the understanding of the class by questioning one student. Further, by repeated questioning on a random basis, the instructor fell victim to the chance of overlooking some students. This was observed on one occasion where, over a 4-hour period, three students out of eleven either asked questions or were questioned 10, 12, and 15 times, respectively. Interactions for the remaining students averaged around four to five. The general conclusion was that programmed instruction of PLATO can reduce non-representativeness of questioning and space student interaction more equitably.

On the other hand, there is something positive to be said for lecture/discussion-type instruction. It was observed that a single question from a student during a lecture could provoke further questions from other students. These interactions then allowed the instructor to adapt his presentation to the needs of the class. In programmed instruction, even CAI, this generalized adaptation is difficult to achieve. If a student has a question during a CAI lesson, he may call the instructor for an expalanation, but while this may answer his question, none of the other students can benefit from hearing the interaction as they would in the classroom. Ideally, CAI lessons would be revised as such problems arose. In practice, however, this ideal is hard to realize. First, each incidence of such a question must be recorded. If the question frequently arises, it would merit changing the CAI lesson. Otherwise, such a change would not be warranted. Attempting to keep a record of questions, while in the midst of monitoring the progress of ten or eleven students through a CAI lesson would be a difficult, if not impossible, task for a single instructor. Hence, the most that can be done without expending a major effort is to refine a lesson to teach to a specified teaching objective. It would seem, therefore, that on a larger scale than simple training objectives, stand-up instruction can be more adaptive than the current use of CAI at Chanute.

Instructional Content. Observing the instruction revealed that students were strongly goal oriented and attended most closely to instruction directly associated with that goal. For example, when instruction dealt with a maintenance task wherein actual equipment was used in a nearly natural setting (the laboratory), the students appeared most interested and involved. On numerous occasions, when students actually engaged in hands-on work, there was total involvement. When the classroom instructor told of an experience he had "in the field" to illustrate a point, or he related a point he was making to an auto owned by one of the students, the students appeared highly interested in the subject and all attended to the instruction. As a further illustration of the strong goal orientation, there were frequent inquiries as to whether a subject would be on the test. There was, however, a general lack of attentiveness during the more abstract explanations of operating principles. This led the observers to believe that the students did not really care how something worked, that they just wanted to know how to fix it. This observation is further reinforced by student behavior on the topic of maintenance manuals or technical orders. Here the students had to learn how to use an index to find the proper maintenance manual, then had to find the proper chapter, and finally had to determine if it was up-to-date. Students were observed not to take this exercise very seriously. There was much disorder, constant repetition of instructions was necessary, and several students still were unable to pass the end-of-lesson test on this subject. Very much the same thing happened with the lesson on security.

These observations pointed up a weakness and a strength of Chanute's lessons. First, the lessons were unable to sense the needs of an individual or group at the level that an instructor could, and then be responsive to these needs. Nevertheless, PLATO had a definite advantage in the presentation of difficult and potentially unattractive instructional sequences; such as technical orders and security. The power of the system to control the instruction, repeat untiringly, and drill to insure mastery was invaluable. Moreover, the consistency of CAI insured that each student received instructions free from problems caused by instructor variability in presentation.

Instructional Styles The third area of observation that could be compared across media was that of instructional styles. These styles related to the manner in which the content was delivered.

In the conventional classroom, perhaps the most noticeable observation was that there were distinct differences in the personalities and teaching "techniques" between instructors. These "techniques" were not limited to the clarity of instruction, but included the way the instructor interacted with the students both as a teacher and as a disciplinarian. Because the students got a new instructor every 2 weeks, there was always a period of uneasiness at each transition, while the students "felt out" their new teacher. During the transition there was usually much less tendency for students to ask questions, but the attention level seemed higher. Not enough observations were made, however, to determine if time taken to adjust decreased as the number of transitions increased.

Just as students had to adjust to new teaching styles of instructors, it was noted that they also had to adjust to different teaching styles across PLATO lessons. In these CAI lessons, there were various strategies employed in no particularly consistent pattern. Some programs were simple and linear; some involved branching to new material on a mandatory or optional basis; some included remedial loops that sent a student back to repeat old material if he failed a test item; and some employed choice pages that allowed the student to choose his own sequence of material. In the majority of cases, students had not been previously exposed to these kinds of instructional strategies in programmed instruction. Now suddenly, they found themselves in a position where they needed to make decisions about how and what to study, if only on a small scale. It was interesting to note, though, that once students learned to manipulate the PLATO system, they quickly adopted methods of "beating the system." for example, several students found ways of going directly to an end-of-lesson test (Master Validation Examination or MVE) without going through the entire lesson. Some found that if they could pass a pretest, they could avoid taking the lesson. Therefore, they concentrated upon taking the pretest over and over again, hoping to pass it by chance alone and not having to go through the lesson. Needless to say, it was necessary to redesign the lesson programs to prevent these kinds of behaviors from continuing.

Discussion. A basic conclusion to be drawn concerning instructional style was that control of the instructional material must be handled very carefully. It should not be assumed that students are motivated to do the best job they can in the time available, for in any large group of students there will always be some who take the line of least resistance. But this does not mean that student control should be completely eliminated, for highly motivated and able students can profit from both pretests, which allow them to avoid unncessary instruction and from other options they can use to tailor the instruction to their needs. Thus, a corollary can be drawn such that any instructional material which can be circumvented eventually will be, and for every decision a student must make, no matter how simple it appears, there is a finite probability that he will make the wrong decision.

Conclusion. In summary, implementing PLATO was observed to have advantages and disadvantages in the area of (a) conduct of training, (b) student interaction, (c) instructional content, and (d) instructional styles. In the conduct of training, PLATO was seen to have mostly disadvantages. It was available only part of the training day and there were times when ECS limitations permitted use of only a few terminals or lessons. The fact that PLATO was not an Air Force resource was pointed out as a major drawback. For student interaction, PLATO supplied benefits in assuring comprehensive and consistent student questioning, but suffered in adaptiveness and generalizability. Instructional content was improved by PLATO's ability to provide consistent and interesting lessons. It was hindered somewhat, on the other hand, by an inability to be responsive or appropriate at unpredictable points in teaching. Finally, with respect to instructional style, consistency of PLATO was an advantage, but the complexity of some lesson designs and decision requirements was a disadvantage.

Two basic conclusions were reached. First, PLATO was *not* found to have a major adverse impact that precluded its potentially effective use in technical training. Second, refinement of lesson material and improved scheduling of terminals and lessons could reduce the observed negative impact on conduct of training.

Impact on Existing Air Force Regulations and Guidance

It was thought that implementation of PLATO would require a great many changes in training methodology which consequently would need to be reflected through changes in numerous Air Force manuals, regulations, and pamphlets. However, such an expectation was not fulfilled with the utilization of the PLATO IV system at Chanute, and probably would not be fulfilled at other Air Force installations that may eventually become involved with CAI/CMI systems.

The basic manuals and pamphlet guiding Instructional Systems Development are AFM 50-2 and AFP 50-58.

AFM 50-2 *Instructional Systems Development*, contains the concepts and principles to begin structuring the systemization process.

AFP 50-58, *Handbook for Designers of Instructional Systems*, outlines the application of philosophy, theory, concepts, and principles in AFM 50-2.

Together, these three sources form the reference literature to analyze, plan, develop, validate, and evaluate an instructional system. Because innovation is a hallmark of the entire ISD process, the use of CAI and CMI was anticipated and included as a possible alternative in this reference material.

Because the use of CAI/CMI is already included as policy in the major reference literature for ISD, and because ISD policy is the governing policy in Air Force technical training, regulations written for ATC usage also include provisions for CAI/CMI implementation. Although not specifically mentioning these concepts, the regulations do reflect capabilities for educational innovation. The ATC 50- and 52-series regulations have the greatest applicability to PLATO (as used in the current context). The following portions of those regulations deal with innovation and provide for CAI/CMI implementation in technical training:

ATCR 52-3, (c1)5m, *Measurement*, provides for innovations in test and analysis procedures.

ATCR 52-6, 2a, *Course Charts*, cites AFM 50-2 for guidelines, which provides for innovations.

ATCR 52-7 2a, *Plans of Instruction and Lesson Plans* cites AFM 50-2 for guidelines.

ATCR 52-18, 2f, *Training Materials*, indicates that one may deviate from ATC approved course control documents to determine the feasibility of proposed course changes. This regulation is normally cited when deviating from course control documents to validate an ISD product and appears quite flexible.

ATCR 50-5 1, 4d, *Instructional Systems Development* indicates that innovations will be utilized to develop cost effective programs. AFM 50-2 is cited and requests to deviate are included as policy.

To summarize the findings, regulations, pamphlets, and manuals utilized at the technical training level were examined and found to make provisions for CAI/CMI innovation and change in measurement, course charts, plans of instruction, and systems development through normal training deviation procedures. Finally, the PLATO IV/ISD process was compared to a typical ISD effort. After the similarities and differences were explored, it was discerned that very little that was abnormal occurred with the PLATO IV effort.

In conclusion, further PLATO efforts at other Air Force installations, if conducted in conjunction with a systematic in-depth Instructional System Development effort, should anticipate few difficulties in coping with existing regulations.

New Training Capabilities

Because of the relatively brief period available for experimental applications of PLATO, it is impossible to present concrete evidence of training capabilities provided by PLATO which cannot be provided by traditional/conventional media. The primary reason for this lack of information is that pressure to get operational training underway as soon as possible prevented experimentation with teaching new skills through PLATO. In order to group-pace students, it was necessary to devote full attention to individualizing the classroom instruction. Thus, PLATO-based laboratory training, where the *unique* capabilities of PLATO could most dramatically be demonstrated, was not attempted. However, based upon work at other locations and assessment of the successful applications of animation and answer-judging capabilities employed in this effort, it seems evident that PLATO could be used to teach laboratory skills now being taught through conventional instructor demonstration and practice.

Two areas in particular suggest themselves as potentially cost-effective applications of PLATO in technical training. These areas are diagnosis/troubleshooting and performance testing.

Diagnosis and troubleshooting are important skills for a mechanic to possess, yet they are uniquely difficult to teach. First, in order to teach diagnostics, it is necessary to have faults to diagnose. Training equipment that is faulty must be simulated by special training devices. Consequently, it is necessary to teach diagnostics through expensive equipment. With PLATO, it is possible to present low fidelity simulations of engine malfunctions. Furthermore, the interactive capatilities of the system allow students to receive immediate in-depth feedback concerning the accuracy of diagnosis. In addition, capabilities for randomly generating simulated faults enable students to experience a wide variety of faults which would not be feasible with less dynamic or expensive media.

Furthermore, the strategy of diagnosis or troubleshooting could be taught in a dynamic interactive mode which closely conformed to behaviors required in the field. Thus, the capabilities of PLATO could enable the teaching of a difficult skill to an acceptable level within the time restrictions of technical training–something that cannot be done through traditional media.

The second area, where PLATO could provide significant new capabilities to technical training, is in the area of performance measurement. At present, the only quantitative measure of student performance is provided by multiple-choice or true/false appraisals and block examinations. These measures have only an indirect relationship to a student's ability to actually perform the task activities. The only direct evidence of task performance comes from the highly subjective pass/fail judgment of the instructor in the laboratory. With PLATO, however, it would be possible to present the procedural aspects of various tasks and to measure how well students can follow the TO in accomplishing the tasks. While still indirect, this procedure would be much more faithful to actual task performance and would give a measure of *each* student's ability to perform. Some laboratory tasks are such that students perform them in groups or only see a demonstration which allows some students to go through training without actually having reached a specified level of proficiency on all tasks.

The importance of this capability is that it permits a direct estimate of the transfer of classroom instruction to performance on actual tasks. In this manner, it would be possible to avoid generalized "nice to know" information and to tie instruction in basic principles and fundamentals directly to the tasks to be performed.

Incorporation of these increased training capabilities could, if carefully done, significantly improve the efficiency of vehicle maintenance training. Whether or not this increase in efficiency is cost-effective, however, depends upon a great many factors ranging from design and coding of the software to management of student and instructor resources.

Overall Summary and Conclusions

The impact of PLATO on attitudes of students was generally positive. Students in the PLATO training conditons had more positive attitudes toward training than their non-PLATO counterparts. While attitudes of all students tended to become less positive over the four blocks of training involved in the service test, attitudes of PLATO students tended to decline more slowly than those of non-PLATO students. Responses to specific attributes of PLATO indicated that students enjoyed working with the system and found it to be an effective means of teaching.

Instructors reported initially positive attitudes toward PLATO, but after several months these attitudes declined significantly. It was suggested that the reason for this decline in attitude was most likely some dissatisfaction with the less direct role of instructors in PLATO instruction.

Daily training activities were most severely impacted by restricted operating hours and occasional ECS shortage. These problems required that unusual management procedures be implemented to accommodate training interruptions. Other advantages and disadvantages were pointed out in the areas of student interaction in training, instructional content, and instructional style. The overall conclusion was that PLATO had no significantly adverse impact, which would preclude its potentially cost-effective use in technical training.

Examining the impact of PLATO on existing ATC regulations, governing conduct of training, revealed that no major changes in these documents were necessary in order to incorporate the new system.

While it was not possible to experiment with new training capabilities, a discussion of potential new capabilities was presented. This discussion pointed out that two areas, troubleshooting and performance testing, are within the capabilitiy of the PLATO system and could significantly enhance cost-effectiveness of vehicle maintenance training. Additional emphasis on use of PLATO for these two areas is strongly encouraged.

In conclusion, the overall impact of PLATO has been more positive than negative. There is no reason to believe that PLATO cannot prove to be an acceptable and useful training medium.

VI. INSTRUCTIONAL MATERIALS DEVELOPMENT

The focal points of this portion of the evaluation are the process used to develop CAI training materials, the factors influencing this process, an evaluative description of the validated lessons, and findings from the validation of the lessons. The following observations pertain to Phase II, or from the time the ISD and PLATO efforts merged, until January 1976.

Method

Observational and interview techniques were used to gather the information for this evaluation area. Instrumented interviews of project personnel were conducted in November and December, 1974. These interviews provided the basis for describing the lesson development paradigm and presenting the factors which influenced lesson development activities. Descriptions of lessons and their validation characteristics relied upon reviews performed by the evaluation team and members of the CERL staff.

Results and Discussion

Process Description. One of the principal project objectives was the derivation of a process to produce effective CAI materials. The process had to integrate the concept of author/instructor, the needs of a military technical training setting, the capabilities and limitations of the PLATO system, and other diverse variables. During Phase I, experience concerning these variables accrued, yet no generalizable, well-defined process emerged. The period saw authors developing lessons with varied methods. The efficiency and utility of these methods were unknown and questionable. During Phase II, project personnel developed a process which integrated concepts, needs, and experience. Efficiency was gained and the basic model may be generalizable to other military and civilian applications of CAI.

The Nature of Technical Training. The development of PLATO Courseware was defined in part by the nature of Air Force technical training. In general, the training received for qualification in a career field is accomplished in two steps. First, the airman is sent to resident technical school where basic career field knowledges and skills are learned. After graduation, the student undertakes a first assignment at an apprentice level where the career field knowledges and skills are refined by a Career Development Course (CDC), and on-the-job training (OJT). Career field tasks are periodically analyzed so that the scope and depth of training is commensurate with the needs of the career field. The technical school graduate, an apprentice mechanic, receives training on a specific set of skills, and attains a certain level of proficiency that allows the airman to step into the next phase of training. To achieve this synchronization, a standardized, controlled course curriculum is required.

An important distinction exists between training and education. In educating a person, the teacher provides a series of learning experiences to aid the student in concept and skill attainment. The scope and depth of education are highly flexible, to accommodate a multiplicity of variables. Within the context of technical training, the desired scope and depth of learning outcomes are fairly well defined for the various portions of student training. As a consequence, Air Force technical training cannot, and should not, have latitude, for the real cost of resources would exceed the benefits of a generalized training experience.

The concept of sufficient training at minimum cost (lean training) is highly relevant to the Air Force. The student who enters the second phase of training should have *only* those basic skills and knowledges that are required for success in OJT. Overtraining, in a sense, is waste and waste is costly. It increases training time and decreases available productive time.

This task-specific nature of technical training has a direct impact upon curriculum development. The ISD team must use a lean approach in developing an instructional system wherein courseware, such as lessons, is written with little elaboration (i.e., examples, detailed explanations) and in large instructional steps. The courseware is then put into successive tryout and validation trials where it is refined and augmented until 90 percent of the students meet all standards specified in the instructional objectives. In this way, the requirement for sufficient training is met while not overtraining or providing superfluous information.

CAI Lesson Development

The Model. The procedural model, described in this section, is a generalized composite of the process actually used. In other words, like all models, deviations frequently were found due to realistic constraints, or the individual differences of the people who used it. However, the basic paradigm held for the majority of lessons.

A team approach was adopted for use with the lesson development process because prior experience, and the conditions prevalent at the time, indicated this to be the best alternative. One beneficial effect of a team effort was the reduction of ego involvement and the promotion of objectivity. Also, the specialization of roles allowed for greater efficiency since personnel accomplished the tasks they were best suited to do. But most important, the possibility of initial high quality products increased, owing to the variety of talents and ideas available, along with the mutual monitorship of team member activities.

The lesson development teams at Chanute consisted of four positions: an author who had the primary responsibility for generating the lesson, a subject-matter expert (SME) who provided technical expertise for the author, an instructional programmer (IP) who assisted the lesson author with programming principles, and a computer coder who helped the author in coding a lesson, or in some cases coded the entire lesson. The central figure was the author, a necessity, since author skills had been developed on a variety of dimensions by this phase of the service test. From July 1974 to January 1975, two such teams were used to develop lessons. Since the author did almost all of the work on a lesson, each team consisted of two or three authors by an SME, IP, and coder.

In presenting the model, the framework of the model's procedural elements will be examined first. The main procedural elements are designated as steps even though they were not clearly delineated in this manner by project personnel. Following the description of the model is an assessment of the procedural aspects in relation to current ISD methodology.

Step 1: Lesson Selection

CAI lessons were developed as a part of the ISD model's Step 4 – "Plan, Develop, and Validate Instruction" (AFM 50-2). Lesson authors had available to them the course objectives, criterion tests or master validation examinations (MVE), and teaching points. These were prepared during Step Three of the ISD Model (Figure 11). As the first lesson preparation activity, the author selected an objective and its associated MVE and teaching points from the pool of cognitive objectives that the ISD teams had targeted for PLATO. The author then initiated a lesson documentation folder where team members recorded lesson development notes and time expenditures, and stored lesson control documents, hard copies of the lesson, and the TUTOR coding.

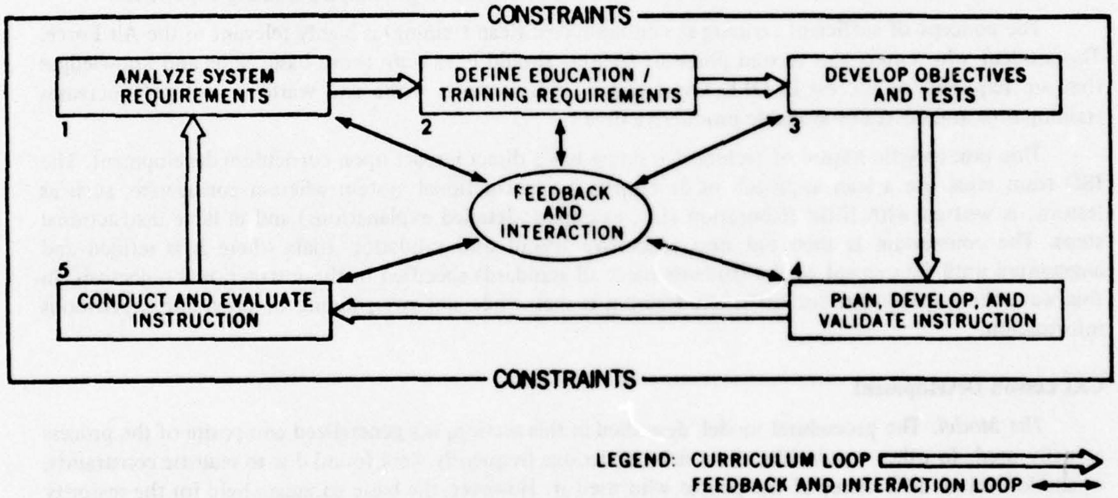


Figure 11. Model for instructional system development (AFM 50-2).

Step 2: Research

To become familiar with the subject matter, the author researched the available information related to the selection. Consulting with the team's IP and SME, the author examined the adequacy of and relationships between objective, MVE, and teaching points. If acceptable, the author proceeded with the next step; if not, then changes were made and coordinated with the Special Purpose Vehicle Repairman course management.

Step 3: Lesson Planning

The author considered an approach to subject matter presentation via the PLATO terminal. The author established the overall lesson strategy, the peripheral media anticipated (touch panel, microfiche, audio), interaction modes, and the sequence of information. A programming plan was then prepared for review by the team IP and SME. In some cases, a coder review was included if, for example, internal lesson routines required checking for feasibility of coding.

Step 4: Off-Line Lesson Preparation

The author then initiated the procurement of the lesson training aids such as slides, drawings, or adjunct components. The textual portions of the lessons were written or outlined, diagrams sketched, and the lesson interactive strategies produced. Following these activities,the lesson was coded.

Step 5: On-Line Coding

The authors had the option of doing all, part, or none of the on-line coding for a particular lesson. Typically, they selected portions of their lesson that were the most difficult or the most tedious for assistance from the team coding specialist. The lesson was coded into its initial format.

Step 6: Pre-Tryout Review

Before the lesson was tested on small groups of students, it was desirable for the team to check the technical, programming, and grammatical accuracy of the lesson, as well as the acceptability of the TUTOR coding. In the event the lesson required modificiation, the team member requesting it conferred with the author to assess the extent of change. The author then adjusted the lesson.

Step 7: Student Tryout

In trying out the lesson with small groups of students, the author hoped to obtain information concerning the effectiveness of the lesson as a whole, and of its individual segments. Major changes to the lesson were generally not made at this stage, since the data represented the results of a small sample of students (1 to 6 students, approximately three tryout attempts). In addition, an author could request course instructors to review the lesson as an added source of feedback and as a method to keep course personnel involved with courseware development.

Step 8: Validation

The lesson was then tested in context with all other new courseware until 90 percent of the students achieved the standard of the objective on their first attempt at the MVE. Approximately 30 students, or three consecutive classes, comprised the validation sample. After the validation attempt of each class, the author examined the summary data for the lesson to determine if validation was possible. In the event the lesson required revision, several data sources for diagnosing specific lesson deficiencies were available. These included an MVE item analysis, lesson time parameters, and internal lesson responses.

Step 9: Finalization

As the final step in the preparation of a CAI lesson, the team instructional programmer performed a grammatical edit since several portions of the lesson had probably been rewritten during the validation step. The lesson was then presented to the course management personnel for an acceptance check.

Assessment of the Model. As with most procedural models, the CAI lesson development process represented an ideal set of procedures. There was no formal written procedure, only an understanding in the minds of the lesson development teams and the ISD management. Several times this collective comprehension was extremely inadequate, a result of poor communication within teams and between teams and management.

The model was not used to produce administration and management routines. When an on-line testing and test item analysis routine or a student router was needed, a coder would work from a set of specifications coordinated with the ISD team. Frequently these specifications were verbal, making use of the expertise of the coder. In one case, an on-line version of the course plan of instruction (POI) was produced by an ISD team IP who had taken interest in coding and felt that an on-line version would expedite preparation.

Even though some limitation exist, the procedural model is compatible with present ISD methodologies for the development of training materials within the Air Force technical training. The ISD team required a lesson development subsystem whose output was commensurate with the primary goal of developing an instructional system. Accordingly, lesson development for CAI was an adaptation of the basic model described in AFP 50-58, Vol. 4.

The important contrasts between the Chanute CAI lesson preparation model and off-line media development models (with the possible exception of some audiovisuals) fell under the major categories of process control, ad hoc functions, and automation impacts. In relation to process control, several additional check points were included in the CAI lesson model for review of the lesson progress, a desirable feature in view of the time investment in coding erroneous or irrelevant material. Most tasks which the IP and SME performed were control functions, not material preparation. The provision of teaching points with objectives and MVEs was not a normal procedure for this ISD team, but it provided an additional control measure.

The design of the model was influenced by the number- and background- of available personnel. The coding function obviously influenced the nature of the model and its deviation from the process used in the development of other programmed materials. For example, it took an SME about 40 hours to develop a 1-hour paper-and-pencil programmed text with moderate interaction with an IP. It took a PLATO author approximately 3 to 4 times that to produce the same validated instructional hour with substantial interaction with his teammates. Moreover, lesson edits were complicated by the coding feature, since the IP had to inform the author a change was required; then verify its consumation.

At this point, one important advantage of the PLATO system should be mentioned. The use of on-line data collection routines, adapted from those available from CERL, took much of the drudgery from the validation task. A summary of the most important data was almost instantaneously available after a validation attempt. Likewise, the tedious textual lesson revision activities which normally require days, weeks, or months (depending on the extent of revision), were typically done in a few hours, or at most, days. In these ways, automation expedited the lesson revision process.

There are a few serious limitations to this procedural model. The foremost is its time-consuming nature. The team coordination and control activities (along with the inefficient use of team specialists) contribute heavily to this limitation. The model also required an excessive dependence on the author, who did most of the development work and utilized other team members as resources. Consequently, the designation "team approach" was a nominal one.

The assumption was made that principles for effective media utilization were known. The lesson selection and lesson planning stages required that the team members would make appropriate decisions, based on their knowledge of CAI and its application. With few such principles established, the efficient execution of these stages was impossible.

Despite these limitations, the model was chosen as the best available for Chanute during June 1974. It evolved from the conditions present at the time, to satisfy the need for a structured process that could effectively and efficiently turn out lessons commensurate with Air Force technical training philosophy.

Appendix A contains a lesson development scenario. The intent of this scenario is to provide the interested reader with a detailed description of lesson development activities, associated problems, and other factors influencing their design.

Courseware Development Issues and Constraints. Many of the PLATO courseware development problems during the first two project phases were site-specific. For example, during the 20-month Phase I, the PLATO system was subject to rapid growth and erratic behavior. Project personnel were struggling with orientation and management problems, as well as the lengthy military and civilian author acquisition and training times. These important influences for the most part inhibited lesson preparation activities, and could be classified as issues and constraints faced by project personnel. After orienting the reader to the prior lesson development efforts of Phase I, the issues and constraints faced during the three phases are discussed under the headings Project Management, PLATO System Hardware/Software, Courseware Considerations, and Authoring.

Prior Lesson Development Efforts. During the initial phase of the project, each author performed his lesson development roles in an independent fashion following the paradigm observed at CERL during TUTOR training. Efforts to produce lessons in a quasi-team fashion still placed prime responsibility on the author and consequently were short-lived. Under this management philosophy, little accountability existed and the standards for quality control of lessons were set by their respective authors. This model of lesson development was termed the Autonomous Author Approach (Dallman, 1974) and was suited to the natures of the original eight authors. These authors were primarily selected on the basis of youth and education, with the assumption that a homogeneous group (with the desired characteristics of low resistance to innovation and rapid skill acquisition) would result. A trade-off had to be made, and instructor experience and subject matter expertise were sacrificed. The nature and background of the original eight authors is further documented by Green (1973).

Throughout the 2-year autonomous author era, a variety of methods was attempted to upgrade author subject matter knowledge and authoring skills such as instructional programming and coding. Of these, the coding skill required the lion's share of an author's attention to learn. This condition was, in part, due to the fascination with the ability to manipulate a complex machine, and be almost instantaneously intrinsically rewarded with the results of invested efforts.

Some serious constraints hindered the attainment of project goals. The Chanute test personnel (project management, authors) had a basic inability to recognize and/or respond to the needs of an extensive curriculum development project. Project management had little experience with operational technical training and even less with curriculum development. Consequently, placing trust in the project personnel through a *laissez-faire* management scheme seemed to be appropriate. It had been assumed that the author group would obtain whatever it required to get a PLATO version of the target course operational. CERL had adhered to the philosophy of individual authors developing CAI lessons, and this reinforced the decision. Unfortunately, the primary assumption upon which the philosophy was dependent, namely, that an author is knowledgeable in both subject matter and educational practices, was overlooked. Chanute's authors were not subject matter experts, nor did they have substantive experience with educational practices. An emphasis on research within the confines of an operationally oriented technical training environment created a condition of passive interest in higher management and, also, a feeling that the project would be short-lived.

Other constraints present during this period limited productivity. The evolving PLATO system had relatively poor reliability in software and hardware. Inexperienced personnel failed to recognize the philosophy and needs of Air Force technical training, and their assistance helped to perpetuate the existing lesson development environment. In addition, hardware delivery date slippages, poor communication, and unstable relations with the host course had a detrimental effect on development activities.

The consequences of an autonomous author approach within the project setting were readily apparent to the attendees of the May 1974 project review, which signaled the end of Phase I. The curriculum was fragmented with little continuity between lessons. Lessons did not relate to the philosophy of Air Force technical training, and followed few of the accepted programmed instruction principles. A change to experienced management was deemed the best solution.

Project Management. The transition from the research atmosphere of Phase I to the rigid production environment of Phase II was abrupt. The ISD team did not have the time to "feel out" the operational situation and make adjustments. The authors had not participated in the analytical first steps of the ISD curriculum development. The ISD team had expected that the authors would be subject matter experts and would be aware of the principles of programmed instruction. The authors expected that the initial versions of criterion tests, teaching points, and MVE would be adequate. The authors were accustomed to *laissez-faire* management, while on the other hand, the experience of the ISD team had shown that initial authoritarian management followed by a gradual reduction of controls as course personnel accommodated to new concepts and procedures was more effective. With such differing expectations many difficulties arose.

Communication problems were apparent between the two groups after ISD assumed lesson development responsibilities. For example, three months after the system tryout and validation phase had begun, some authors, including those responsible for collecting feedback information, could not describe the procedures for validating a lesson. Apparently, neither element within the ISD/PLATO team was completely successful at coordinating evaluation activities.

The primary mission of a technical training center is the training of students. The intervention of an experimental medium or innovative program into such an environment may produce stress because of its apparent interference with the primary mission. Consequently, the new program most often receives a low priority when action is required. The impact of "resistance to change" on the instructional materials development process may be noted in subsequent paragraphs of this section, as well as the courseware development and authoring sections.

The major goals of the ISD team were to insure training relevancy and adequacy while striving for maximum training efficiency. Accomplishing these required changes within organizations which were resistant to new concepts. The intervention of the PLATO research program in this situation, with its many unique needs and problems, acted as a multiplicative factor. School action on project-related needs was correspondingly slower. For example, two author positions remained vacant for over 9 months. Requests to remove several project personnel from additional duties were not acted upon in a timely manner. Project personnel action to ameliorate the problem involved external pressure and internal salesmanship. Sustained interest in the project from ATC Headquarters and internal promotion of the project within the technical school hierarchy gradually increased organizational support.

The management of lesson development lacked specific direction. Aside from a general experiential learning goal, the project was not committed to a specific goal. Project direction vacillated between research and operations, depending on the agency providing directional assistance. Fortunately, this conflict was recognized and decisions concerning the issue were brought out after the May 1974 project review.

The operational-research conflict had its repercussions upon the ISD efforts, where adaptation of educational innovations was a strength of the systems approach. Within this PLATO/ISD project, the emphasis on operational concerns took priority over innovative uses of the computer, resulting in conservative lesson development.

Some authors were distraught over the sterility of the PLATO lessons prepared within the ISD managerial scheme. ISD personnel believed PLATO to be like most other media at their disposal; consequently, PLATO lessons were developed using similar techniques. On the other side, some PLATO authors felt that ISD people were not knowledgeable in the area of CAI lesson development and objected to being restricted to a particular style and set of values. Being linear and lean, the lessons did not tax the capabilities of the PLATO system. The lessons were to be augmented with branching based on student response and history, but, in most cases, these strategies were not necessary to achieve validation.

Hardware- and Software-Related Constraints. The TUTOR language used to code the PLATO lessons was adequate for the needs of the site. This observation was predicted upon the conditions of lesson strategies and site personnel. In general, the more innovative a lesson, the greater the demand on an author/coder's knowledge of the language. Most lesson authors had little trouble coding; therefore, they required assistance with only the most difficult portions. The data collection and analysis, the on-line block testing and analysis, as well as some student management and administrative routines, were effectively handled by the coders. If lessons and/or routines were more complex and coders were not available, the site was hard pressed to prepare them efficiently.

Hardware limitations hindered the development of instructional materials. The delayed installation of a microwave link limited the number of operable terminals to nine until October 1974. File space on disk memory and shortages of ECS delayed coding. Design deficiencies in the slide selector made frequent adjustments necessary and further slowed the validation process. High user demands on the central processing unit and ECS increased response latency and lesson condensing times, which were very irritating to authors. These cyclical periods of hardware resource, abundance and famine, reliability and unreliability, characterized the evolution of the PLATO system.

Courseware Development. Throughout the entire project, microfiche procurement was a perplexing constraint. It essentially took one full-time instructional programmer several months to refine the process until the final product could be attained within a suitable time frame. Even then, it required in-person coordination at CERL, including personal handling to limit mailing delays.

Quality control of the final microfiche products should permit only microfiche suitable for long-term student use. The test microfiche used during validation had resolution and color distortion problems. Some slide images were retaken because of poor contrast, unreadable text, and other difficulties.

The lack of subject matter expertise within the author group necessitated several adjustments, including the necessity for authors to review subject matter thoroughly. Additional research impeded the rate of individual lesson development, thus reducing the scope and delaying the tryouts of the automated management and administrative routines programs.

The lesson development process had new lessons placed "on the shelf" after initial student tryouts until the validation and tryout phase began. Many of the authors disliked the fact that their lessons were not being used on a continuing basis by the course. They would have preferred to receive continuing student feedback on their lessons.

A complex issue in the courseware development was the depth of training required for an apprentice mechanic. This issue is not specific to a PLATO-based training system and is certainly not unusual in ISD efforts. However, it was a recurring theme in the project personnel interviews and of importance to course personnel. Information for determining training scope and depth came from a variety of sources such as the occupational survey report (OSR), field evaluations, instructor field experience, Specialty Training Standard (STS), *et cetera*. The scope of training depended primarily on a quantitative basis (OSR and field evaluation), while the basis for depth of training was qualitative. That is, quantitative data establishing the percentage of technicians performing a task were obtainable: however, the level at which they should perform after graduating from technical school was the consensus of opinion and often arbitrarily interpreted. The depth of training may not be set appropriately. Two safeguards, formative product evaluation and field evaluation, are built in the ISD model to insure adequacy of training. In developing instruction, formative product evaluation enhances the probability that background and specific task-related cognitive information attains the minimum level that allows a student to achieve the standard of the objective associated with the task. Field evaluation insures that the standard of the objective is representative of the predesignated level, the STS "2b level" for example. Herein lies the problem that may negate these safeguards. Real-world constraints contaminate the interpretation of the performance level. For example, it may not be practical to have a student perform all parts of a task; i.e., he may only do a third of it in a three-man group, or even less if he is a follower and allows others to do his portion. After the task is performed, the group receives a satisfactory rating and is allowed to progress. The STS standard for most tasks is "2b," which means: "Can do most parts of the task, needs help only on the hardest parts. May not meet local demands for speed or accuracy." This is a terminal level, the entry behavior of the student into the OJT program. None of the students in this group truly demonstrated that they met the standard.

They probably would be able to, but there is no tangible evidence that they can; thus, in some cases, they may not. In those cases, the training prior to the criterion test is suspect, however, the formative evaluation will not detect this for the students have technically achieved criterion. One impractical alternative is to impose a requirement that each student will actually perform most parts of a task. The ramifications of such an action in relation to increased training time and equipment make the option prohibitive. Moreover, if the training is really inadequate, the field evaluation should detect inadequacies.

Field evaluations are highly reactive measures; that is, the dependent variable is influenced by the measurement device. A shop chief who is filling out a field survey and must recall information about an airman who has been with him for several months relies on more factors than the airman's ability. How his observation is influenced by his assessment of the man's character, isolated instances, overall ability, unwillingness to make negative ratings, etc., is uncertain. At best, the field evaluation is a gross assessment. Only if training is dramatically deficient will the evaluation detect it.

Much current training may border in the grey zone between the minimal training philosophy and training inadequacy. Course personnel and project authors frequently expressed concern about insufficient depth of training during the pre-extension period. The ISD team accommodated somewhat, but adhered to the minimal training philosophy since the evolutionary facet of the ISD model will remove discrepancies.

Authoring. As the lesson development model description depicted, the author retained the primary role in the preparation of a CAI lesson. From the author's viewpoint, all higher levels of the organization existed to assist in the performance of author duties and to insure that courseware development was expeditiously accomplished. It was at this level where all lesson development constraints and issues were most keenly felt and many authors were openly critical of their working environment. One aspect of their environment became a focal point for attention. Dissatisfaction with work incentives was necessarily expressed from the time the project was a year old. For instance, interest in obtaining an adequate job description intensified during the transition to ISD management. Civilian authors were very concerned about their promotion future and relative standing with instructors who actually were performing in-class instructional duties. They desired documented credit for their extensive efforts under difficult circumstances and for their acquired expertise. However, technical school management had no real justification or need for creating a job description depicting the unique duties of a PLATO author. Moreover, one intention of the service test was to examine the feasibility of using lay instructors as authors, thus increasing the potential for cost effectiveness by reducing production costs.

Intrinsic work incentives remained consistent throughout the service test. CAI authoring allowed the individual to be creative, avoiding the somewhat repetitious activities of conventional instructing. Most authors felt the problem-solving nature integral to CAI lesson development posed challenges which made the work more interesting. Nevertheless, these intrinsic motivating aspects of authoring lessons diminished as task familiarity and frustrations accumulated.

As the validation of new courseware neared completion, so too did the initial training of Chanute CAI lesson authors. Though most had worked on lesson preparation for several years, a finalized product was never achieved, due to the changeable service test conditions. The authors had received most of their training through the trial and error method and an assortment of *ad hoc*, self-study programs. Even after the merger of the PLATO and ISD projects, author training was inadequate, for the ISD team had overestimated the available expertise. As late as the validation stage, the need for training was apparent.

Lesson Characteristics. A detailed report was prepared by CERL at the request of the PLATO project evaluation team on lesson characteristics (MTC Report 10, 1977). The interested reader will find these reports quite helpful in making lesson design, preparation, and evaluation decisions. During lesson validation, the project evaluators felt that a detailed review of a sample of the Chanute lessons before and after validation would reveal important insights to CAI courseware design. Moreover, this would satisfy an ancillary goal of obtaining a detailed description of the Chanute lessons for evaluative purposes. This section is not intended to overlap the findings contained within the CERL reports, but to elaborate and, where important, reinforce their general findings.

This section covers four major CAI courseware areas. Instructional Strategies, refers to the basic format of the lessons (tutorial, drill and practice, simulation, etc). Interaction refers to the exchange of information between student and lesson. Instructional Programming Features discusses presentation techniques formating of displays, student affective consideration and the like. Finally, student evaluation pertains solely to the end-of-lesson testing procedure.

In no way was the effectiveness of any lesson feature systematically investigated. Comments were collected from a sample student critique form, but no frequency data were obtained. Evaluative statements should therefore be regarded as considerations and should not be interpreted as hard guidelines.

Instructional Strategies. Virtually every lesson developed for mainstream instruction followed the simple tutorial learning activity model. Levien (1972, p. 355) described a simple tutorial as being composed of "a linear series of factual statements interspersed with predetermined questions and responses. Each student, regardless of ability, performance, or prior knowledge is required to proceed through the same materia." Typically, the simple tutorial closely resembled a programmed text, used few CAI system capabilities, and was often denigrated as being computer-assisted page turning. This model was selected for a number of reasons, the first being expediency. From a writing and computer coding standpoint, this was the easiest type of lesson to prepare. Mean initial development time dropped by a factor of approximately one-half to 100 hours per student contact hour. Second, the level of subject matter complexity was low, as was the requirement for comprehension and retention. For the tasks that graduates performed in the field at the apprentice level, a strong cognitive base was not required. Hence the tutorial paradigm permitted most vehicle maintenance students to achieve the desired level of comprehension. Higher order lesson strategies were not needed for most subject matter. CAI lessons met the same 90 percent validation criterion as programmed texts. Since augmentation of a lesson is generally needed for lower ability students, higher ability students are forced to wade through amplifications of the material. This suggests that a more complex tutorial should be used in a totally self-paced system. PLATO lessons with tracks for students of varying ability were successfully employed in an Army technical training environment (Dept of the Army, 1975).

Some mainstream lessons used drill and practice strategies. One lesson required the student to identify each battery ignition system component before proceeding to subsequent lesson modules. The sequence of microfiche image projection was random to avoid a serial position learning effect.

The student was able to exercise some learner control over his path through about half the lessons by a lesson index that allowed the student to choose the order. Even though this feature was present, most students followed the prescribed sequence. The index was valuable in that it allowed the student to selectively review portions of a lesson.

Almost all lessons contained a provision to allow a student to page backward through a lesson. This was not an original design feature, though the need quickly materialized. Students frequently wanted to review previously displayed material.

One learner control feature which was removed was the lesson by-pass test. Many students would select this option even if they had limited entering knowledge concerning the subject area. They did this to familiarize themselves with the end-of-lesson test, keying in on the test items. Since most tests sampled the content area, it became necessary to delete this option.

Few adaptive strategies were built into the lessons. Branching consisted mainly of forced review. The student was required to repeat a segment of a lesson if response(s) to a sub-terminal exercise were not to the standard of the author. For most lessons, if the student did not achieve the end-of-lesson test standard, he was required to reaccomplish the entire lesson. Some lesson tests were programmed to determine which lesson modules the students should review and then automatically routed them through an individualized review.

Lessons which employed more of the flexibility offered by PLATO were prepared during the first project phase. A part-task simulation of a laboratory exercise required the student to practice battery hydrometer reading skills. A dialogue strategy was chosen to reinforce starter system diagnostic skills. These lessons demonstrated that these strategies could be developed by an experienced technical training author or author team. The generalizability is somewhat limited though owing to the background of the authors responsible: college education, interest in education, and intrinsic motivation. The motivation is important, because such lessons are very difficult to design, code, and evaluate.

More creative lesson strategies were not used principally because of Service Test conditions. It can not be determined if other strategies could have produced greater instructional efficiency gains; however the simple tutorial strategy, when used to present facts and principles, was effective, and could be efficiently prepared.

Interaction. The continuous exchange of information and responses between student and medium is one of the major purported advantages of CAI. From observation of students in the PLATO laboratory, it seemed that interaction was motivational and promoted learning for the majority of vehicle maintenance students. For the purposes of this report, interaction will include those lesson techniques which elicit student responses, PLATO system response judging, and author-generated feedback.

The mainstream lessons used three major interaction modes, multipl-choice, fill in the blank, and true/false questions. Matching routines were employed less frequently, used most often in end-of-lesson tests, and were more difficult to incorporate into the lesson coding even though a special routine could be adopted.

The frequency and distribution of interaction modes varied considerably. Table 31 (adapted from Klecka, 1977) depicts the interaction modes and the ratio of interaction to individual lesson displays. For this sample of eight lessons, the ratio of interaction to textual display is about one to three; i.e., on the average the student examined three instructional displays and then received a question. Several of these lessons used massed practice questions which were clustered at the end of a lesson section. Research in the area of distribution of interaction generally has shown that for most subject matter types, levels of subject matter complexity, student abilities, etc., spreading the interaction is preferable. Moreover, it is desirable to have the student relate to all new information. Since many validated Chanute lessons violated these rules of thumb, it was decided that the statistical relationship between degree of interaction and longitudinal lesson effectiveness should be examined. Percentage of interaction was correlated with student failure rates, $r(6) = .49$. $p > .05$. The high probability of chance occurrence limits further discussion to speculation. If in fact a moderate positive relationship exists between these lesson attributes; i.e., high interaction rates are associated with high failure rates, it is probably because of their relationship to at least one concomitant variable: subject matter complexity, in particular. Any future research design which sought to study the frequencies and disposition of interaction with these lessons must contain appropriate controls.

Table 31. **Frequency of Lesson Interaction Types and Interactive Display Percentage Rates**

	Interaction Type			
Lesson Title	Fill In	Multiple Choice	True/False	% Interactive Displays
Emission System	2	12	1	36
Starter System	13	33	0	48
Transmissions	0	14	11	58
Diesel Engines	8	6	0	19
Principles of Hydraulics	3	20	5	38
Drive Shafts	3	8	1	38
Power Takeoffs	1	2	4	43
Electrical Fundamentals	1	7	0	33

The TUTOR language had an impressive response-judging capability; however, it was not extensively utilized by the lesson authors during initial lesson development. Ideally, data gathered during lesson validation would be used to modify response-judging flexibility of an item. Unfortunately, lesson revision all too often consisted of quick fixes. All too often the multiple-choice judging routine would not be programmed to provide appropriate feedback or route the student to review after several incorrect combinations of answers. Similarly, a fill-in-the-blank item judger would often not accept synonyms or close misspellings. With inadequate feedback and no bypass option, a deadend would result: the student could not proceed, go back, or ask for assistance.

Students often commented on fill-in-the-blank items. Along with the response-judging inflexibility, they disliked typing responses because of keyboard unfamiliarity and because they were required to recall and spell newly introduced terminology. For these reasons and because fill-in questions were more time-consuming to code, they were not often used. Also multiple-choice questions are typically selected for block tests and it was felt that the lesson and test styles should be similar.

The feedback given to a student varied widely as a function of the desires of the author, experience, and work conditions. If under pressure to complete a lesson, for example, the author might rely solely on a very elementary form of feedback: a "yes," or "no," or "ok" after the student initiated judging. Under other circumstances, the author provided feedback which was tailored for each possible item response as in multiple-choice questions. As a group, the lessons did not employ good feedback techniques. The instructional efficiency of these validated lessons could have been substantially increased if general instructional programming guidelines were followed.

PLATO offers a rich potential for interaction between student and courseware. The Chanute lessons did not tap this potential extensively; consequently, there was room for improvement within each facet of interaction. It was believed that the efficiency of the entire lesson population could have been substantially increased if deficiencies were corrected and generally accepted technqiues followed during modification efforts. This could have been done systematically so that research design related to instructional programming techniques might have been performed.

Instructional Programming Features. The PLATO system provides graphics, microfiche projection, touch panel, and audio capabilities for use in lesson delivery. With the exception of the latter two capabilities, which were unavailable until extremely late in the project, these presentation techniques were frequently utilized in the lessons developed for the Special Purpose Vehicle Repairman courses. The various presentation techniques were selectively used to best exploit their perceptual, instructional programming, affective, and procedural capabilities.

Within the perceptual area, the graphics and microfiche capability were used to reduce the need for training aids, especially actual pieces of operational equipment adapted for training use. The graphical representation of equipment ranged substantially as to realism, but the effect of this variable on transfer to a task such as component identification was not investigated. Students frequently commented that they liked the graphics, especially when accompanied by animations. It was felt that graphics animation had a definite advantage for teaching certain system operation concepts and movable component interrelationships.

Microfiche application was somewhat limited by its poor resolution and registration (image position) problems. In a typical lesson, the slide would appear along with textual material written in a darkened portion of the plasma screen. Gross slide features were typically discernible, but fine details sometimes were not, even when the student manipulated the focus wheel. Overwriting the image was a problem, since bright lights washed out the contrast between the orange writing and the image. Moreover, the position of the slide image varied considerably.

For parts identification, microfiche should be used, while graphics are generally better adapted to instructional goals that do not require visual realism, or when additional realism is distracting. Many authors expressed that they would have liked to use microfiche in this way, but found that the preparation process was too lengthy.

One observation related to the presentation of textual material is worth emphasizing. Displays which plot slowly are distracting. Unless the technique which causes a reduced plotting speed has a clear instructional value, it should not be employed.

Although several copies of *Educational Psychology* by Anderson and Faust (1973), were available to the authors, few of their instructional concepts were noted in the lessons. In part, this condition existed because of the high attrition rate among the more experienced authors. These authors had reached a plateau in their coding proficiency and were ready to learn more of the instructional programming concepts. Another reason was the necessity to complete lesson development activities before the first tryout class. One abused concept was that of avoiding the copy frame. Unless the instructional goal was to teach new terminology, this programming technique was of limited value. Very few questions required the student to think about the material; most required him to parrot it. This activity may explain a student criticism of some end-of-lesson test items. Numerous complaints were made that the test questions did not say things in the same way as they were stated in the lesson. It seemed that these students were not acquiring concepts for there was no reason to suspect that many test item stems were ambiguous. They were associating words.

Though the author group had limited expertise in the use of instructional programming concepts, they were more knowledgeable than the majority of ISD team SMEs who generate materials for ISD projects. These materials typically demonstrate the same lack of expertise. It is unfortunate that the IPs who monitored the work of these SMEs did not provide sufficient training and allowed the courseware produced to contain violations of programming concepts. It was apparent that some PLATO project IPs had a limited knowledge in this facet of their occupation. This belief will be reinforced later when validation findings are discussed.

One criticism of CAI and programmed instruction in general was that it was cold and impersonal. In hopes of producing good affect, many of the authors interjected humor and personalization into their lessons. *Personalization* typically refers to the technqiue whereby the student's name is displayed within the text he is reading. Since students in the PB and CP condition did not perceive PLATO training as mechanistic, these techniques may be considered as partially successful.

Several procedural aspects were related to materials presentation. Students were allowed to take notes if they desired, even though this lengthened lesson completion times. Early in the initial tryout, students stated that they were anxious, because they had nothing to review for the block tests. To alleviate this anxiety, note taking was allowed.

Student Evaluation. End-of-lesson tests performed at least three functions. They established minimum standards for student achievement, provided information for lesson improvement, and aided in diagnosing individual student difficulties. The format of most end-of-lesson tests was matching, with some multiple-choice items. Students were allowed to change any answer before they initiated judging. If the student passed the test (criterion was typically 80 percent of the items), they proceeded to the next learning module. Upon failure, they were required to repeat all or part of a lesson.

Some students complained because they were not given feedback if they passed the test. Feedback was not provided for three reasons. First, the test sampled the instructional content area; therefore, it was not beneficial to limit student attention to a portion of the lesson. Second, students received the same test version each time; therefore, they could remember the correct answer without comprehension. Third, students would be more prone to compromise the test if they were sure of the correct answers. This procedure for assessing student performance worked reasonably well. Most students were not aware of the one or two items that they missed, nor why they were missed. The content and structure of the end-of-lesson test indicated the low learning level required of the student. The field evaluation depicted that the four courses were successfully performing their role; thus, it can be surmised that substantial task background knowledge was not required to perform adequately in the field.

Lesson Validation. Ideally, the lesson validation process involves the analysis of student tryout data to make improvements to a lesson until 90 percent of the students sampled attain the standard specified in the lesson objective. Objective attainment is assessed by the MVE which later becomes the end-of-lesson test. The test determines the desired learning level. The role of the lesson author is to revise instruction until the validation criteria are met. The decision is made after consulting with or observing students, and looking at the student responses within that lesson module. Since the test samples a portion of the content areas, the author's revision technique is applied to the entire section, not just the sample which is covered by the validation examination. Ideally, the outcome of the validation is a refined product suitable for above 90 percent of the student population.

Validation Techniques. The lesson revisions consisted primarily of obtaining passing scores, rather than insuring comprehension and promoting retention of material. When a lesson was long – usually greater then 1 hour – it was divided into as many as four parts, each with its own separate test. This served three purposes: (a) to promote retention by limiting interference of new and old related materials (proactive and retroactive inhibition); (b) to decrease the time between presentation and measurement, minimizing forgetting; and (c) to increase attention since practical experience indicated that students' attention diminished if they were made to interact with the same material for long periods. Of the 33 lessons, only one exceeded an average completion time of 1 hour.

Another technique to increase the frequency of passing test scores involved overprompting the students (Remember this for the test!). Sometimes the prompting would be more subtle, but still identifiable to the student. To illustrate, statements related to test items were italicized in some lessons.

The most effective test-teaching approach was keying interaction items directly to the test items which were missed. Thus, a multiple-choice question might be inserted to provide practice for a matching test item.

The only major change to the organization of the lessons as a result of the validation process was the introduction of indices. These allowed the students to select their own path through the lesson and selectively review sections. Minor changes consisted of correcting grammatical, spelling, and technical errors.

No general guidelines for lesson presentation techniques were ascertained from the study of lesson changes made to achieve validation criteria. Instead, it was noted that the true intent of validation–formative lesson evaluation–had been reduced to an exercise of teaching a test. The long-term effects of circumventing the role of validation were apparent after all lessons were validated. Many lessons still had grammatical and technical errors, and student comments related to poor comprehension were found in the critique forms.

Conclusions

The following conclusions follow from the observations of the project evaluation team:

1. The process used to develop PLATO materials during the second phase of the project was more effective and efficient than that used in Phase I.

2. The lessons prepared did not fully exploit many potential PLATO capabilities, chiefly because of resource constraints, a lack of expertise with CAI, and inadequate training in instructional programming concepts and techniques.

3. Role specialization contributed to increasing the efficiency of lesson preparation. The concept of an author/instructor is too unwieldy for a technical training environment; with too many roles to perform, the efforts of an author become diluted. The author/instructor concept may linger through efforts to concentrate training and to provide author aids; however, the evolution should be toward a team specialist approach.

4. The PLATO system was very flexible in terms of instructional design capabilities and lesson tryout data handling.

5. Sophisticated CAI capabilities may not be necessary for efficient lessons which present low order task knowledges. Low order task knowledge refers to the condition where course graduates require only a limited understanding of task-related knowledge to perform field tasks to supervisor satisfaction.

VII. MANAGEMENT OF THE PLATO-BASED COURSE

This section will attempt to pinpoint the extent to which management of the PLATO resources contributed to project effectiveness. Management outcomes will be discussed in terms of daily training activities, student control, lesson control, instructor roles, and test management. Comparative evaluations, under controlled conditions, of various management schemes were beyond the scope of this study. Consequently, the conclusions share the limitations of the methods used to collect the data.

Method

Information for the evaluation of management practices was obtained by observational and interview techniques. Informal interviews of project and course personnel occurred for the most part during the summer of 1976.

Result and Discussion

General Management Structure. Each course had a course supervisor, assisted by block supervisors who in turn were assisted by instructor supervisors. All were qualified instructors and could assume classroom duties. Instructor supervisors normally participated as instructors in addition to their supervisory duties.

In the area of personnel, the major departure of the PLATO environment from standard operating procedures was the formation of a special PLATO author group which consisted of three people, created to maintain the PLATO software. Their duties primarily centered around maintaining lesson materials with corrections, updates, or revisions as necessary, keeping the student router functioning to collect on-line data, and generally acting as system troubleshooters to keep training running smoothly. This team consisted of two authors and one TUTOR programmer.

Maintenance and support of training materials would normally be carried out by the Training Services Division. This group is responsible for all training devices, procedures trainers, textual materials, visual aids, and demonstration models. Under normal circumstances, training branches have no responsibility for the maintenance of training material once it has been incorporated as a part of operational training. In this regard, establishment of a section of people in the course specifically dedicated to maintenance of training material was a major break with normal management procedures in resident training. For a small operation dealing with a very limited number of courses within a single training branch, establishing a dedicated group of people was probably the most workable management scheme possible

This management scheme for general maintenance and support of PLATO training was judged to be effective for the limited application observed. If wider application were pursued, a different means of supporting the software would be necessary.

Daily Training Management. Student attended training from 6 a.m. to noon each day, Monday through Friday. Because PLATO was down for maintenance from 6 a.m. to 7:40 a.m., the system was not available for the full training shift. Thus, the first part of each student's day excluded PLATO. Instead, the time was utilized with off-line instruction, usually in the laboratory, but frequently in class, working with special tools and observing demonstrations conducted with models and cut-away training devices.

Working from a lesson plan, which will be described more fully in the section covering management of instructional materials, the instructor estimated when students would be ready to proceed to the next PLATO session. Usually this estimate was made the day before the training was needed. The instructor then scheduled the class by making an entry on a large scheduling board in the PLATO lab indicating the number of students, lessons to be used, and approximate start and finish times. There were occasions when schedules of different classes conflicted. These conflicts were usually resolved by compromise; however, an informal priority system was established to assist in determining access to the system. First priority went to students ready to take block examinations on PLATO, and second priority went to classes that were engaged in operational training; third priority went to authoring or other indirect uses of the system. In cases where a conflict existed over a few terminals, faster students who were working with enrichment materials were assigned off-line material, while the rest of the class caught up. The terminals they had been using were then taken by the other class for operational training.

Some conflicts arose which could not be resolved by compromise. These problems involved the PLATO system itself and were due either to system failure or to insufficient ECS. When the system failed and it appeared that it would be inoperative for an extended period of time, instructors reverted to stand-up instruction with specially prepared back-up lesson outlines. These outlines covered the same information presented in the PLATO lesson, but it was delivered via traditional lecture/discussion. In addition to the lecture outline, films and sound-slide presentations were utilized in the absence of PLATO.

When there was insufficient ECS, the instructor would either rearrange the instructional sequence slightly to postpone the PLATO session, or revert to the lecture mode, depending on time or sequence constraints.

In summary, management of the daily training activities required a great deal of flexibility from all instructors. Unexpected system failure, shortages of ECS or terminals, conflicts of schedules, and variations in student progress through the curriculum made it essential to leave most management to the instructor.

Under circumstances of resources limitations, management of PLATO-based training, though imprecise, was perhaps the most effective possible. Expanding PLATO to other operational application would entail sizable management problems that would have to be approached with care and planning.

Management of Student Flow. Group-pacing was selected for the service test application. That is, to optimize the time-saving capabilities of PLATO, students in a group progressed through the curriculum at the rate of the slowest group member. Previous flow management used the lock-step method wherein students were allotted a fixed amount of time for each major objective in the curriculum. With lock-step management, instructors were sometimes faced with a problem of having too much time for a particularly fast class or too little time for an unusually slow group. In group-pacing, the instructor could progress to the next objective as soon as he felt the group was ready. The group-pacing strategy proved more flexible than lock-step and generally allowed instructors to complete training in significantly less time.

On the other hand, one of the major advantages of lock-step training was that it permitted simpler management controls. Time on limited equipment could be scheduled more precisely, there were fewer requirements to fall back on alternate contigencies, and, in general, it was much simpler for supervisors to manipulate. Group-pacing, on the other hand, placed a greater management burden on the individual instructor and left much of the control of training in his hands.

A third alternative, one which was not attempted in this setting, was that of computer self-pacing, where individual students progress through the course at their own individual rate. Several problems precluded self-pacing. PLATO was limited in its capability to support simultaneous use of several different lessons. The number of lessons allowed in ECS (i.e., "condensed") was a function of the number of terminals at a PLATO site. Depending upon the size of lessons in use, only around ten or so could be condensed at any one time and still be within ECS limits. The net effect of the ECS limitation was that self-pacing might not have been a feasible strategy, since it would not always have been possible to provide all needed lessons at a specific time. Another difficulty with self-pacing would have been that PLATO training comprised the first part of training, and the latter portion was designed to accept students on a group basis. The shred areas did not have individualized media; consequently, the classroom instruction had to be conducted by instructors in a lecture discussion mode. Moreover, a heavy investment in training equipment was required. These problems prevented self-paced training, though, in general, self-pacing would remain the most efficient means of getting students through training.

A group-paced system of student flow has some distinct disadvantages along with the advantages. One of these disadvantages is a difficulty posed by individual differences in learning speed. There could be, and often were, several hours difference in the time required for the fastest and slowest students (in a particular class) to finish a group of lessons. One procedure adopted to eliminate student waiting time was to have those who finished early repeat some, or all, of the lessons. This served to keep faster students occupied. It also insured that they did not miss some important, though perhaps untested, aspects of the lesson material on their first pass. Unfortunately, such redundancy may have had a negative impact on their motivation since there was no reward for efficient completion of materials. Other means for filling this "waiting time" were to allow the fast students to review "enrichment" materials. These were instructional materials which were not essential to achieving the required (2b) level of performance, but which still contributed to their general competence as a mechanic.

Sometimes faster students were placed with slower students to act as "peer instructors." Where the faster student was actually a good teacher, this was an effective means for speeding slower students along. On the other hand, many times the student peer instructor was not so much interested in how well the "student" learned the material as in how fast the student completed the lesson. As a result, the slower student sometimes tended to rely on the helper too much for the answers and thereby failed to learn the material as well as if left on his own.

Extremely slow students were brought back during the SIA time after the normal training day to catch up. Such a practice was not encouraged, however, and consequently was used only infrequently. Students were allowed to return on voluntary SIA to make up time lost earlier. As a result of these procedures, classes usually completed the PLATO portion of the course at approximately the same time, within 2 to 4 days of each other.

In summary, management of student flow under the group-pacing strategy both saved time and was operationally feasible. It posed problems for coping with individual differences in lesson completion rates, but various contingencies were developed for resolving those difficulties. While it is premature to recommend full-scale self-pacing, it is strongly urged that the strategy be implemented on a limited basis for at least one course to make a direct determination of its operational feasibility.

Management of Instructional Material. Control of student learning materials was done principally by the instructor. In the event PLATO was unavailable for some reason, the instructor lectured from an outline of the material required to meet the training objective. If PLATO was available, the instructor would assign his students to a PLATO module. There were four modules, one for each major block of training.

When students signed onto PLATO, they were shown a listing of all the lessons in their current module. They had to complete the lessons in sequence listed. After completing each lesson, they were returned to the listing display. Students could not go to a new module until they had successfully completed all of the lessons. If they completed a module, and there was time available, the option was provided to return to a previous module and review other lessons completed or interact with enrichment material.

Use of lesson modules enhanced instructional flexibility. Instructors generally assigned students to a subset of lessons in a module at each session. The number of lessons assigned generally depended upon the amount of time available, terminal or ECS resources, and daily training objectives. It was necessary for the instructor to monitor the progress of the students to be sure that they were not proceeding too fast or spending time on lessons other than those assigned.

This management procedure relied rather heavily on instructor intervention. Some tasks done by the instructor could have been assumed by PLATO (i.e., monitoring student progress), though this was probably not feasible in this instance because of the terminal and ECS limitations. Fully automating management of PLATO material might also have produced negative side effects. For example, it was felt that instructor participation in the training process was an important element in maintaining job satisfaction. Under the intervention mode of operation, the instructor had a substantial and active role in the PLATO training. If these tasks were automated and not directly under instructor control, there would be a loss of involvement. The potential effects of this loss of personal involvement were reflected in the measures of instructor attitudes discussed earlier.

In spite of this problem, it is important that instructor participation in routine administrative matters eventually be reduced to a minimum. Instructor involvement is important, but it should be limited to areas directly related to delivery of information and the acquisition of knowledge.

Management of student flow in the PLATO portion of training developed by a process of evolution. Many traditional teaching methods were employed and it appeared that little in-depth examination of optimum student management techniques was carried out. The course was operated under the assumption that PLATO would not reduce instructor requirements and, therefore, the system should be utilized only in ways that fit into traditional modes of instruction. It was impossible to achieve major cost savings through PLATO applications while this attitude was present.

Instructor Role in PLATO-Based Training. The role of instructors in the new PLATO environment, like management of student flow, also took shape through an evolutionary process. The instructor tended to become less of a dispenser of information and more of a facilitator of instruction. For the most part, the role was primarily one of dealing with uncertainties including: how long it would take to get through a lesson; whether enough terminals would be available when needed; if sufficient ECS would be provided to support all of the lessons as needed; whether the system would be operating; and, if it would fail during an on-line session making it necessary to revert to backup material. With this substantial amount of unpredictability facing the instructor each day, his management role in making on-the-spot adjustments was critical. Instructors were not only responsible for the direct instructional processes associated with monitoring the delivery, acquisition, and evaluation of learning, but also for indirect processes to establish a learning environment.

Evaluating this role could not be done realistically without considering characteristics of PLATO. If the system were perfectly reliable, ample ECS were always available, and terminals never failed, many of the contingencies facing instructors would not have existed. In this case, less of a management load would have been levied on instructors and more time would have been spent in direct instructional activities. During the course of the project, however, the instructor role continued to incorporate a great deal of uncertainty management. This was a negative aspect of the PLATO system, but ready solutions were not apparent.

Instructor duties in the PLATO lab were very different from the conventional classroom. PLATO students dealt with a far more versatile and complex teaching medium than textbooks or lectures. PLATO lessons included remedial loops, branches to HELP sequences, conditional answers, and sequential animations. If a student asked for help in a particular lesson, the instructor was required to determine where the student had been, how he had arrived at his difficulty, and how to help him in the most instructionally effective way. To do this efficiently, the instructor had to be intimately familiar with all of the PLATO lessons; not just lesson content, but with the strategies used, answer idiosyncracies, rationales and logical structures. Being thoroughly familiar with even the limited number of PLATO lessons involved in this service test was a major instructor accomplishment. The instructor task was further complicated by the fact that many of the PLATO lessons were not designed for "browsing." That is, there was often no simple way to go back to a previous display or otherwise reconstruct the student's progression. Such options are not precluded by TUTOR software, but are complex to code and were generally not employed in the interest of coding efficiency and rapid lesson development.

The job of the instructor in the classroom was made very difficult by such lesson inflexibility. While expertise in anticipating, comprehending, and correcting student difficulties came with time and experience, new instructors were at a severe disadvantage. These considerations pointed out a strong need to work toward making PLATO lesson material self-supporting so that instructor intervention would be kept to a minimum. This would require a long period of continuous evaluation and revision as lessons are used in operational training.

Evaluation and revision of PLATO lesson material created another facet of the instructor role. As instructors used the lessons, they noticed areas where students had consistently encountered difficulties. The instructors brought this information to the author group for corrective action. When the lessons were first introduced, there was a great deal of such feedback. Each instructor had different ideas on how lessons should be improved. Some suggestions entailed substantial improvements in efficiency, while others were fairly trivial and dealt with minor word changes, additions, or rearrangements that were concerned more with aesthetics than lesson content. Instructors went directly to the author group with their comments and left the decision as to whether or not to incorporate the comments to the authors. The number of comments was so great that it would have been impossible to respond to each. To alleviate this burden for the authors, a procedure was established whereby instructors took their comments to their supervisor, who was expected to forward them to the authors. This procedure resulted in an instant bottleneck for instructor feedback on the lessons. When instructors had a comment, they had to explain where a change should be made in the lesson. The supervisor, not intimately familiar with the content of all the lessons, usually had to be shown what the instructor was trying to change and then would have to translate the request to the author group.

Introducing a supervisor into the link between instructors and authors created a subtle barrier between them. Instructors became more distant from the lessons they worked with daily. As a result, one of the better features of PLATO, the ability to rapidly change or alter lesson material, was pushed into the background and its benefits diminished. Furthermore, it encouraged instructors to accept undesirable characteristics in lessons rather than to struggle with changing them. The net effect of the procedure was that lessons never reached levels of self-sufficiency that would reduce or eliminate needs for instructor intervention in PLATO training.

A development in systems software enabled a great deal of progress to be made in solving the lesson revision/feedback problem. The new software change allowed a student to write a note about a particular lesson. The note was stored in a file which could then be accessed by any author or instructor in the course. The students could also review notes they had written, as well as notes written by other students or instructors. When a student wrote a note, the name of the lesson and location within the lesson were displayed in the note. This feature greatly facilitated locating and correcting troubleshome areas within lessons. For CAI to work effectively, it will be necessary to emphasize to students and instructors alike that the comments feature is available and that it should be used often.

A fourth aspect of the instructor role in PLATO training concerns control of student learning strategies. It was an important function of instructors to insure that students applied proper reading and study techniques to acquire knowledge in their independent learning activities. One area some instructors emphasized for their students was that of note taking, since, students had no way to review PLATO material outside of the lab. To remedy this problem, some instructors insisted that students take notes while going through each lesson. This strategy imposed some unusual considerations for computer-based training.

Most computer-based lessons were designed and validated in such a way that students were expected to be able to pass an end-of-lesson test solely on the basis of knowledge gained as a result of interacting with the lesson. Introducing note taking allowed students to write down information they were supposed to have stored in memory. When the end-of-lesson test was encountered, students had their notes to refer to for assistance on each question. The validity of the test may have been compromised, as it did not necessarily measure retention so much as it did note taking ability.

A possible solution to this problem was to design lessons with the thought in mind that students *would* be taking and using notes throughout the lesson and end-of-lesson test. The author could then create interactions with the lesson that required students to synthesize facts and principles which could be recorded in notes, but which had to be combined to satisfy response requirements. Likewise, end-of-lesson test questions could be carefully constructed so that they do not require responses that are simply verbatim reproductions of information presented in the lesson.

Such a practice would be more congruent with what a student must do on the job after training. It is rare that an individual in the field is faced with a problem that he must solve without access to some form of written material. This may also prove to be a more effective learning technique than study without notes for it would require deeper thought and actual understanding than is required by simple verbatim reproduction of facts.

In summary, it was observed that instructors served a very important function as managers in the daily performance of their training responsibilities. Their jobs were complicated by inflexibilities in lessons and by requirements to be intimately familiar with lesson content and structure. They provided authors with information to improve lessons, but inefficient communication hampered this activity. Finally, instructor control of student study strategies and note taking was observed to complicate aspects of lesson validity and effectiveness. Allowing note taking could, nevertheless, be a powerful technique for improving training effectiveness.

In general, the instructor role was still evolving during the preparation of this report. It was not well-defined and will require additional experience before a truly summative assessment can be made. As the system continues to develop, efforts should be directed toward increasing instructor involvement in direct instructional support, reducing requirements for instructor intervention in learning from PLATO material, and increasing involvement in lesson refinement.

Management of Student Testing. This section deals with use of PLATO for on-line administration, scoring, and critique of the end-of-block examination, the principal tool for evaluating student learning. Occurring at the end of each major section of training, the end-of-block examination was 20- to 50-item multiple-choice test, designed to sample the student's knowledge of the subject matter covered. The test was taken by the class as a group and use of notes was prohibited. There were three alternate forms of each test with a controlled overlap of items that were common to all forms. All end-of-block examinations were administered on the PLATO system to all classes for each block, including the shred area blocks where no actual instruction was presented on PLATO.

Access to PLATO-administered tests was controlled by the instructor. When a class was ready to take a block examination, the instructor entered a particular test form for each student. All students in a class received the same form of the test. The instructor's guidance was to select the form that had been used least. The instructor went to each student's terminal and entered a code (which the student did not see) which "unlocked" the test and allowed the student to complete it. After a student had gone through all of the items on his test, he was given the option of either having it graded or going back and making desired changes to any of his answers. Once satisfied with his answers, he had the test graded. An instructor then assisted students individually as each missed item was reviewed. Students who had completed the test were required to wait until the instructor was free to complete the grading and review procedure.

This method of testing proved to be effective, although less efficient than may have been possible. It was less time-consuming than traditional paper-and-pencil testing and conserved materials. Perhaps the only disadvantage was the critique procedure. Since test items were not discussed in a group situation, students who guessed answers correctly missed a discussion of why the answer was right.

Management of the on-line testing material seemed somewhat less than optimal. A more efficient use of PLATO's power could reduce the instructor activity presently required to prepare for testing sessions. An algorithm could be designed to automatically output on any given day the least used test form. As long as a secure "lock-out" code had to be entered before the file could be used, students would not be able to get premature access to end-of-block tests.

Test creation, revision and security were generally facilitated by PLATO. For example, a new test could be ready for administration a few hours after the test items were approved. The items were typed into designated locations within the TUTOR code which was reproduced for each new test. This saved the time lag and additional efforts associated with off-line reproduction. In addition, revision of tests was greatly simplified, since changes could be made without the same time lags and clerical functions associated with off-line testing. Revision was further facilitated by providing a subroutine which allowed instructors to enter comments about items which were ambiguous, in error, or otherwise caused problems for their students. These comments were then reviewed by the supervisory staff. Security of test materials was also facilitated by the absence of a need to lock them in a file cabinet to be checked out for use and checked in afterwards. Instructors did not have to visually inspect each page of each test for pencil marks left by the student. A printed copy of each block test was maintained by the course. This copy was initialed by a member of the Instruction and Measurement unit, and all items on the PLATO version of the test had to match this hard copy. If a minor change were to be made in a particular item, it was entered in pen-and-ink on the hard copy which was sent for approval. If approved, the change was initialed and returned to the course. A PLATO author then took action to change the coded item in the system. Tests were periodically reviewed to insure that coded items matched the approved hard copy.

Test item analyses paralleled ATC procedures, except that they were performed by PLATO personnel. These analyses provided a rough measure of the reliability and validity of the test and its items. What the instructor viewed on PLATO was a representation of the test analytic forms which were once prepared manually. Test evaluation could be improved via the PLATO system since the data collection and computational aspects of the task could be automatic. More sophisticated test analysis is possible, as long as instructors are trained to properly interpret the results.

In summary, management of on-line testing had advantages and disadvantages, although its advantages appeared to be more numerous. It is likely that management of tests has perhaps become as efficient as possible under the current circumstances, with the exception of providing student access to tests when needed. It is recommended that further attention be given to reducing the need for instructors to manually select and set up tests for student use.

General Conclusions Concerning Management

This section examines various aspects of the management portion of PLATO-based operational training. Management activities in daily operations, procedures for controlling student flow, the management of instructional material, instructor roles, and testing were each discussed in detail relative to unique contributions of PLATO. While many benefits were provided by PLATO in each of these areas, there were certain disadvantages. On the whole, however, it was observed that PLATO did not lead to insurmountable management problems. With continual interest in smoothing and streamlining the PLATO operation and reducing the need for "hand feeding" it, increased training program efficiency is possible.

With the relatively limited experience available in managing a complex medium such as PLATO, management was remarkably good. Management of PLATO-based training in Air Force technical training did not entail unusual or drastic measures to function. While different techniques were necessary to allow for PLATO's idiosyncracies, these techniques served to facilitate efficient training rather than impede it. Keys to success in future Air Force applications are contained in the experience gained from this effort. For example, to insure success, it is necessary to engage in substantial preplanning and possess a willingness to depart from traditional methods of training management. With such an approach, implementation of computer-based concepts into technical training should be carried out with increasingly greater efficiency.

VIII. HUMAN FACTORS ANALYSIS

Introduction and Method

The PLATO system was analyzed from human factors engineering standpoints of usage problems and parameters, reliability, student courseware adaptation, hardware familiarization, and TUTOR coding difficulties. For the sake of convenience, the methodology for each human factor standpoint is included within the results and discussion.

Results and Discussion

Usage Problems and Parameters. Student usage problems were measured in several ways: (a) attitudinal questionnaires administered 1 to 3 days prior to the block examinations in the first four blocks, (b) a "Human Factors Questionnaire" developed by the evaluation team given midway (approximately 2 weeks) into block II, and (c) "Student Critique" forms given at the completion of block IV and at course completion. Ongoing observation by evaluation team members, as well as continuous feedback from instructors and managers of the PLATO IV system, supplemented these primary data.

The data revealed few usage problems with the major components of the PLATO IV system. Approximately 90 percent of the respondents to the Human Factors Questionnaire indicated no major problems with the use of the keyboard or reading the plasma panel. The remaining comments, such as the seating arrangements, terminal position, system reliability, lighting, glare, and microfiche resolution (color and focus), were not mentioned with sufficient frequency to warrant further examination. In part, this was due to the existing PLATO laboratory environment. The 26- by 50-foot laboratory space was lighted by three blue fluorescent lamps, and a small variable-intensity lamp was located in each of the terminal carrels. Thus, sufficient light was available for note taking, while reflective glare was minimized. There were some instructor complaints about the blue lights in the room; consequently, a better solution to the glare problem would be diffused lighting.

Attitudes concerning the optimal length of PLATO sessions were obtained by using an open-ended question on the Human Factors Questionnaire. The average length recommended was approximately 60 minutes, with responses ranging from 10 minutes to 2 hours. Approximately 10 percent wanted to individually set session time according to need. The main factor determining desired session time before breaks appeared to be tradition, since 60 minutes is the normal amount of time spent in a classroom before a break. Eyestrain and headaches were additional factors, with 10 percent of the respondents indicating that using PLATO beyond 60 minutes was not desirable.

PLATO System Reliability. The relationship between the student and the PLATO medium is most obviously influenced by the reliability of the PLATO system. CERL maintained records and this information is presented in Table 32. The data basically reflect the service test's second phase, when development tryout and evaluation activities were ongoing. Most interruptions were short and more frustrating than representive of a real problem. Overall, terminal and system reliabilities were good during the latter portion of the service test. Terminals which failed were usually repaired within 1 to 2 days.

Table 32. **PLATO Reliability Information**

	Hardware and Software Interruptions	
Mean Percent Usable Time	Mean Hours Between Interruptions	Mean Hours Duration
	PLATO System	
94.7	9.52	.38
Mean Weeks Between Terminal Failures	Mean Hours Unavailable[a]	
	Terminals	
11.31	7.02 (per terminal/per month)	

[a] Includes time when no maintenance was available (nights and weekends).

Student Adaptation. Student adaptation to CAI learning strategies was measured by an open-ended question on the Human Factors Questionnaire as well as by periodic student interviews. The results appeared to suggest no significant adaptability problems with using the PLATO IV lessons. Of the 76 students in the CP and PB conditions who responded to the Human Factors Questionnaire, approximately 91 percent indicated that it did not take long to get used to the PLATO lessons. Of the few students who indicated adaptability problems, most were related to the remedial branching strategy of the lessons (being "kicked back" in the lesson for missing a question) or to signing-on difficulties, both of which were found to be relatively unimportant. Periodic student interviews confirmed these findings.

Terminal and Keyboard Familiarization. Terminal and keyboard familiarization were measured with an open-ended question on the Human Factors Questionnaire. The majority of respondents indicated that orientation to PLATO IV did not take very long. Of the 76 usable responses, the mean time indicated to become used to the terminal was approximately 2 hours, with a wide range of 3 minutes to 2 weeks. Only two respondents indicated they had not become used to the terminal. There were a few comments on how relatively simple and easy it was to use, and that prior typing experience had helped to speed up the familiarization process.

TUTOR Coding Difficulties. Information on this topic was obtained from the instructional materials developments interviews conducted in November 1974. The results showed that authors had no major problems in manipulating the terminal for lesson coding activities. One problem was that the keyboard did not indicate all the various functions. For example, an author had to remember the keys which had to be pressed to obtain special characrers. In this case the author could create his own chart of characters and functions, or access a lesson which described them.

Conclusions

This investigation into the human factors consideration of a military PLATO site found no major human factors problems at Chanute's PLATO laboratory.

IX. EXPERIMENTAL STUDIES

ARPA supported an extension of the PLATO IV service test at Chanute so that sufficient time to fully implement and evaluate the PLATO-based Special Purpose Vehicle Repairman courses was available. Additional objectives were specified in the revised management plan (see historical perspecrive, Phase III). One of the objectives included the performance of seven studies which were directed at examining PLATO's potential in selected CAI strategies, and CMI applications. Due to author attrition, managerial problems, the fact that the collective ability of the remaining authors could not meet the demands of the task, and other commitments, only one study was completed.

The study attempted involved the development of a lesson dealing with the Air Force technical order system. Technical Orders (TO) had been a difficult subject area for technical training students because they had little background information with which to associate the new material. Moreover, TOs are a low-interest subject area. It was, however, critical that students learned to rely on TOs, which were the only official guidance for conducting maintenance activities. Through the use of CAI simulation and gaming instructional strategies, it was expected that greater learning efficiency and positive affect would result.

The final TO instructional sequence deviated from the original design in that the simulation exercise was not completed, and that the gaming activities were curtailed and modified. The aforementioned problems which reduced the scope of activities, were responsible for these deviations.

This section of the report will present findings derived from the evaluation of the TO instructional sequence. At best, it could be called a pilot study since operational constraints weakened the evaluation design considerably.

Lesson Sequence and Development Time

The TO instructional sequence consisted of seven modules, each with its own test. Students had to attain a minimum score of 80 percent for each module test to proceed to the next module. Five games were prepared and were included in the instructional sequence for some of the students in the vehicle maintenance courses. Figure 12 depicts the instructional sequence and the points at which the games were added to the lesson.

The five games were intended to keep the student involved with TO material and to promote a positive attitude toward subject matter and learning environment. It was expected that learning acquisition

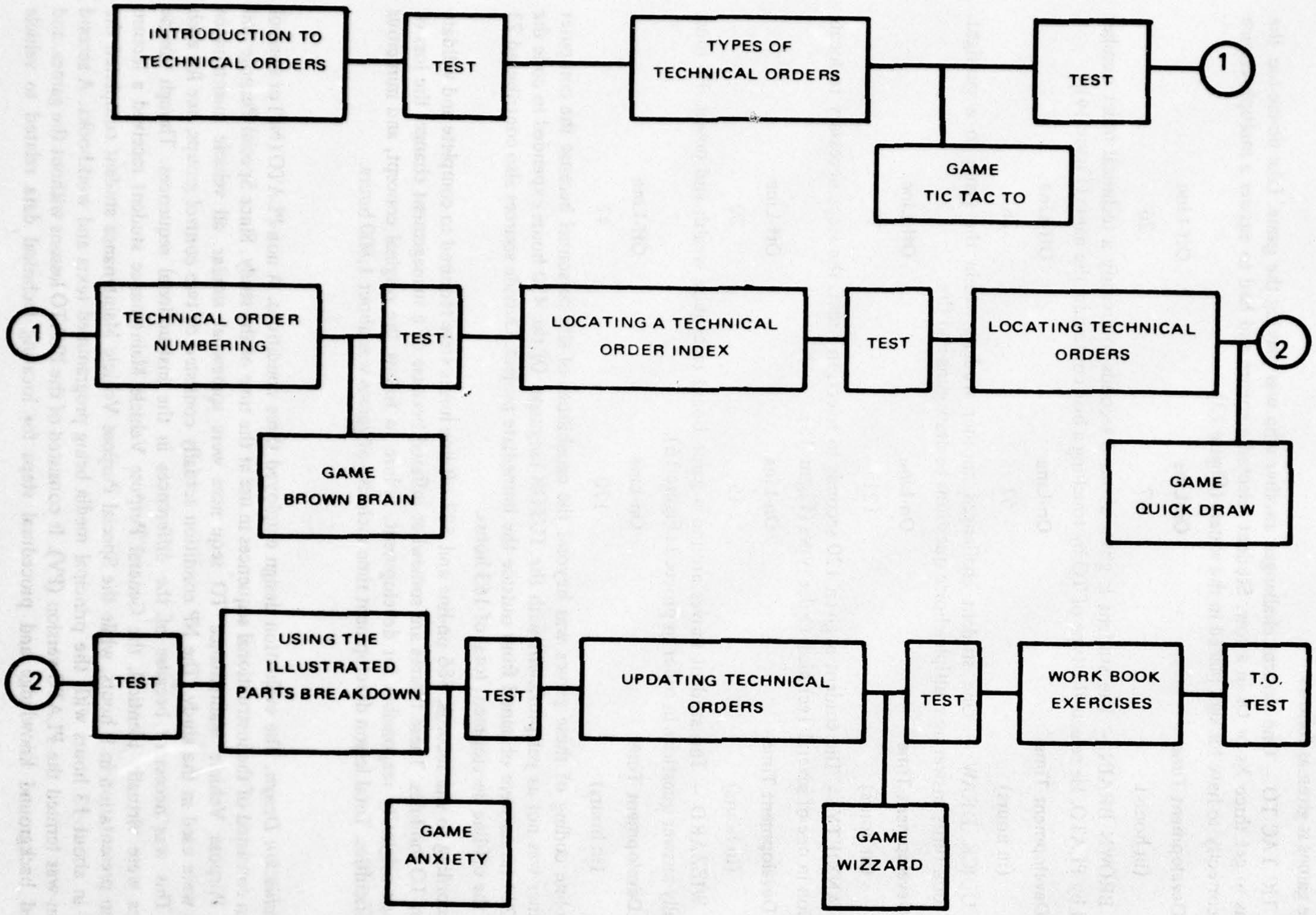


Figure 12. **Technical order lesson sequence.**

and retention, task performance, and the attitudinal measures taken for each student would indicate an improvement over the leasson versions without gaming. Two of the games offered competition between the student and PLATO (timed games) while three offered competition between students. A brief description of the five games is given as follows:

1. TIC TAC TO – One student challenged another who was playing the game. Like tic-tac-toe, the object was to get three Xs or Os in a row. Student selected a square and had to answer a multiple-choice question correctly to have his sign placed in the square (Figure 13).

Development Time	**On-Line**	**Off-Line**
(in hours)	47	26

2. BROWN BRAIN – The student is given about 5 seconds to identify a technical order number generated by PLATO. He selects the type of TO by touching a box containing the name (Figure 14).

Development Time	**On-Line**	**Off-Line**
(in hours)	57	28

3. QUICK DRAW – One student challenged another student within the game to a gunfight. Students took turns answering multiple-choice questions to draw guns and fire.

Development Time	**On-Line**	**Off-Line**
(in hours)	121	33

4. ANXIETY – The student is given 120 seconds to select, in order, the steps necessary to locate information in one of several Technical Order types (Figure 15).

Development Time	**On-Line**	**Off-Line**
(in hours)	45	20

5. WIZZARD – The student moves around a game board to acquire wealth and power. He must periodically answer questions in order to proceed (Figure 16).

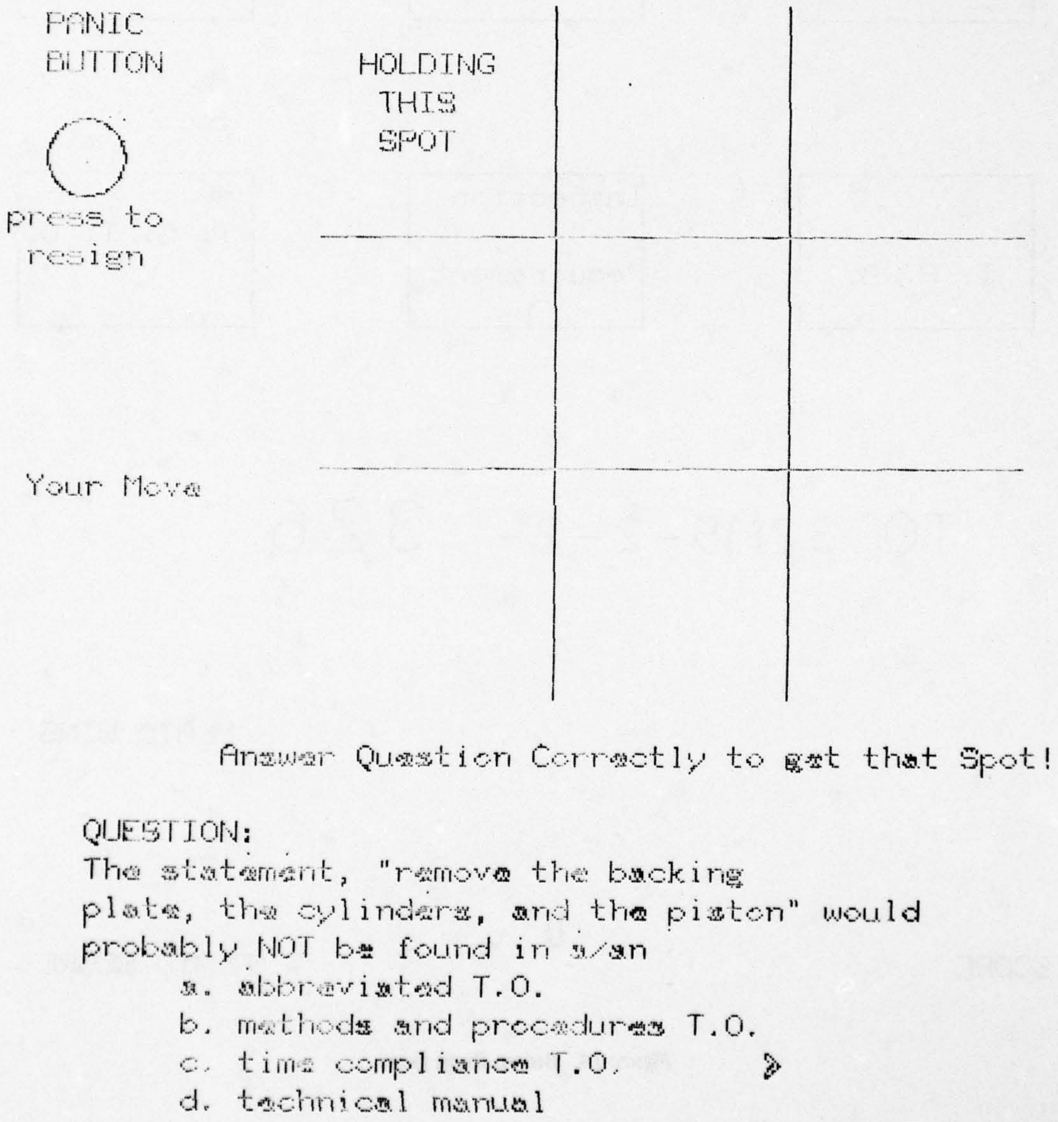
Development Time	**On-Line**	**Off-Line**
(in hours)	170	42

On-line coding of these games was beyond the capabilities of site personnel because the computer programmer was not as yet proficient with the TUTOR language. Of the 430 hours expended to code the lessons, 244 hours were obtained from outside the immediate project. Outside sources also contributed 73 hours of the off-line development total of 163 hours.

According to site records, 586 on-line and 587 off-line hours were required to complete and validate the seven TO modules. These figures are somewhat inflated because of a management change, the loss of the author originally responsible for development, failure to follow the original concept, and numerous other difficulties. Total lesson development time inclusive of games was about 1,800 hours.

Method

Evaluation Design. The evaluation design employed three conditions. A non-PLATO (NP) or control condition consisted of the instructional sequences in use at the time of the study. Since Special Purpose and General Purpose Vehicle Maintenance TO sequences were somewhat similar, all vehicle maintenance students were used in the study. The NP condition actually consisted of two control groups, one for each course. This was necessary because of the differences in the instructional sequences. Though course objectives were virtually identical, the General Purpose Vehicle Maintenance student received a lecture discussion presentation in 9 hours, while the Special Purpose Vehicle Maintenance student completed the material in about 13 hours with the principal media being programmed texts and workbooks. A second condition was termed the PLATO version (PV). It consisted of the PLATO lessons without the games, and presented background knowledge and procedural steps for locating technical data related to vehicle

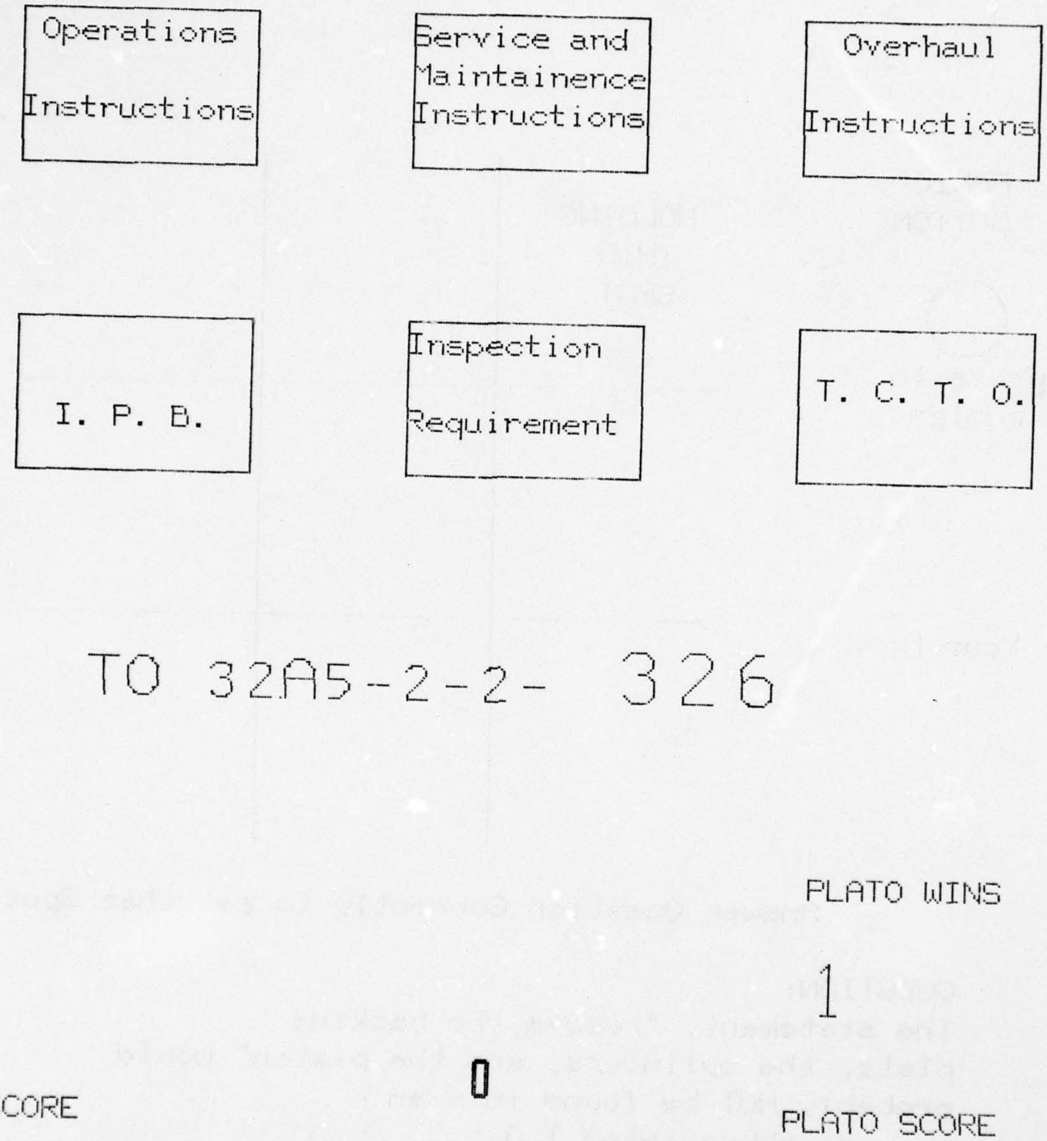


Answer Question Correctly to get that Spot!

QUESTION:
The statement, "remove the backing plate, the cylinders, and the piston" would probably NOT be found in a/an

a. abbreviated T.O.
b. methods and procedures T.O.
c. time compliance T.O. >
d. technical manual

Figure 13. **TIC TAC T.O. game.**



Operations Instructions

Service and Maintainence Instructions

Overhaul Instructions

I. P. B.

Inspection Requirement

T. C. T. O.

TO 32A5-2-2- 326

PLATO WINS

1

MY SCORE

0

PLATO SCORE

Figure 14. **Brown Brain game.**

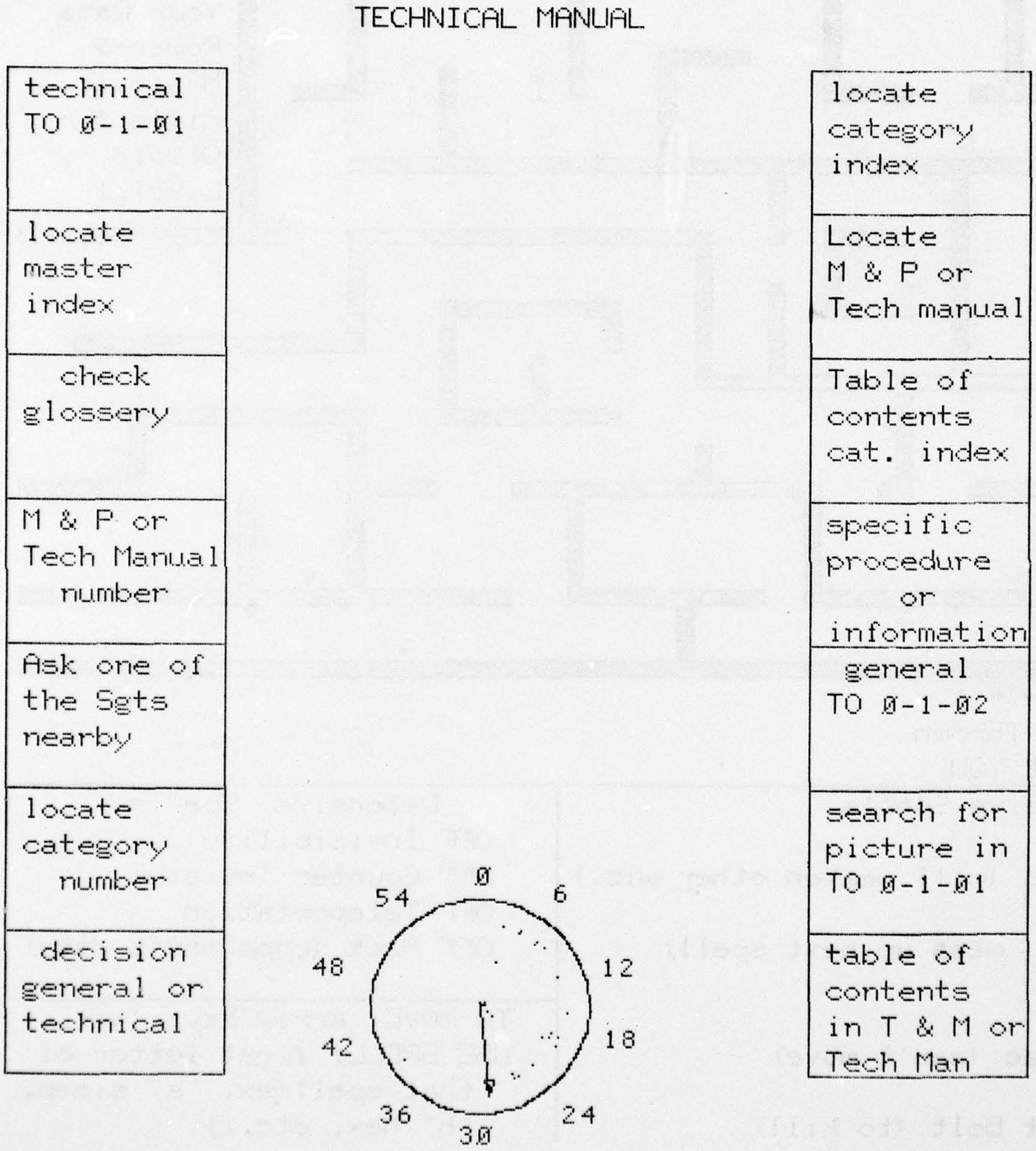
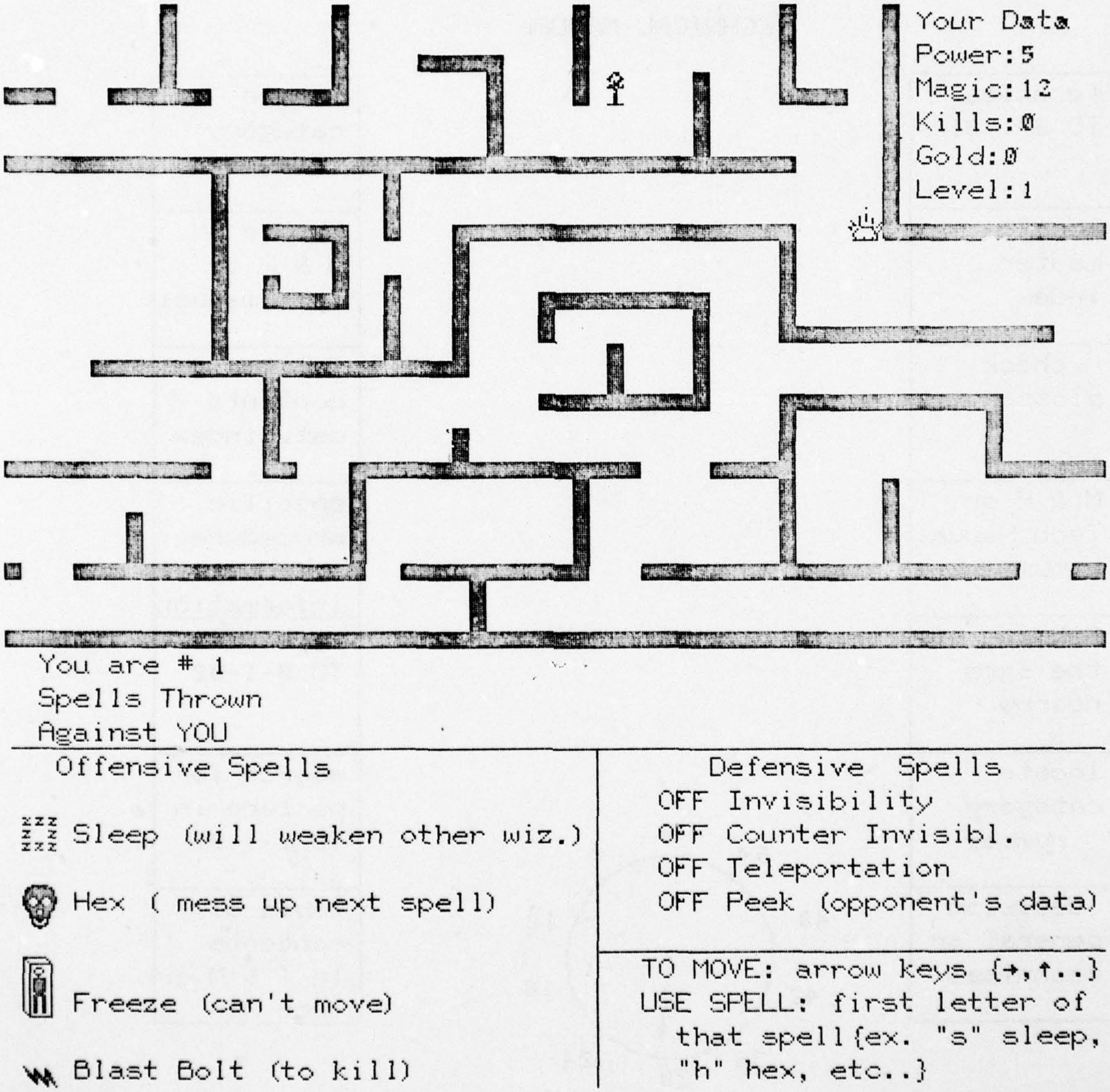


Figure 15. **Anxiety game.**



Your Data
Power:5
Magic:12
Kills:0
Gold:0
Level:1

You are # 1
Spells Thrown
Against YOU

Offensive Spells

Sleep (will weaken other wiz.)

Hex (mess up next spell)

Freeze (can't move)

Blast Bolt (to kill)

Defensive Spells
OFF Invisibility
OFF Counter Invisibl.
OFF Teleportation
OFF Peek (opponent's data)

TO MOVE: arrow keys {→,↑..}
USE SPELL: first letter of
that spell{ex. "s" sleep,
"h" hex, etc..}

Figure 16. **Wizzard game.**

maintenance. The remaining condition, adjunct gaming (AG), combined the five PLATO games with the basic PLATO lessons. Students in the General Purpose and Special Purpose Vehicle Repairman courses were assigned to the PV and AG conditions.

Measures. Performance measures included lesson completion time, end-of-lesson test scores, and a specially constructed TO topical test. Items were prepared by selecting subject areas that were common to all lesson versions, and insuring that the items would not favor a particular lesson version. The final version of the TO test consisted of 39 multiple-choice items, after numerous revisions to enhance reliability.

The attitude questionnaire consisted of four *a priori* dimensions (four items each): TO lesson effectiveness, gaming affect, competition, and TO subject matter. A 9-point (0 = Strongly Disagree to 9 = Strongly agree) Likert-type scale was used for each item.

Subjects. A total of 79 General Purpose and Special Purpose Vehicle Maintenance students participated. Table 33 gives a course by condition breakdown. No Special Purpose Vehicle Maintenance students were obtained for the NP condition, and numerous constraints account for missing observations in subsequent tables.

Table 33. **Sample Breakdown for TO Lesson Evaluation**

Condition	Course	N
Non PLATO (NP)	General Purpose	31
	Special Purpose	0
PLATO Version (PV)	General Purpose	11
	Special Purpose	12
Adjunct Gaming (AG)	General Purpose	15
	Special Purpose	10

Procedures. Slightly different procedures were followed for each condition. In the NP condition, students received the normal instructional program and then received the TO test and attitude questionnaire. PV students received the PLATO lesson in lieu of the programmed text on TOs. AG students received the seven CAI lesson modules, but played a game prior to taking the end-of-lesson test for those modules which contained games. If a game required a student competitor, and no other students were presently within the module, an instructor acted as the opponent. Data collection for end-of-lesson test scores, lesson times, and times within games were automatically accomplished via PLATO, for the AG and PV conditions.

Procedures differed between courses as well. General Purpose Vehicle Maintenance students received the TO lesson sequence at the end of their first instructional block, while the Special Purpose Vehicle Maintenance students, after an introductory lesson to the PLATO system, received their lesson as the first in the course. Test and questionnaire administration times were approximated 1 day apart for the courses. General Purpose Vehicle Maintenance students were required to take block tests before they received the evaluation instruments.

Results

Lesson Performance Findings. Lesson module mean completion times and scores are presented in Table 34. Mean game completion times are also included. Accurate lesson completion times for the NP condition were not obtained; however, it was estimated that General Purpose Vehicle Maintenance students were given about 330 minutes to learn the same material. As constraints (i.e., low student load) prevented the assignment of any Special Purpose Vehicle Maintenance students to the NP condition, no data were obtained. All NP condition students were from the General Purpose Vehicle Repairman course.

Table 34. **Mean TO Lesson Module Times and Scores**

Lesson Module (game)	Time (Minutes)		Score (Percent)	
	PLATO Version N = 21	Adjunct Gaming N = 16	PLATO Version N = 21	Adjunct Gaming N = 16
1. Introduction	47.85	34.00*	72.06	75.88
2. Types of TOs (Tic Tac TO)	54.23	50.68 (24.7)[a]	80.53	78.24
3. TO Numbering (Brown Brain)	47.40	57.29 (9.8)	83.18	84.11
4. Locating an Index	52.41	69.12	65.29	73.12
5. Locating TOs (Quick Draw)	34.19	35.94 (10.8)	72.38	68.82
6. Using the I.P.B. (Anxiety)	37.36	37.06 (8.0)	80.50	76.87
7. Updating TOs (Wizzard)	24.90	22.88 (24.0)	81.09	75.88
Total	298.34	306.97 (77.3)		

[a] Mean game time is not included in the mean lesson time for adjunct gaming condition.

$*p < .05$.

Each set of module completion times for the PV and AG conditions was analyzed through ANOVA techniques. Only the first module had a significant difference (F (1,35) = 5.20, $p < .05$). The mean total completion times for students in either condition were about 300 minutes or 5 hours, with the inclusion of gaming strategies adding 1 hours and 15 minutes.

Module scores were analyzed in a similar fashion. There were no important differences for any of the seven sets of module scores, or the average of module scores.

When administered in the actual experiment, the 39-item test of student achievement had an estimated reliability of .63; therefore, five items were deleted, increasing Cronbach's alpha to .68. A one-way analysis of variance was performed on the raw scores with conditions as the independent variable (F (2,76) = 4.34, $p < .05$). The least significant difference (LSD) multiple comparison method showed that the mean raw score for the PV condition was significantly greater than the NP condition, ($M_{NP} = 16.77$, $M_{PV} = 20.26$, $M_{AG} = 19.24$; LSD = 2.82, $p \leqslant .05$). Moreover, the combined PLATO means were also significantly different.

Attitudinal Findings. The internal consistency of the four dimensions was estimated using Cronbach's alpha. Table 35 indicates that all but the competition scale had adequate reliability. The competition scale was, therefore, dropped from further consideration for the remaining scales. A scale score was computed by summing individual item responses and dividing by the number of items. Scale means are reported in Table 36. The attitudinal scales were constructed so that a score of 4.5 constituted a neutral point with higher favorability being indicated by a higher score. An analysis of variance was performed on student scale scores with condition as the independent variable. No significant differences were found for perceived lesson effectiveness or gaming affect using the .05 level of confidence. From the ANOVA results (Table 37), it can be seen that mean scores for the PV condition were significantly higher than those of the other conditions on the technical order affect scale.

Discussion

The findings suggested that gaming had little effect on student performance and attitudes. Lesson module completion times and scores were not different, PV and AG condition achievement scores did not

Table 35. **Attitude Scale Alpha Reliability Coefficients**

Scale	α	N
Lesson Effectiveness	.73	78
Gaming Affect	.86	78
TO Subject Matter Favorability	.70	78
Competition	.23	78

Table 36. **Condition Means for Attitude Instrument Scales**

	Condition					
	Non-PLATO		PLATO Version		Adjunct Gaming	
Scale	M	N	M	N	M	N
Lesson effectiveness	5.16	31	5.76	23	5.0	24
Gaming affect	5.15	31	6.43	23	6.12	24
TO affect	3.49	31	5.11	23	3.70	24

Table 37. **Analysis of Variance: Technical Order Affect Scale Scores**

Source	DF	SS	MS	F	P
Condition	2	38.38	19.19	6.8	<.01
Within Groups	75	211.41	2.82		

differ significantly, and attitude differences were for the most part unimportant. The one significant lesson completion time difference was probably spurious, and could not have been related to gaming since it occurred in the first lesson module which included no game. The substantive impacts were not favorable. Efficiency was reduced and attitudes toward the subject area were much lower. It was evident that this application of games had no specific or general facilitative effect on the acquisition of information.

It would be a mistake to try and generalize these findings past this immediate environment. Though the games were characteristically dissimilar, the training strategy was the same in each; i.e., the students were asked questions in the hope that they would be stimulated by this activity. Many other gaming strategies with methods that required the student to process or use information were possible. Thus, instructional design personnel might be wary of games which merely ask the student questions, but this feeling should not extend to, say, competitive simulations which require the student to perform job tasks in a gaming atmosphere.

Both the internal and external validity of this study were questionable. Performance data collection was suspect owing to "bugs" in the data collection routine. Obviously poor data were not included within the analysis; however, the validity of the remainder are suspect. AG-condition attitudes data may reflect sequence router "bugs" which sent students to the wrong lessons. Game time variability was very high, since specifications to limit interaction times were not followed. Numerous other problems could be explicated, but the effect is clear: the findings are contaminated and questionable.

Another observation which was consistent with other evaluation results should be mentioned. The PLATO version of the TO lesson was superior to the lock-step instructor-presented lesson. It was more efficient (5 hours as opposed to 6 hours) and produced more favorable student attitudes toward the subject matter.

X. OVERALL CONCLUSIONS AND RECOMMENDATIONS

Overall Conclusions

The following is a listing of the overall service test conclusions which establish a basis for some of the final recommendations.

1. PLATO, as an instructional medium for technical training, was instructionally effective for presenting task-related cognitive materials.

2. The Chanute PLATO application was not cost-effective when compared to courses employing less sophisticated individualized media to perform similar functions. The potential for a cost-effective application exists through (a) deriving cost-effective CAI applications, (b) deriving additional PLATO CMI roles, (c) attempting alternative course organizational structures to fully exploit computer applications and minimize instructor and administrative staff requirements, and (d) maximizing terminal usage.

3. Several conclusions resulted from examining PLATO's impact on some important aspects of training. From the standpoint of student and instructor attitudes, PLATO was an acceptable and even desirable facet of the training environment. PLATO's incorporation within technical training was compatible with existing organizational resistance to the introduction of PLATO; resistance was considered to be a normal and expected reaction to a major innovation. Little in the way of new training capabilities was demonstrated.

4. Courseware preparation was a complex process and more time-consuming than for less sophisticated media. The feasibility of the single instructor/author concept in the preparation of cost-effective computer applications was found to be questionable. Greater efficiency in materials preparation resulted from a team approach employing role specialists.

5. In terms of potential applications, the Chanute effort was limited owing to constraints in management, resource acquisition, personnel training and experience. Plato resource instability was derived from its evolving, experimentally oriented nature, and traditional views toward applying an innovation.

6. Some training management difficulties were experienced because PLATO was not an Air Force resource. Adjustments were necessary in the areas of training activity scheduling and course instructional design selection.

7. Few usage problems were present in terms of student interaction or courseware authoring. PLATO was found to be a reliable tool, once system expansion and experimentation were moderated.

Recommendations

The following recommendations were prepared after considering the total experience with the PLATO IV Service Test. They originate from the empirical and qualitative observations made during the incorporation of PLATO IV into the military technical training environment. The recommendations are grouped in three categories: (a) those which are specific to Chanute, (b) those related to the development of CAI materials, and (c) those concerned with PLATO applications.

Recommendations Specific to Chanute

1. If PLATO is continued as an operational medium, the Technical School Operations Division should encourage and guide future PLATO applications by establishing a functional area within the Training Operations Division to manage expanded usage of PLATO. To attain cost effectiveness, a PLATO

applications section should be created within the Training Services Division. This organization would be the focal point for current and future PLATO applications and should be provided with adequate resources; e.g., trained personnel. The consolidation of personnel resources will provide necessary organizational importance, allow for improved courseware production, as well as prevent deterioration of authoring skills. PLATO applications should be selectively expanded to other corse areas, wherein CAI capabilities might be used to solve training problems, increase instructional efficiency, reduce training resource, and requirements. Finally, a detailed long-range plan should be developed to identify organizational structure, manpower needs, objectives and guidelines for systematic expansions, internal program evaluation, and the numerous other elements necessary to achieve a well-defined program.

2. If the present application is continued, the Special Purpose Vehicle Repairman course should be self-paced. This would take advantage of CAI's individualized nature, limit the need for enrichment materials, and provide for more efficient use of available terminals.

3. Terminal utilization within the SPV course should be maximized by determining the fewest number of terminals required to maintain a given approach. Additional terminals should be shifted to other courses so that other cost-effective applications of CAI may be exploited.

4. Direct communication between authors and instructors should be promoted to facilitate application of PLATO, and increase instructional efficiency.

5. Indirect lighting should be installed in the PLATO terminal room to eliminate the interfering glare from the plasma panels.

6. The number of instructors in the self-paced course version should be reduced. An instructor aide concept, where noninstructional activities associated with student management are performed by a less expensive resource, should be implemented.

Development of CAI Materials

1. The PLATO microfiche procurement process should be analyzed, then improved, for greater efficiency.

2. Redesign of the microfiche projector is desirable to eliminate the focus and registration problems.

3. CAI courseware should be developed through a team approach, using specialists who have overlapping knowledge of other team member's roles in the lesson development process.

4. A training program should be provided for individuals who perform courseware development functions. This program would emphasize instructional programming concepts used for preparing individualized training materials.

5. Instructor and supervisor involvement should be increased in the review and revision of PLATO courseware.

PLATO Applications

1. To minimize the effect of traditional attitudes toward computer applications, potentially cost-effective CAI and CMI applications should be derived. At Chanute, PLATO could be used for:

a. Performance measurement in task-related training objectives;

b. Data analysis, to automatically provide more useful test information, such as reliability, validity, item difficulties, rather than the descriptive information currently gathered in block measurement programs through time-consuming methods;

c. Simulation of complex equipment and/or tasks;

d. Managing student progress;

e. Assuming the interrogative role of instructors to monitor learning from sources other than PLATO;

f. Teaching direct, task-related skills and procedural knowledges rather than simple principles and fundamentals; and

g. Continuous monitoring of training effectiveness; i.e., collection and analysis of data concerning training content, training time, learning achievement, and student abilities/aptitudes for each training objective.

2. Criteria should be established for selecting potentially cost-effective applications and/or those applications which substantially improve methods, but on which no cost value can be placed. Some candidate applications are:

a. Instructional modules where low efficiency with existing media is present;

b. Areas where reductions could be made in expensive resources (instructors, equipment);

c. Training tasks where increased safety is required; and

d. Training sequences where greater productivity/less mistakes could be achieved by continuous monitoring of student performance.

3. It is very important that findings of other CAI projects be reviewed to incorporate those results which are applicable to training environments.

4. Different CAI strategies should be compared to determine if greater efficiency can be obtained for different subject matter areas and student abilities.

Final Remarks

Computer-based instruction will be expanded throughout Air Force technical training because of the desire to use technology to improve the training environment. Testing PLATO within the Special Purpose Vehicle Repairman courses assisted in this endeavor. The evaluation findings demonstrated that PLATO, as an instructional medium, could be successfully incorporated into the technical training process. Its training effectiveness, impact on attitudes, reliability and utility were acceptable. The only major disadvantage was that the cost of instruction was higher than it would be with less sophisticated media used for the same applications. Yet, it is a mistake to think of PLATO as just as instructional medium. It should be considered as an educational tool, with potentially cost-effective applications in the areas of administration and student management, as well as training instruction. When it is understood how to best use this tool, cost effectiveness can be attained.

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APPENDIX A: SPECIAL PURPOSE VEHICLE JOB TASKS

Practice Automotive Personnel and Equipment Shop Safety

1. Apply safety practices with tools and equipment
2. Practice housekeeping

Vehicle Maintenance Publications

3. Use technical orders

Maintenance and Inspection System and Forms

4. Use maintenance data collection forms
5. Use man-hour accounting forms

Use Maintenance Tools and Equipment

6. Hand tools
7. Special tools
8. Test equipment

Engine Maintenance

9. Disassemble and reassemble engines
10. Inspect engine parts for defects and wear Test, troubleshoot, service, and/or adjust engine;
11. Valve trains
12. Lubrication systems
13. Cooling Systems
14. Fuel Systems (gas)
15. Fuel Systems (diesel)
16. Air and exhaust system
17. Emission control and anti-pollution devices

Electrical Systems Maintenance

18. Use electrical schematics and diagrams Test, troubleshoot, and maintain:
19. Starting systems
20. Charging systems
21. Ignition systems
22. Lighting systems
23. Warning systems
24. Batteries

Hydraulic System Maintenance

25. Use hydraulic schematics and diagrams

26. Inspect and troubleshoot hydraulic systems
27. Service, adjust, and test hydraulic system components

Power Train Maintenance

28. Dissassemble, reassemble, service, and adjust power train systems and components
29. Troubleshoot and test power train system

Brake Systems Maintenance

30. Disassemble, reassemble, service, adjust and test brake systems

Mechanical and Power Streering Maintenance

Disassemble, reassemble, service, test, and adjust:

31. Mechanical steering system
32. Power steering system

Heater Maintenance

33. Inspect, service, troubleshoot, adjust and test heating system

APPENDIX B: SHORT FORM SURVEYS

BLOCK #______________

SHRED A B C -1

PLATO QUESTIONNAIRE

NAME____________________________SSAN_______________DATE________________

Circle the number that represents how you feel about the following statements.

	Very Strongly Disagree Very Strongly Agree
1. I enjoyed the time I spent on PLATO.	0 1 2 3 4 5 6 7 8 9
2. I learned what the PLATO lessons tried to teach.	0 1 2 3 4 5 6 7 8 9
3. I would like to study more PLATO lessons.	0 1 2 3 4 5 6 7 8 9
4. I feel PLATO didn't teach me very much.	0 1 2 3 4 5 6 7 8 9
5. I feel challenged to do my best work on PLATO.	0 1 2 3 4 5 6 7 8 9

6. What have you enjoyed most about using PLATO? (You may use the other side).

7. If you could change anything about PLATO what would you change? (You may use the other side).

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BLOCK #____________

SHRED A B C -1

BLOCK QUESTIONNAIRE

NAME________________________SSAN____________DATE____________

Circle the number that represents how you feel about the following statements.

	Very Strongly Disagree — Very Strongly Agree
1. I enjoyed the time I spent in class.	0 1 2 3 4 5 6 7 8 9
2. I learned what the instructor and the material tried to teach.	0 1 2 3 4 5 6 7 8 9
3. I would like to study more with this instructor.	0 1 2 3 4 5 6 7 8 9
4. I feel the instructor and the material didn't teach me very much.	0 1 2 3 4 5 6 7 8 9
5. I feel challenged to do my best work in this class.	0 1 2 3 4 5 6 7 8 9

6. What have you enjoyed most about this class? (You may use the other side).

7. If you could change anything about this class what would you change? (You may use the other side).

APPENDIX C: LONG FORM SURVEY

SSAN________________

PLATO QUESTIONNAIRE
SECTION II

		Very Strongly Disagree									Very Strongly Agree
1.	The method by which I was told whether I had given a right or wrong answer became monotonous.	0	1	2	3	4	5	6	7	8	9
2.	Nobody really cared whether I learned the course material or not.	0	1	2	3	4	5	6	7	8	9
3.	I felt challenged to do my best work.	0	1	2	3	4	5	6	7	8	9
4.	I felt isolated and alone.	0	1	2	3	4	5	6	7	8	9
5.	I felt as if someone were engaged in conversation with me.	0	1	2	3	4	5	6	7	8	9
6.	As a result of having studied by this method, I am interested in learning more about the subject matter.	0	1	2	3	4	5	6	7	8	9
7.	I was more involved in operating the terminal than in understanding the course material.	0	1	2	3	4	5	6	7	8	9
8.	The learning was too mechanical.	0	1	2	3	4	5	6	7	8	9
9.	I felt as if I had a private tutor.	0	1	2	3	4	5	6	7	8	9
10.	The equipment made it difficult to concentrate on the course material.	0	1	2	3	4	5	6	7	8	9
11.	The situation made me quite tense.	0	1	2	3	4	5	6	7	8	9
12.	PLATO as used in this course, is an inefficient use of the student's time.	0	1	2	3	4	5	6	7	8	9
13.	My feeling toward the course material after I had completed the PLATO portion of the course was favorable.	0	1	2	3	4	5	6	7	8	9
14.	I felt frustrated by the situation.	0	1	2	3	4	5	6	7	8	9
15.	I found the computer-assisted instruction approach in this course to be inflexible.	0	1	2	3	4	5	6	7	8	9
16.	Material which is otherwise interesting can be boring when presented on PLATO.	0	1	2	3	4	5	6	7	8	9

		Very Strongly Disagree Very Strongly Agree
17.	I was satisfied with what I learned while taking the course.	0 1 2 3 4 5 6 7 8 9
18.	In view of the amount I learned, this method seems superior to classroom instruction for many courses.	0 1 2 3 4 5 6 7 8 9
19.	I would prefer PLATO to traditional instruction.	0 1 2 3 4 5 6 7 8 9
20.	PLATO instruction is just another step toward de-personalized instruction.	0 1 2 3 4 5 6 7 8 9
21.	I was concerned that I might not be understanding the material.	0 1 2 3 4 5 6 7 8 9
22.	The responses to my answers seemed appropriate.	0 1 2 3 4 5 6 7 8 9
23.	I felt uncertain as to my performance in the programmed course relative to the performance of others.	0 1 2 3 4 5 6 7 8 9
24.	I was not concerned when I missed a question because nobody was watching me.	0 1 2 3 4 5 6 7 8 9
25.	I found myself just trying to get through the material rather than trying to learn.	0 1 2 3 4 5 6 7 8 9
26.	I knew whether my answer was right or wrong before I was told.	0 1 2 3 4 5 6 7 8 9
27.	In a situation where I am trying to learn something, it is important to me to know where I stand relative to others.	0 1 2 3 4 5 6 7 8 9
28.	I guessed at the answers to some questions.	0 1 2 3 4 5 6 7 8 9
29.	I was aware of efforts to suit the material specifically to me.	0 1 2 3 4 5 6 7 8 9
30.	I was encouraged by the responses given to my answers of questions.	0 1 2 3 4 5 6 7 8 9
31.	In view of the time allowed for learning, I felt too much material was presented.	0 1 2 3 4 5 6 7 8 9

		Very Strongly Disagree Very Strongly Agree
32.	I entered wrong answers in order to get more information from the machine.	0 1 2 3 4 5 6 7 8 9
33.	I felt I could work at my own pace.	0 1 2 3 4 5 6 7 8 9
34.	Questions were asked which I felt were not related to the material presented.	0 1 2 3 4 5 6 7 8 9
35.	Material which is otherwise boring can be interesting when presented by PLATO.	0 1 2 3 4 5 6 7 8 9
36.	I could have learned more if I hadn't felt pushed.	0 1 2 3 4 5 6 7 8 9
37.	I was given answers but still did not understand the questions.	0 1 2 3 4 5 6 7 8 9
38.	The course material was presented too slowly.	0 1 2 3 4 5 6 7 8 9
39.	The responses to my answers seemed to take into account the difficulty of the question.	0 1 2 3 4 5 6 7 8 9
40.	While on PLATO, I encountered mechanical malfunctions.	0 1 2 3 4 5 6 7 8 9
41.	Computer-assisted instruction did not make it possible for me to learn quickly.	0 1 2 3 4 5 6 7 8 9
42.	PLATO could be much better if the lessons were improved.	0 1 2 3 4 5 6 7 8 9
43.	The lessons on PLATO were interesting and really kept me involved.	0 1 2 3 4 5 6 7 8 9
44.	What I learned from PLATO made the classroom and laboratory instruction easier to understand.	0 1 2 3 4 5 6 7 8 9
45.	The PLATO lessons were dull and difficult to follow.	0 1 2 3 4 5 6 7 8 9

SSAN________________

PLATO QUESTIONNAIRE
SECTION III

Very Strongly Disagree — Very Strongly Agree

As a student, I do my best work with

1. Movies and filmstrips. 0 1 2 3 4 5 6 7 8 9
2. PLATO lessons. 0 1 2 3 4 5 6 7 8 9
3. Study guides and workbooks. 0 1 2 3 4 5 6 7 8 9
4. Instructor lectures. 0 1 2 3 4 5 6 7 8 9
5. Laboratory instruction. 0 1 2 3 4 5 6 7 8 9
6. Porgrammed texts. 0 1 2 3 4 5 6 7 8 9

Working with the PLATO system:

7. Is fun. 0 1 2 3 4 5 6 7 8 9
8. Is frustrating. 0 1 2 3 4 5 6 7 8 9
9. Is challenging. 0 1 2 3 4 5 6 7 8 9
10. Is annoying. 0 1 2 3 4 5 6 7 8 9
11. Is confusing. 0 1 2 3 4 5 6 7 8 9
12. Makes me proud of myself. 0 1 2 3 4 5 6 7 8 9
13. Is boring. 0 1 2 3 4 5 6 7 8 9
14. Is relaxing. 0 1 2 3 4 5 6 7 8 9
15. Is depressing. 0 1 2 3 4 5 6 7 8 9
16. Is enjoyable. 0 1 2 3 4 5 6 7 8 9
17. Is de-personalizing. 0 1 2 3 4 5 6 7 8 9
18. Is exciting. 0 1 2 3 4 5 6 7 8 9

		10% of the Time									100% of the Time
19.	How often has PLATO worked when you have attempted to use it?	0	1	2	3	4	5	6	7	8	9
20.	During how many sessions have the mechanical interruptions made you want to stop using PLATO?	0	1	2	3	4	5	6	7	8	9
21.	During your school day, if you had your choice, how much of your time would you spend working with PLATO?	0	1	2	3	4	5	6	7	8	9

APPENDIX D: RESULTS OF LONG FORM FACTOR ANALYSIS

Item #	Description	Factor Loading
	Factor I – PLATO Instruction	
3	I felt challenged to do well	.764
5	Felt as if in conversation	.695
6	More interest as result of study	.788
9	Felt I had private tutor	.691
13	Feelings toward course material favorable	.762
17	Satisfied with info learned	.733
18	PLATO method superior relative to amount learned	.767
19	Prefer PLATO to traditional instruction	.768
22	Responses to answers seemed appropriate	.508
30	Encouraged by responses to my answers	.687
35	Boring material can be interesting on PLATO	.717
41	CAI did not make learning quicker	.506
43	Lessons on PLATO interesting and kept me involved	.737
44	PLATO instruction helped in lab and classroom	.794
45	PLATO lessons were dull and difficult to follow	.624
47	Do best work with PLATO lessons	.752
52	PLATO is fun	.844
54	PLATO is challenging	.750
57	Makes me proud of myself (accomplishment)	.714
58	PLATO is boring	.633
59	Is relaxing	.531
61	Is enjoyable	.747
63	Is exciting	.721
64	Reliability	.518
66	Amount of time desired on PLATO	.724
	Factor II – Frustration	
14	I felt frustrated by situation	.649
53	PLATO is frustrating	.735
55	PLATO is annoying	.769
56	PLATO is confusing	.707
60	PLATO is depressing	.575
	Factor III – Training Stress	
11	The situation made me tense	.482
23	I felt uncertain about my performance	.447
31	I felt too much material was presented	.768
33	I felt I could work at my own pace	.450
34	Irrelevant questions were asked	.417
36	I felt pushed	.608
37	I got answers but still did not understand questions	.440
	Factor IV – Non-PLATO Media	
48	I do best work with study guide workbooks	.863
49	I do best work with instructor lectures	.673
51	I do best work with programmed texts	.833
	Factor V – Mechanistic and Impersonal Leaning	
2	No one cared if I learned or not	.501
4	I felt isolated and alone	.493
8	The learning was too mechanical	.657
10	The equipment interfered with learning	.526

APPENDIX E: TECHNICAL TRAINING SURVEY

TECHNICAL TRAINING STUDENT SURVEY
PE 7403
AIR FORCE HUMAN RESOURCES LABORATORY

SSAN

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⓪①②③④⑤⑥⑦⑧⑨
⓪①②③④⑤⑥⑦⑧⑨

GENERAL INSTRUCTIONS:

1. The items contained on this form are designed to measure student attitudes toward Air Force technical training.
2. The form is intended to give you the opportunity to help improve student training.
3. It is very important that your answers reflect your true feelings. This is not a test and you are not required to put your name on the form.
4. Please carefully follow the instructions at the beginning of each of the four main sections of this form.

DATE

Yr. 19- ⓪①②③④⑤⑥⑦⑧⑨
⓪①②③④⑤⑥⑦⑧⑨

Day ⓪①②③④⑤⑥⑦⑧⑨
⓪①②③

Mo. ○ JAN ○ FEB ○ MAR ○ APR ○ MAY ○ JUN ○ JUL ○ AUG ○ SEP ○ OCT ○ NOV ○ DEC

SECTION I:

1. Below are statements describing rewards a student might receive if he performs well in technical training.

2. Beside each statement are two separate rating scales.

   On Scale 1 indicate how likely it is for you to receive the reward if you perform well in training.

   On Scale 2 indicate how important the reward is to you. Consider only its importance, not how likely or unlikely you are to receive the reward.

3. Notice that each scale has five circles. The words above the scales describe the meaning of the circles at the ends of each scale. The three circles in the middle of each scale represent feelings between those described at the scale ends. You might want to think of each scale as similar to a thermometer lying on its side.

4. Answer each item by darkening one circle on each scale to indicate how you feel about the statement. Read each statement carefully and take all the time you need.

	SCALE 1: IF YOU PERFORM WELL					SCALE 2: HOW IMPORTANT TO YOU				
	Very Unlikely				Very Likely	Not Important				Very Important
1. Increased job security after graduating from technical school	○	○	○	○	○	○	○	○	○	○
2. Faster promotion	○	○	○	○	○	○	○	○	○	○
3. Greater chance to participate in important decisions after graduating from technical school	○	○	○	○	○	○	○	○	○	○
4. More challenging duty assignments after graduating from technical school	○	○	○	○	○	○	○	○	○	○
5. More job responsibilities after graduating from technical school	○	○	○	○	○	○	○	○	○	○
6. Greater chance of being skilled and competent in your career field	○	○	○	○	○	○	○	○	○	○
7. Increased chance of getting a good civilian job after Air Force service	○	○	○	○	○	○	○	○	○	○
8. Greater chance to be assigned to your base of choice	○	○	○	○	○	○	○	○	○	○
9. Increased off-duty privileges (for example, three-day passes or no squadron detail)	○	○	○	○	○	○	○	○	○	○
10. Greater freedom in deciding how to accomplish class work	○	○	○	○	○	○	○	○	○	○
11. Increased chance of being admired and respected by fellow students	○	○	○	○	○	○	○	○	○	○

ATC Form 1631, Jun 74

GO TO THE NEXT PAGE

SECTION I:	SCALE 1: IF YOU PERFORM WELL					SCALE 2: HOW IMPORTANT TO YOU				
	Very Unlikely				Very Likely	Not Important				Very Important
12. Instructors pay more attention to your ideas and suggestions	○	○	○	○	○	○	○	○	○	○
13. Increased educational growth and development	○	○	○	○	○	○	○	○	○	○
14. Greater chance to help other students learn the subject matter	○	○	○	○	○	○	○	○	○	○
15. Greater chance to do better on tests and receive better grades	○	○	○	○	○	○	○	○	○	○
16. Receive compliments, recognition and praise from instructors	○	○	○	○	○	○	○	○	○	○
17. Fewer "Mickey Mouse" duties in the Squadron	○	○	○	○	○	○	○	○	○	○
18. Fewer "Mickey Mouse" assignments in class	○	○	○	○	○	○	○	○	○	○
19. Feeling of self-respect and sense of accomplishment	○	○	○	○	○	○	○	○	○	○
20. Increased opportunity to use your abilities	○	○	○	○	○	○	○	○	○	○
21. Receive more challenging class assignments	○	○	○	○	○	○	○	○	○	○
22. Greater opportunity to study subject matter of special interest to you	○	○	○	○	○	○	○	○	○	○
23. Increased chance of completing training ahead of schedule	○	○	○	○	○	○	○	○	○	○
24. Provided with more spare time	○	○	○	○	○	○	○	○	○	○
25. Instructors less critical of your work	○	○	○	○	○	○	○	○	○	○
26. Increased chance of being an "Honor" graduate	○	○	○	○	○	○	○	○	○	○

SECTION II:

1. Please use the scales below to describe your SSAN of main (lead) instructor.
2. Darken the <u>one circle on each scale</u> that best expresses your feelings.

27. Ineffective ○ ○ ○ ○ ○ Effective

28. Knowledgeable ○ ○ ○ ○ ○ Ignorant

29. Boring ○ ○ ○ ○ ○ Interesting

30. Dependable ○ ○ ○ ○ ○ Undependable

31. Disorganized ○ ○ ○ ○ ○ Organized

32. Unsure ○ ○ ○ ○ ○ Confident

33. Convincing ○ ○ ○ ○ ○ Unconvincing

34. Unprepared ○ ○ ○ ○ ○ Prepared

35. Intelligent ○ ○ ○ ○ ○ Stupid

36. Inefficient ○ ○ ○ ○ ○ Efficient

37. Encourages ○ ○ ○ ○ ○ Discourages

38. Criticizes ○ ○ ○ ○ ○ Praises

39. Fair ○ ○ ○ ○ ○ Unfair

40. Impatient ○ ○ ○ ○ ○ Patient

41. Considerate ○ ○ ○ ○ ○ Inconsiderate

42. Hinders ○ ○ ○ ○ ○ Helps

43. Friendly ○ ○ ○ ○ ○ Unfriendly

44. Supportive ○ ○ ○ ○ ○ Hostile

45. Ridicules ○ ○ ○ ○ ○ Compliments

46. Cooperative ○ ○ ○ ○ ○ Uncooperative

GO TO THE NEXT PAGE

SSAN		
	⓪①②③④⑤⑥⑦⑧⑨	
	⓪①②③④⑤⑥⑦⑧⑨	
	⓪①②③④⑤⑥⑦⑧⑨	
	⓪①②③④⑤⑥⑦⑧⑨	
	⓪①②③④⑤⑥⑦⑧⑨	
	⓪①②③④⑤⑥⑦⑧⑨	
	⓪①②③④⑤⑥⑦⑧⑨	
	⓪①②③④⑤⑥⑦⑧⑨	
	⓪①②③④⑤⑥⑦⑧⑨	

SECTION III:

1. Below are a series of statements related to both your training and training environment.
2. Please darken the one circle on each scale that best expresses your feelings.

	Definitely Disagree				Definitely Agree
47. Certain students are hostile toward other class members	○	○	○	○	○
48. Most students get along well together	○	○	○	○	○
49. Fellow students look out for each other	○	○	○	○	○
50. Certain students are uncooperative	○	○	○	○	○
51. Certain students are responsible for petty quarrels and bad feelings among class members	○	○	○	○	○
52. There are tensions among some students which interfere with training activities	○	○	○	○	○
53. Certain students are incapable of working together	○	○	○	○	○
54. Students help each other to learn the necessary course material.	○	○	○	○	○
55. Some students are not liked or accepted by fellow students	○	○	○	○	○
56. Students have to take advantage of others in order to succeed in training	○	○	○	○	○
57. Students are given an equal opportunity to demonstrate their capabilities	○	○	○	○	○
58. Students are subject to strict discipline	○	○	○	○	○
59. Student training is too closely supervised.	○	○	○	○	○
60. Students are encouraged to speak their minds even if it means disagreeing with the instructors	○	○	○	○	○
61. Students are encouraged to suggest improvements or solutions to training problems	○	○	○	○	○
62. Students are encouraged to participate in classroom discussions	○	○	○	○	○
63. Students are given the opportunity to participate in class	○	○	○	○	○
64. Student suggestions and recommendations are considered with fairness	○	○	○	○	○
65. Students are seldom able to use their own judgment	○	○	○	○	○
66. Students have no say about what happens to them	○	○	○	○	○
67. Students have little chance to influence the way the class is conducted	○	○	○	○	○
68. Students have the freedom to establish their own study schedules	○	○	○	○	○
69. Spare time in class may be spent as each student sees fit	○	○	○	○	○
70. Students are rarely given the chance to freely express their ideas in the classroom	○	○	○	○	○

GO TO THE NEXT PAGE

SECTION III:

	Definitely Disagree				Definitely Agree
71. Students are seldom allowed to act independently	○	○	○	○	○
72. Pressure for perfection is unbearable	○	○	○	○	○
73. The military atmosphere in the classroom interferes with learning of the subject matter	○	○	○	○	○
74. Squadron duties interfere with study	○	○	○	○	○
75. In order to do well in training, students have to do things that are against their personal values.	○	○	○	○	○
76. Students don't know what is expected of them	○	○	○	○	○
77. There is confusion in the planning and organization of classroom activities	○	○	○	○	○
78. There is considerable conflict among training objectives	○	○	○	○	○
79. Performance standards are unreasonably high	○	○	○	○	○
80. Emphasis is placed on passing the course rather than learning subject matter	○	○	○	○	○
81. There is a good deal of disagreement on how this training should be conducted	○	○	○	○	○
82. The student workload is too heavy	○	○	○	○	○
83. The quantity of class work interferes with how well it is done	○	○	○	○	○
84. Emphasis on military bearing and appearance detract from student performance	○	○	○	○	○
85. Training hours are too long	○	○	○	○	○
86. Conflicts exist in the training requirements	○	○	○	○	○
87. Training equipment (including trainers) is adequate	○	○	○	○	○
88. Training equipment (including trainers) is readily available for student practice	○	○	○	○	○
89. Time allowed on training equipment (including trainers) is sufficient	○	○	○	○	○
90. Training evaluation or testing is an accurate indication of student performance	○	○	○	○	○
91. Study guides are difficult to understand	○	○	○	○	○
92. Excessive attention is given to unimportant details	○	○	○	○	○
93. Course materials are so poor that they contribute little to learning	○	○	○	○	○
94. Course materials are not closely related to the course objectives	○	○	○	○	○
95. Course materials are more difficult than they should be	○	○	○	○	○
96. My progress in class is not what it should be due to the poor quality of training or course materials	○	○	○	○	○
97. Classroom temperature is satisfactory	○	○	○	○	○
98. Dormitory sleeping facilities are adequate	○	○	○	○	○

GO TO THE NEXT PAGE

SSAN
⓪①②③④⑤⑥⑦⑧⑨
⓪①②③④⑤⑥⑦⑧⑨
⓪①②③④⑤⑥⑦⑧⑨
⓪①②③④⑤⑥⑦⑧⑨
⓪①②③④⑤⑥⑦⑧⑨
⓪①②③④⑤⑥⑦⑧⑨
⓪①②③④⑤⑥⑦⑧⑨
⓪①②③④⑤⑥⑦⑧⑨
⓪①②③④⑤⑥⑦⑧⑨

SECTION III:

	Definitely Disagree				Definitely Agree
99. Classroom lighting is adequate	○	○	○	○	○
100. Classroom chairs are comfortable	○	○	○	○	○
101. Classroom seating arrangement is satisfactory	○	○	○	○	○
102. Length of class breaks is about right	○	○	○	○	○
103. Number of class breaks is sufficient	○	○	○	○	○
104. Study facilities outside the classroom are adequate	○	○	○	○	○
105. Classroom ventilation is about right	○	○	○	○	○
106. Time allowed for testing is sufficient	○	○	○	○	○
107. Classroom noise control is effective	○	○	○	○	○
108. Classroom work space is sufficient (desk or table top area)	○	○	○	○	○
109. Supplementary study materials (manuals, regulations, technical orders, etc.) are readily available for student use	○	○	○	○	○
110. Base recreation facilities are adequate	○	○	○	○	○
111. Off duty study time is sufficient	○	○	○	○	○
112. Time allowed for review of tests is adequate	○	○	○	○	○
113. Enough training time is spent on difficult and important subject matter	○	○	○	○	○
114. Some students would perform better on a different shift	○	○	○	○	○

SECTION IV:

1. **Below are statements about your satisfaction with your training and career field.**
2. **Please darken the circle that best expresses your feelings about the statement in the same way you have in the other sections of this form.**

	Completely Dissatisfied				Completely Satisfied
115. How do you feel about your technical training?	○	○	○	○	○
116. How do you feel about your assigned career field?	○	○	○	○	○
117 How do you feel about the Air Force?	○	○	○	○	○

GO TO THE NEXT PAGE

SECTION IV:

118. How similar is your assigned career field to your preferred career field? . . . . Completely Different ○ ○ ○ ○ ○ Identical

119. How accurate was the information you received about your career field before entering technical training? . . . . Highly Inaccurate ○ ○ ○ ○ ○ Highly Accurate

120. What effect has technical training had on your feelings about your career field? . . . . Strongly Negative ○ ○ ○ ○ ○ Strongly Positive

121. If you have the chance, will you change to another career field? . . . . Definitely No ○ ○ ○ ○ ○ Definitely Yes

REMARKS:

APPENDIX F: COMPARISON OF STUDENT MOTIVATION AND ATTITUDE FOR THE FIRST ADMINISTRATION OF THE TECHNICAL TRAINING SURVEY

VARIABLE	SAMPLE'	OBSERVED MEAN	RANGE OF POSSIBLE POPULATION MEANS (95% CONFIDENCE)	CHANUTE POPULATION MEAN	ATC POPULATION MEAN
Instrumentality	PB	94.63	92.14 $\leq \mu \leq$ 97.12	93.64	93.50
	CP	87.03[a,b]	80.71 $\leq \mu \leq$ 93.35		
	NP	91.85	83.35 $\leq \mu \leq$ 100.35		
	BL	88.60	83.07 $\leq \mu \leq$ 94.14		
Valence	PB	102.40[a,b]	99.88 $\leq \mu \leq$ 104.92	105.02	105.02
	CP	98.03[a,b]	91.92 $\leq \mu \leq$ 104.14		
	NP	98.80	88.78 $\leq \mu \leq$ 108.82		
	BL	102.30	97.61 $\leq \mu \leq$ 106.97		
Valence of Performance	PB	387.84	371.92 $\leq \mu \leq$ 403.75	396.71	394.78
	CP	342.24[a,b]	302.59 $\leq \mu \leq$ 381.90		
	NP	368.50	307.88 $\leq \mu \leq$ 429.12		
	BL	360.29[a,b]	328.33 $\leq \mu \leq$ 392.25		
Instructor Technical Competence	PB	38.56[a,b]	37.34 $\leq \mu \leq$ 39.78	42.41	42.68
	CP	31.46[a,b]	27.69 $\leq \mu \leq$ 35.22		
	NP	41.65	38.92 $\leq \mu \leq$ 44.38		
	BL	40.79	38.74 $\leq \mu \leq$ 42.84		
Instructor Personal Relations	PB	37.92[a,b]	36.70 $\leq \mu \leq$ 39.15	40.80	41.03
	CP	32.64[a,b]	29.19 $\leq \mu \leq$ 36.08		
	NP	40.75	37.74 $\leq \mu \leq$ 43.76		
	BL	37.29[a]	34.42 $\leq \mu \leq$ 40.16		
Physical Setting	PB	60.22[a,b]	59.34 $\leq \mu \leq$ 61.11	63.64	63.36
	CP	58.09[a,b]	56.13 $\leq \mu \leq$ 60.05		
	NP	61.45	58.32 $\leq \mu \leq$ 64.58		
	BL	59.18[a,b]	57.52 $\leq \mu \leq$ 60.85		
Global Training Satisfaction	PB	12.51	12.16 $\leq \mu \leq$ 12.86	11.34	11.20
	CP	11.30	10.49 $\leq \mu \leq$ 12.12		
	NP	11.90	10.87 $\leq \mu \leq$ 12.93		
	BL		$\leq \mu \leq$		

VARIABLE	SAMPLE'	OBSERVED MEAN	RANGE OF POSSIBLE POPULATION MEANS (95% CONFIDENCE)	CHANUTE POPULATION MEAN	ATC POPULATION MEAN
Career Choice Satisfaction	PB	13.91[a,b]	$13.57 \leq \mu \leq 14.26$	12.70	12.66
	CP	13.39	$12.52 \leq \mu \leq 14.27$		
	NP	13.75[b]	$12.68 \leq \mu \leq 14.82$		
	BL	12.10	$11.33 \leq \mu \leq 12.88$		

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1. $N_{pb} = 152$; $N_{cp} = 33$; $N_{np} = 20$; $N_{bl} = 38$

2. N = 2484

3. N = 12666

[a] Observed mean differed from Chanute population

[b] Observed mean differed from ATC population

APPENDIX G: COMPARISON OF STUDENT MOTIVATION AND ATTITUDES FOR THE SECOND ADMINISTRATION OF THE TECHNICAL TRAINING SURVEY

VARIABLE	SAMPLE'	OBSERVED MEAN	RANGE OF POSSIBLE POPULATION MEANS (95% CONFIDENCE)	CHANUTE POPULATION MEAN	ATC POPULATION MEAN
Instrumentality	PB	$98.51^{a,b}$	$95.75 \le \mu \le 101.26$	93.64	93.50
	CP	90.83	$85.38 \le \mu \le 96.28$		
	NP	93.00	$85.65 \le \mu \le 100.35$		
	BL	92.05	$86.47 \le \mu \le 97.62$		
Valence	PB	102.80	$99.88 \le \mu \le 105.71$	105.02	105.02
	CP	103.83	$99.82 \le \mu \le 107.85$		
	NP	102.75	$96.11 \le \mu \le 109.39$		
	BL	104.33	$99.29 \le \mu \le 109.38$		
Valence of Performance	PB	409.38	$392.29 \le \mu \le 426.47$	396.71	394.78
	CP	381.52	$349.81 \le \mu \le 413.21$		
	NP	387.45	$341.14 \le \mu \le 433.76$		
	BL	388.48	$353.05 \le \mu \le 423.90$		
Instructor Technical Competence	PB	41.88	$40.71 \le \mu \le 43.02$	42.41	42.68
	CP	$44.29^{a,b}$	$42.74 \le \mu \le 45.83$		
	NP	41.65	$38.16 \le \mu \le 45.14$		
	BL	$39.17^{a,b}$	$36.29 \le \mu \le 42.05$		
Instructor Personal Relations	PB	40.48	$39.32 \le \mu \le 41.65$	40.80	41.03
	CP	$43.86^{a,b}$	$42.41 \le \mu \le 45.30$		
	NP	42.60	$39.50 \le \mu \le 45.70$		
	BL	41.71	$39.21 \le \mu \le 44.22$		
Fellow Students	PB	34.53^{a}	$33.26 \le \mu \le 35.81$	33.14	33.29
	CP	32.93	$30.45 \le \mu \le 35.40$		
	NP	34.05	$31.05 \le \mu \le 37.05$		
	BL	34.81	$31.97 \le \mu \le 37.65$		
Organizational Control	PB	$32.15^{a,b}$	$30.83 \le \mu \le 33.48$	37.10	36.78
	CP	39.02	$35.68 \le \mu \le 42.36$		
	NP	36.15	$31.11 \le \mu \le 41.19$		
	BL	35.17	$31.56 \le \mu \le 38.78$		
Training Stress	PB	$32.65^{a,b}$	$30.93 \le \mu \le 34.36$	38.21	38.52
	CP	38.26	$34.58 \le \mu \le 41.94$		
	NP	38.30	$33.43 \le \mu \le 43.17$		
	BL	35.83	$32.21 \le \mu \le 39.46$		

VARIABLE	SAMPLE^{1}	OBSERVED MEAN	RANGE OF POSSIBLE POPULATION MEANS (95% CONFIDENCE)	CHANUTE POPULATION MEAN	ATC POPULATION MEAN
Training Materials	PB	38.16^{a,b}	$37.12 \leq \mu \leq 39.20$	35.18	34.77
	CP	34.12	$31.82 \leq \mu \leq 36.42$		
	NP	34.60	$32.09 \leq \mu \leq 37.11$		
	BL	35.67	$33.31 \leq \mu \leq 38.02$		
Physical Setting	PB	68.88^{a,b}	$67.04 \leq \mu \leq 70.72$	63.64	63.36
	CP	65.48	$61.97 \leq \mu \leq 68.98$		
	NP	68.85^{b}	$63.60 \leq \mu \leq 74.10$		
	BL	67.88	$64.48 \leq \mu \leq 71.28$		
Global Training Satisfaction	PB	12.08^{a,b}	$11.68 \leq \mu \leq 12.49$	11.34	11.20
	CP	10.76	$9.95 \leq \mu \leq 11.57$		
	NP	10.85	$9.38 \leq \mu \leq 12.32$		
	BL	11.98	$11.12 \leq \mu \leq 12.83$		
Career Choice Satisfaction	PB	13.69^{a,b}	$13.11 \leq \mu \leq 14.27$	12.70	12.66
	CP	12.29	$11.22 \leq \mu \leq 13.35$		
	NP	11.10^{a,b}	$9.59 \leq \mu \leq 12.61$		
	BL	13.62	$12.23 \leq \mu \leq 15.01$		

1. $N_{pb} = 158$; $N_{cp} = 42$; $N_{np} = 20$; $N_{bl} = 42$

2. $N = 2484$

3. $N = 12666$

a. Observed mean differed from Chanute population

b. Observed mean differed from ATC population

APPENDIX H: INSTRUCTOR SURVEY

BLOCK #
SHRED A,B,C, -1

INSTRUCTOR CAI QUESTIONNAIRE

NAME______________________________ SSAN____________________ DATE____________

	Very Strongly Disagree — Very Strongly Agree
1. I am very happy with my present job.	0 1 2 3 4 5 6 7 8 9
2. I do not enjoy being an instructor.	0 1 2 3 4 5 6 7 8 9
3. My general attitude towards computers is very favorable.	0 1 2 3 4 5 6 7 8 9
4. Instructional Systems Development (ISD) is very useful in the Air Force technical training environment.	0 1 2 3 4 5 6 7 8 9

As an instructor, I get very good results with:

5. Movies and filmstrips	0 1 2 3 4 5 6 7 8 9
6. PLATO lessons	0 1 2 3 4 5 6 7 8 9
7. Study guides and workbooks.	0 1 2 3 4 5 6 7 8 9
8. Instructor lectures.	0 1 2 3 4 5 6 7 8 9
9. Laboratory instruction.	0 1 2 3 4 5 6 7 8 9
10. Programmed texts.	0 1 2 3 4 5 6 7 8 9

As an instructor, I feel the best strategy to teach students is:

11. Lock-step.	0 1 2 3 4 5 6 7 8 9
12 Group or team-paced.	0 1 2 3 4 5 6 7 8 9
13. Self-paced.	0 1 2 3 4 5 6 7 8 9

The following section deals with questions about PLATO. Whether or not you have spent much time on PLATO or in the PLATO lab, please answer them to the best of your ability. If you have spent no time with PLATO, answer the questions the way you feel about the PLATO system.

14. Approximately how many hours have you spent on the PLATO terminal?	____________
15. Approximately how many hours have you spent in the PLATO lab area. (B-105 Truemper Hall)?	____________
16. I enjoy working with the PLATO system.	0 1 2 3 4 5 6 7 8 9
17. I am very positive concerning the use of PLATO in Air Force technical training.	0 1 2 3 4 5 6 7 8 9

		Very Strongly Disagree — Very Strongly Agree
18.	I believe PLATO is an efficient means of teaching students	0 1 2 3 4 5 6 7 8 9
19.	The students are being taught what they need to learn using PLATO.	0 1 2 3 4 5 6 7 8 9
20.	I feel challenged to do my best work while instructing with the PLATO system.	0 1 2 3 4 5 6 7 8 9
21.	PLATO provides better training when combined with the ISD process.	0 1 2 3 4 5 6 7 8 9
22.	I believe more can be taught with PLATO than with the system of stand-up instruction.	0 1 2 3 4 5 6 7 8 9

Working with the PLATO system:

23.	Is fun.	0 1 2 3 4 5 6 7 8 9
24.	Is frustrating.	0 1 2 3 4 5 6 7 8 9
25.	Is challenging	0 1 2 3 4 5 6 7 8 9
26.	Is annoying.	0 1 2 3 4 5 6 7 8 9
27.	Is confusing.	0 1 2 3 4 5 6 7 8 9
28.	Makes me proud of myself.	0 1 2 3 4 5 6 7 8 9
29.	Is boring.	0 1 2 3 4 5 6 7 8 9
30.	Is relaxing.	0 1 2 3 4 5 6 7 8 9
31.	Is depressing.	0 1 2 3 4 5 6 7 8 9
32.	Is enjoyable.	0 1 2 3 4 5 6 7 8 9
33.	Is de-personalizing.	0 1 2 3 4 5 6 7 8 9
34.	Is exciting.	0 1 2 3 4 5 6 7 8 9
35.	Personally, I would like to spend more time operating the PLATO terminal.	0 1 2 3 4 5 6 7 8 9
36.	Personally, I think it would be a good idea to get more involved with programming on PLATO.	0 1 2 3 4 5 6 7 8 9

		Very Strongly Disagree Very Strongly Agree
37.	The lessons on PLATO are well written.	0 1 2 3 4 5 6 7 8 9
38.	The lessons on PLATO are for the most part technically accurate.	0 1 2 3 4 5 6 7 8 9
39.	PLATO instruction will always need to be supplemented by normal instruction.	0 1 2 3 4 5 6 7 8 9
40.	I do not feel my job is threatened by PLATO.	0 1 2 3 4 5 6 7 8 9

APPENDIX I: LESSON DEVELOPMENT SCENARIO

The first items required to develop a lesson were the criterion objective, master validation examination (MVE), and the teaching points. We will follow one author, Mr. Arthur, through the process of preparing a lesson. Let us say that he selected the objective concerning clutches and obtained the necessary items from the ISD team (see Figure I1).

STS Element 14A　　　　STS Code Level B

OBJECTIVE: Without reference, identify the relationship of basic facts and general operating principles of clutches with 75% accuracy.

TEACHING POINTS:

1. Clutch component identification
    - a. Driving Members
        - (1) Turn with engine
        - (2) Cast iron plates
            - (a) Flywheel
            - (b) Pressure plate
    - b. Driven Member
        - (1) Friction plate (disc)
            - (a) Types
                - *1* Wet
                - *2* Dry
                - *3* Single disc
                - *4* Multiple disc
            - (b) Application
                - *1* Splined hub
                - *2* Dished
    - c. Pressure Plate Assembly
        - (1) Cover
        - (2) Springs
            - (a) Coil (small)
            - (b) Helical (large)
        - (3) Diaphragm
        - (4) Release Levers
    - d. Linkage
        - (1) Mechanical
            - (a) Levers
            - (b) Yoke
            - (c) Release (throw out) Bearing
            - (d) Collar
        - (2) Hydraulic
            - (a) Master Cylinder
            - (b) Slave Cylinder
            - (c) Hydraulic lines
            - (d) Also includes (b), (c), and (d) under mechanical

Figure I1. **Objective teaching points, and MVE for a PLATO lesson on clutches.**

MVE: 2. Operation of Clutch Components

INSTRUCTIONS: Match the lettered statement or phrase on the **right** with the numbered statement or phrase on the left.

1. _____Driving Member
2. _____Conventional Clutch Principle
3. _____Driven Member
4. _____Hydraulic Linkage Component
5. _____Part of Mechanical Linkage in direct contact with release bearing
6. _____Strengthens Disc
7. _____Performs the same function as the large coil in Single Spring Clutch
8. _____Does not rotate with the flywheel when clutch is engaged.

a. Solid Friction
b. Throw out Bearing
c. Master Cylinder
d. Asbestos Fibers
f. Helical Springs
g. Yoke
h. Friction Plate
i. Copper Wires

Figure I1 *(Continued)*

Mr. Arthur then collected available information to familiarize himself with the subject area. He asked instructors about the difficulties they had teaching airmen about clutches, any techniques they used, what training devices were in current use, *et cetera*. He examined career field training literature, and, being a thorough person, he looked through library and personal materials. Having gained an awareness of the efforts involved for the lesson he got together with the other members to discuss ideas, but mainly to verify the relationship between objective, MVE and teaching points. This operation was critically important for it fixed the scope and depth of training. Having accomplished the research step, Mr. Arthur was confident that he knew what the student was expected to learn about clutches.

Shielding himself from distractions, Mr. Arthur mentally mapped out the lesson. He considered instructional strategies, types of interactive routines, use of graphics, locations for microfiche slides, and potential uses of the touch-sensitive panel that detects screen locations. He knew it was best to plan for features like microfiche far in advance since procurement was often a lengthy process.

After mulling over everything, Arthur drew out a programming plan (see Figure I2) for the lesson. Arthur was not content, for he would have liked to try a more innovative approach which he saw another author use before the PLATO and ISD projects were merged. Nevertheless, he knew time was short, and the lean programming philosophy pointed toward testing simple designs first. Sgt. PIP, the instructional programmer, reviewed the plan and noticed three things he did not like about lesson strategy. First of all, the step size was too large; i.e., the interaction was massed together into two lumps after the presentation of substantial amounts of material. Secondly, Pip felt uneasy since Arthur demanded total recall: the student could not view the information presented while doing a matching exercise called for in the lesson. Finally, this matching exercise just was not Pip's way of getting the student involved with the principles of operation of clutches. Far too often he had seen the authors use interactive technqiues that required simple recognition of a statement. Feeling recalcitrant, Arthur rejected Pip's negative comments as opinions. Arthur stated that PLATO was a new media and the approaches used should not be governed by past prejudices derived from experiences with other media. Pip felt like retaliating by mentioning that most instructional programming principles are independent of media. But he declined, partly because Arthur could be right–the machine's arcane functioning and capabilities befuddled him–but mostly because he remembered his own recalcitrance when he first got into the instructional programming career field. Pip knew that student tryouts, revisions, and the multiple attempts at lesson validation would soon modify Arthur's opinion. Considering his feelings and constraints, he decided that the innovation associated with this project must be tempered with moderation; Arthur would have to yield.

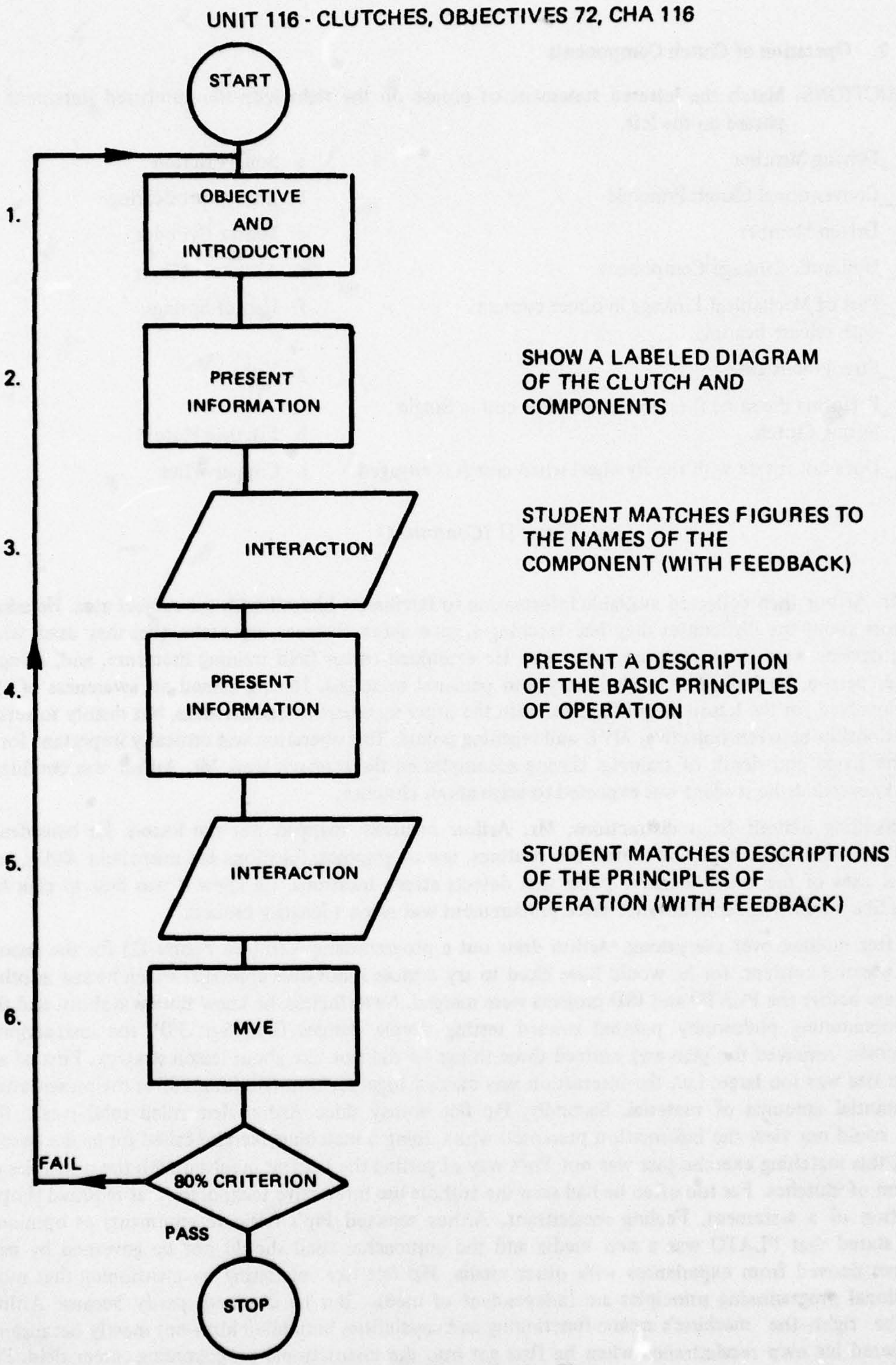


Figure I2. **Programming Plan.**

After compromising with Pip, Arthur consulted with his team SME, Sergeant Gear. From Arthur's research notes and verbal descriptions, Gear and he concluded that the proposed lesson contained the information necessary for the student to pass the MVE and that it was technically accurate. Arthur was glad that this lesson planning step was over and that he could now get to work on the lesson.

Normally, Arthur would start off-line lesson preparation by anticipating the use of microfiche, so that all the steps involved in that process would be complete by the time the lesson was to be tried out. However, he decided to use computer graphics as the exclusive vehicle for component identification. Arthur listed the drawings he would need, then went to work on outlining or writing the test for various portions of the lesson. He also wrote the type of interactions the student would be required to do, like multiple-choice questions, matching, fill-in-the-blank, *et cetera*. Guiding him throughout this period is his qualitative assessment of the ability of students to read, comprehend, and retain the information, and operate the terminal. With the reading problems some of the students have, he wondered how they graduated from grade school, let alone high school. Using the keyboard was another constraint; Arthur decided not to use constructed response items because he noticed that some students disliked typing or were very slow at it.

With conceptualization and some written portions of the initial version of the clutch lesson complete, Arthur felt it was time to initiate on-line coding. Mr. Atwright, the TUTOR coding specialist, and Arthur decided that the coding task could be handled most expeditiously if Atwright were to assist in the creation of certain clutch component diagrams and some of the more complex coding routines necessary to drive the master validation examination and link the lesson with the student routing and data collection routines. In some respects Arthur wanted Atwright to do all the coding, for after 2 years he was satiated with the task and was not looking forward to the plethora of difficulties ahead. Atwright thrived on computer programming, it was his job and what he really cared about. He knew of the tasks the other team members were expected to perform and that was sufficient for his needs. When he encountered problems, they were regarded as challenges; he got great satisfaction from his developed problem solving skills. Arthur knew, however, that in order to maintain his level of proficiency, he would have to continue coding regularly. This was a source of aggravation to Arthur, since he was expected to be a subject-matter expert, instructor, instructional programmer, as well as being qualified to code in the TUTOR language, yet his job description said he was an instructor. Arthur and the other civilian authors had attempted to change their position description so it would be commensurate with their actual activities. It became a crusade and a way of releasing frustrations accrued over the initial phases of the project.

Of all tasks associated with developing an on-line lesson, the coding requires the most time and expenditure of mental energy. Arthur believes it would be simpler to teach nuclear physics to monkeys than code a lesson. At least with a monkey you can assume it knows something; you don't have to be explicitly precise. Arthur used a certain subset of TUTOR commands available to him, often in most inefficient ways. However, as long as the terminal displayed or did what he wanted it to do, he was satisfied. On the other hand, Atwright strived for machine efficiency, and wondered how much time could be saved if all PLATO authors strived for the same efficient machine coding. Arthur did not wonder; at the end of 6 hours of looking at the plasma panel, he was ready to go home.

Together, Arthur and Atwright spent 68.5 hours to code the clutch lesson. The 60.5 hours Arthur expended occurred over a 3-week period. Satisfied that the lesson was ready for the pre-tryout review, Arthur informed his team members that they could perform their editing functions. The instructional programming and grammatical edit by Pip went quickly. He had checked periodically with Arthur in the lesson preparation phase when he wanted relief from the other ISD projects and additional duties which demended his time. Consequently, his familiarity with the lesson and the words Arthur was most likely to misspell made the task easier. Pip did not care for Arthur's reliance on computer graphics. Pip hoped that the real component would be available as an adjunct to the lesson. However, the initial group-paced system tryout would require six or more multiple copies of equipment. Anyway, one concern was to determine if PLATO could reduce equipment needs.

Technical edit by Gear also went quickly, but two technical inaccuracies were found. These he listed in the lesson documentation folder where a history of the development of the lesson was supposed to be kept by team members. Atwright searched the lesson for coding bugs by imitating the behaviors of the curious and mischievious students. The he reviewed the TUTOR coding (see Figure I3) as the last activity in the pre-tryout review.

```
unit      quiz1
term      quiz1
calc      n6⇐0
back      t9
do        drivere(1)
pack      n1,caaabdbdad
at        1524
write     <at,1625>What is the component indicated below?
write     <at,1925>a.
b.
c.
d.
calc      n12⇐0
entry     quireal
at        2521
erase     10
calc      n12⇐n12+1
jump      n12=11,out,x
join      n12-2,fin,csp,goo,ped,fly,spr,bac,pre,dis,thr,
calc      n2⇐rit(n12)$cls$54
arrow     2521
long      1
storea    n4
specs     bumpshift
judge     n2=n4,ok,no
join      ansok,yes,bad
endarrow
mode      erase
join      n12-2,fin,csp,goo,ped,fly,spr,bac,pre,dis,thr,
mode      write
goto      quireal
```

Figure I3. **TUTOR code.**

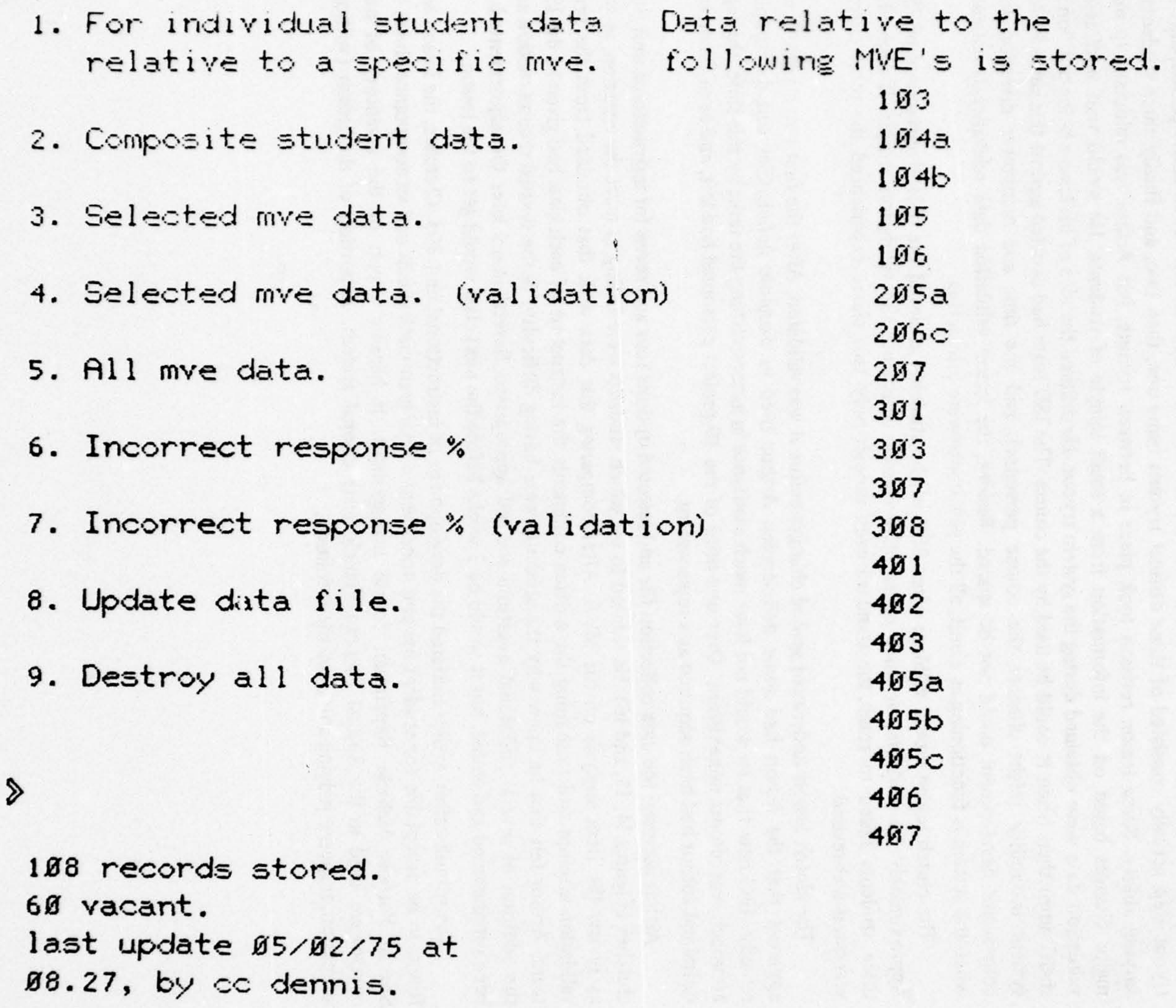
The student tryout of the clutch lesson was the first in which Arthur was an active participant. The tryout step actually consisted of three distinct tryouts using one, then two, and finally three students of varying ability. Some lesson revision took place in between tryouts, but Arthur was reluctant to make major changes based on the information from a small sample of students. He would wait until lesson validation data were obtained during the system tryout. He disliked the idea of his lesson being put "on the shelf" until then when it could be used by the course. The ISD team had decided against this since PLATO system instability might alienate the course personnel, and the time and manpower diversion from courseware development could not be spared. Besides, the lesson validation data relevance is enhanced when the system is functioning as a unit, all the new courseware interacting.

The clutch lesson would validate when 90% of the students achieved the objective standard of 75%. Approximately 30 students, or three consecutive classes, constitute the validation sample. If more than three students failed to reach the standard even though only two clases experienced the most current version, it was revised.

The clutch lesson underwent several changes before it was validated. After the first two classes, it was apparent that the lesson had some deficiencies. Arthur tried to diagnose deficiencies and determine a remedy. He knew that he would not have much assistance in accomplishing the task; by this time, the team approach was almost nonexistent. Over one-third of the 19 project personnel had left, and as of them, one untrained author had been acquired as a replacement.

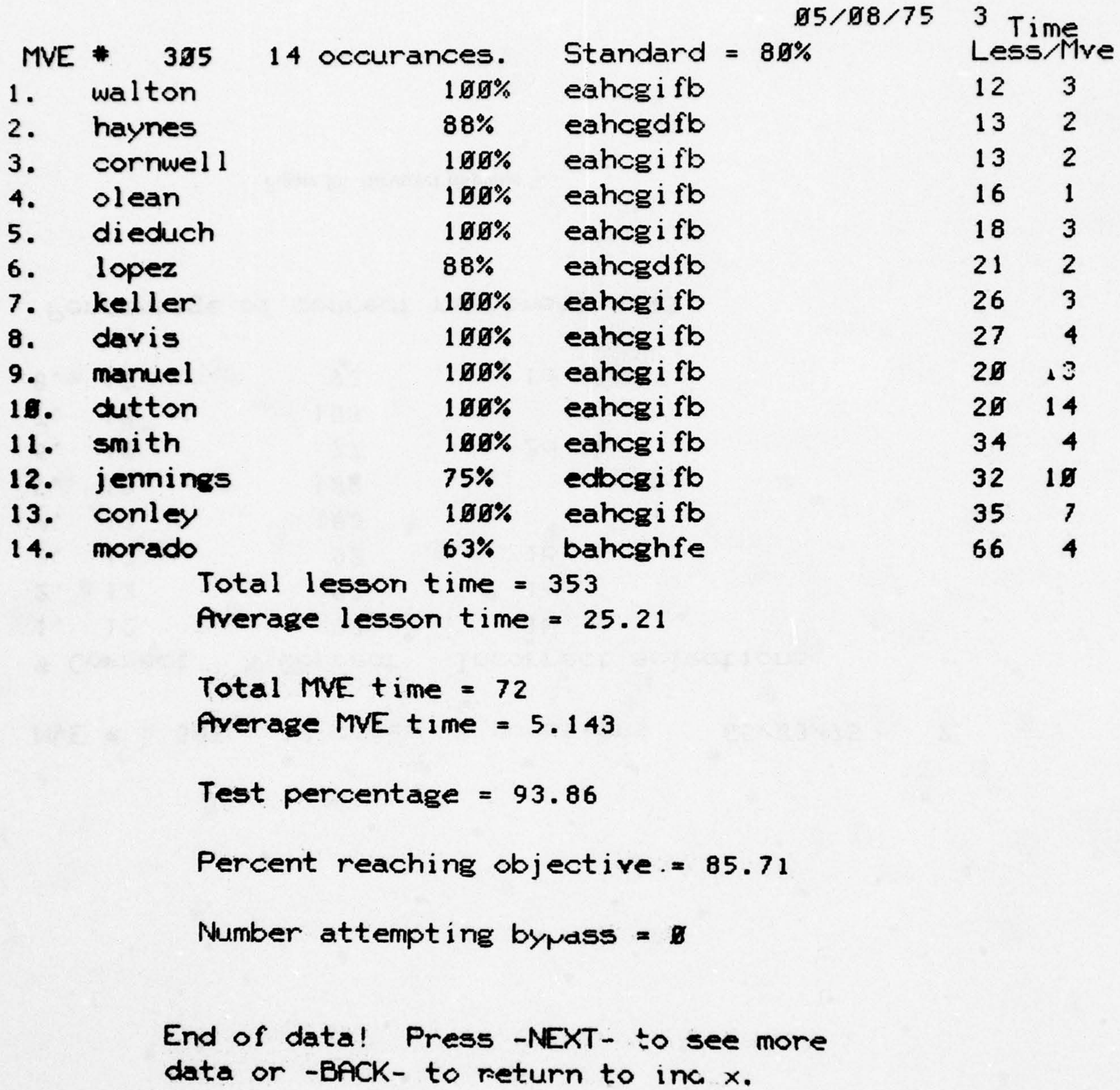
Arthur accessed the data collection file and selected options four and seven for instructional unit 305, clutches (Figures I4, I5, and I6). He wanted to see which students were failing to meet the criterion, as well as review the item analysis on the MVE. After comparing this data with that obtained from the prior validation attempt and examining the written comments the instructors of each class had given to the ISD team, Arthur felt that he knew why the students were having difficulty. Some textual reconstruction and the addition of several additional questions seemed appropriate. Several hours later the adjustments had been programmed and coded, but it would be 2 weeks before the next class would get to the lesson.

Ten months after Arthur initiated the development of instructional unit 305, Clutches, the lesson was found to be acceptable for student use and underwent a final grammatical edit and an acceptance check by Special Purpose Vehicle Repairman course management. It became a part of the inventory of new courseware used in the Special Purpose Vehicle instructional system. A portion of the lesson (without animation, response judging and branching) follows.



```
1. For individual student data   Data relative to the
   relative to a specific mve.    following MVE's is stored.
                                              103
2. Composite student data.                    104a
                                              104b
3. Selected mve data.                         105
                                              106
4. Selected mve data.  (validation)           205a
                                              206c
5. All mve data.                              207
                                              301
6. Incorrect response %                       303
                                              307
7. Incorrect response % (validation)          308
                                              401
8. Update data file.                          402
                                              403
9. Destroy all data.                          405a
                                              405b
                                              405c
>                                             406
                                              407
108 records stored.
60 vacant.
last update 05/02/75 at
08.27, by cc dennis.
```

Figure 14. **"CHA 95" data retrieval and analysis options.**



```
                                          05/08/75   3  Time
MVE #    305    14 occurances.    Standard = 80%        Less/Mve
1.    walton               100%   eahcgifb              12    3
2.    haynes               88%    eahcgdfb              13    2
3.    cornwell             100%   eahcgifb              13    2
4.    olean                100%   eahcgifb              16    1
5.    dieduch              100%   eahcgifb              18    3
6.    lopez                88%    eahcgdfb              21    2
7.    keller               100%   eahcgifb              26    3
8.    davis                100%   eahcgifb              27    4
9.    manuel               100%   eahcgifb              20   13
10.   dutton               100%   eahcgifb              20   14
11.   smith                100%   eahcgifb              34    4
12.   jennings             75%    edbcgifb              32   10
13.   conley               100%   eahcgifb              35    7
14.   morado               63%    bahcghfe              66    4
          Total lesson time = 353
          Average lesson time = 25.21

          Total MVE time = 72
          Average MVE time = 5.143

          Test percentage = 93.86

          Percent reaching objective = 85.71

          Number attempting bypass = 0


         End of data!  Press -NEXT- to see more
         data or -BACK- to return to inc. x.
```

Figure 15. Selected MVE data.

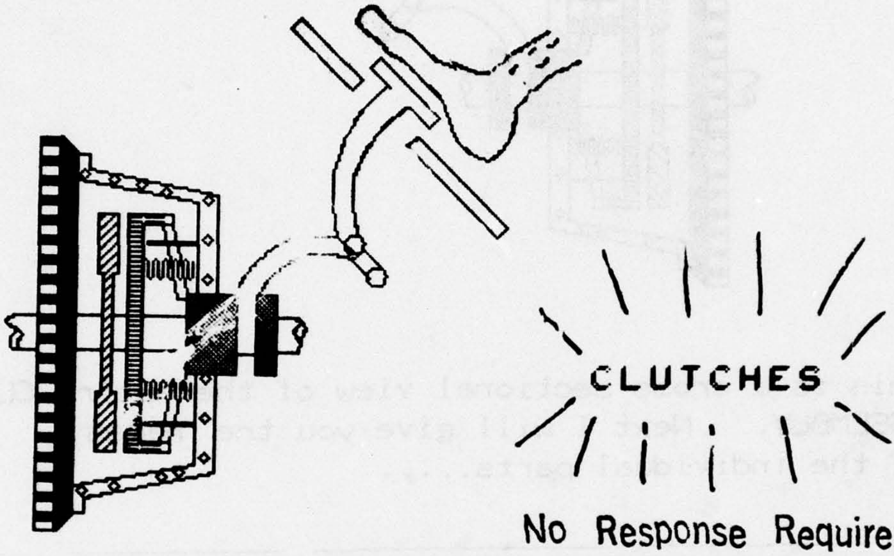
```
MVE #    305   13 cases   8 questions    05/08/75     7

# Correct    % Correct   Incorrect selections
1.   12          92          1b
2.   12          92          1d
3.   12          92          1b
4.   13         100
5.   13         100
6.   10          77          2d 1h
7.   13         100
8.   12          92          1e

 Percentage of correct responses = 93
```

Figure I6. Incorrect response %.

Frame 1

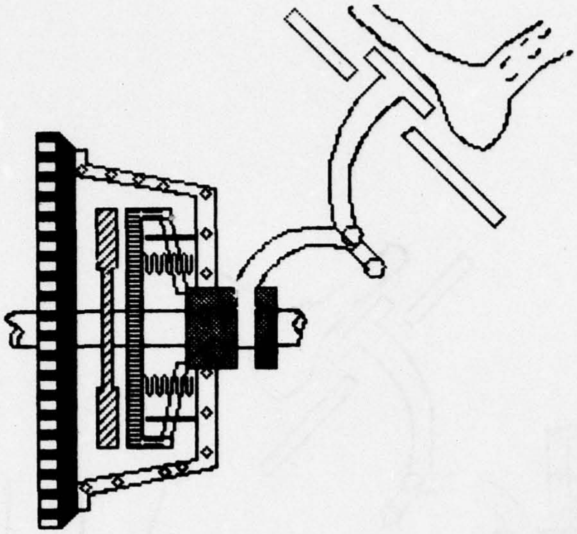


No Response Required

Frame 2

The clutch connects and disconnects the engine from the manual transmission. The clutch must do this smoothly to prevent jerky starts and shock to the parts of the power train.

Frame 3



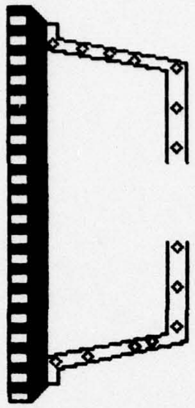
This is a cross sectional view of the entire CLUTCH ASSEMBLY. Next I will give you the names of the individual parts.....

Frame 4

Recognize this? We called it part of the engine before.....right now think of it as part of the clutch assembly.

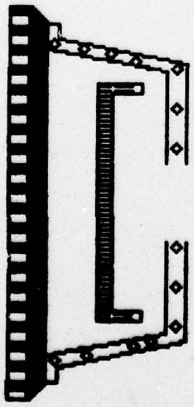
It's called the FLYWHEEL.

Frame 5



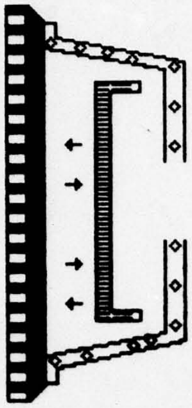
Now this is new...Bolted right to the flywheel is the PRESSURE PLATE BACKING

Frame 6



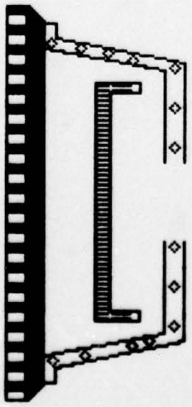
This piece is...you guessed it....the PRESSURE PLATE

Frame 7



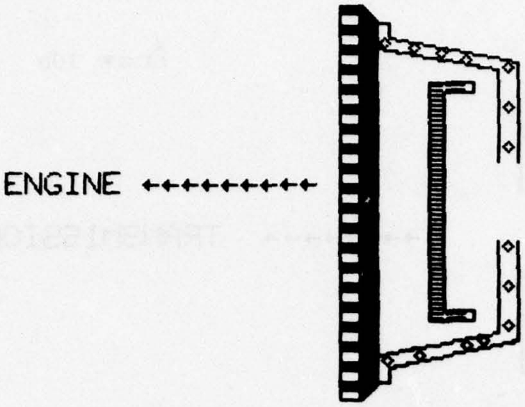
The inner surfaces of the FLYWHEEL and PRESSURE PLATE (see the arrows) are machined and ground to a smooth finish. They are made of cast iron which contains enough graphite to provide some lubrication.

Frame 8



The PRESSURE PLATE is directly connected to the PRESSURE PLATE BACKING. (This connection is not shown in the diagram) Remember that they both turn together!

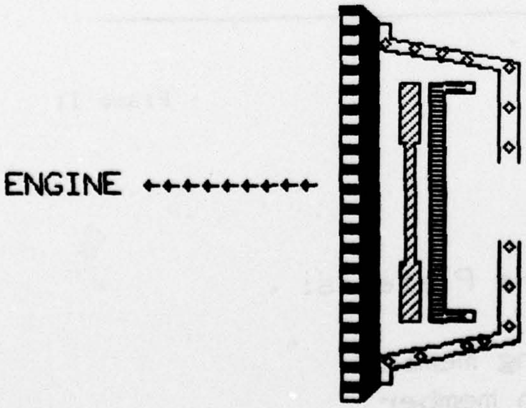
Frame 9



The three parts you see here are all known as "drivING members". This is because they all turn with the engine.

The next part you will see is known as the "drivEN member". Because it is not directly connected to the engine.

Frame 10

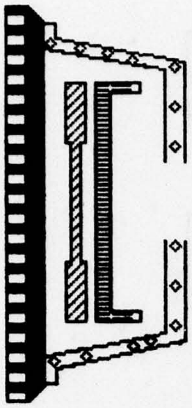


This is the CLUTCH DISC (or FRICTION PLATE). Notice that it fits between two of the driving members, the flywheel and the pressure plate.

clutch disc ↔ drivEN member

Frame 10b

ENGINE ←←←←←←←←←



→→→→→→→→→ TRANSMISSION

This is the CLUTCH DISC (or FRICTION PLATE). Notice that it fits between two of the driving members, the flywheel and the pressure plate.

clutch disc ↔ drivEN member

The clutch disc is connected to the input shaft of the transmission, by splines!! This allows the disc to slide back and forth on the shaft!

Frame 11

The Pressure Plate is:

a. a driving member
b. a driven member
c. an operating member
d. linkage component

Frame I2

The Pressure Plate Backing is:

a. a driving member
b. a driven member
c. an operating member
d. linkage component

Frame I3

The Clutch Disc is:

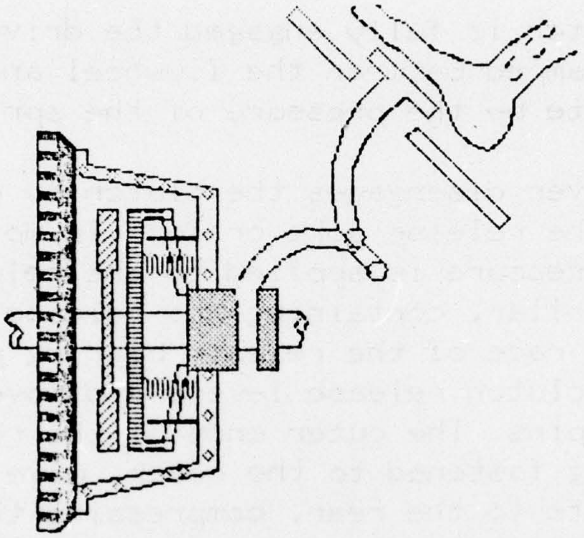
a. a driving member
b. a driven member
c. an operating member
d. linkage component

Frame 14

Here are 5 varieties of clutch discs:

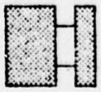
1. DRY	This is the conventional clutch disc. It is made of spring steel with facings riveted to each side. The facings are made of molded cotton and asbestos fibers. Often copper wires are woven into the material for strength.
2. WET	Oil is supplied to the disc surface to provide for cushioning between the surface of the disc and drivING members.
3.SINGLE	Has only one clutch disc
4.MULTIPLE	Has 2 or more discs. These are used on vehicles with heavy loads.
5.DISHED DISC	Disc is dished so that the inner and outer surfaces of the facing make contact gradually as spring pressure is increased and the disc flattens out.

Frame 37



What is the component indicated below?

a. linkage
b. pressure plate
c. multiple disc
d. release bearing



>

Frame 38

You got 7 out of a possible 10 questions correct on the first try.

Frame 39

2) Operating principles:

The operation of the clutch is as follows:

When the clutch is fully engaged the driven disk is firmly clamped between the flywheel and the pressure plate by the pressure of the springs.

When the driver disengages the clutch by depressing the pedal, the release yoke or fork is moved on its pivot, and pressure is applied to the release bearing sleeve, or collar, containing the release bearing. The rotating race of the release bearing presses against the clutch release levers and moves them on their pivot pins. The outer ends of the release levers, being fastened to the cover, move the pressure plate to the rear, compressing the clutch springs and allowing the driving members to rotate independently of the driven member.

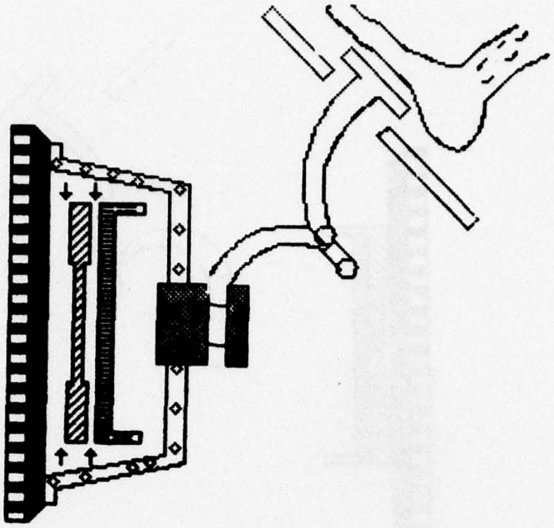
Frame 40

Operating principles (continued)

All parts of the clutch, except the release bearing and collar, rotate with the flywheel when the clutch is engaged.

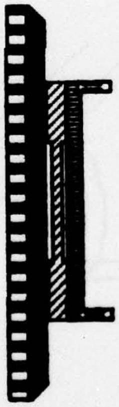
When the clutch is disengaged, the release bearing rotates with the flywheel, but the driven disk and the clutch shaft come to rest.

Frame 42



Notice that in the disengaged position shown above that the pedal is depressed!

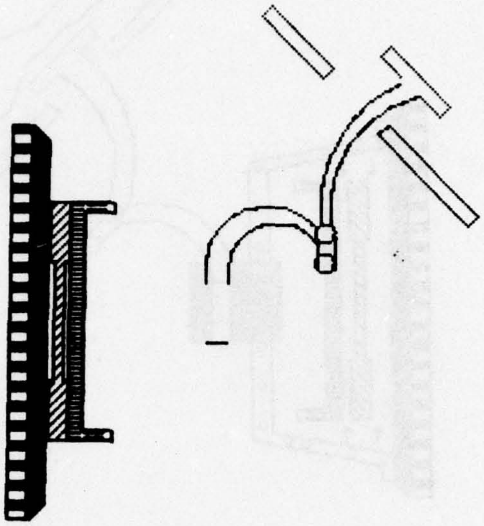
Frame 43



Now the clutch is shown in the engaged postion.

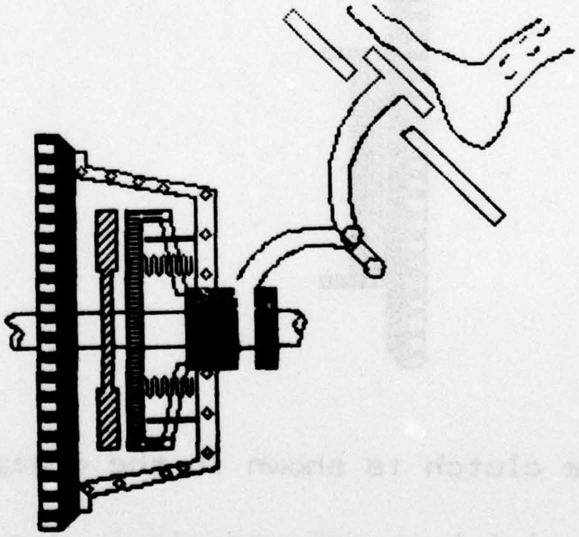
As the clutch is engaged slowly (in normal operation) the vehicle will start to creep even though there is a great deal of slippage. The engine cannot transmit its maximum power to the transmission until maximum friction is obtained between the clutch members. That is, when all slipping has stopped and there is a direct connection between the driving and driven parts.

Frame 44



Notice that in the engaged position shown above that the pedal is released!

Frame 45



Let's take a look at the entire assembly in both the engaged and disengaged position.

This is the entire assembly in the disengaged position.

Match the lettered statement or phrase on the <u>right</u> with the numbered statement or phrase on the left.

1. Driving Member

2. Conventional Clutch Principle

3. Driven Member

4. Hydraulic Linkage Component

5. Part of Mechanical Linkage in direct contact with release bearing collar

6. Strengthens Disc

7. Performs the same function as the large coil in Single Spring Clutch

8. Does not rotate with the flywheel when clutch is engaged

a. Solid Friction
b. Throw out Bearing
c. Master Cylinder
d. Asbestos Fibers
e. Pressure Plate
f. Helical springs
g. Yoke
n. Friction Plate
i. Copper Wires

Match the lettered statement or phrase on the <u>right</u> with the numbered statement or phrase on the left.

1. e Driving Member

2. a Conventional Clutch Principle

3. h Driven Member

4. c Hydraulic Linkage Component

5. g Part of Mechanical Linkage in direct contact with release bearing collar

6. i Strengthens Disc

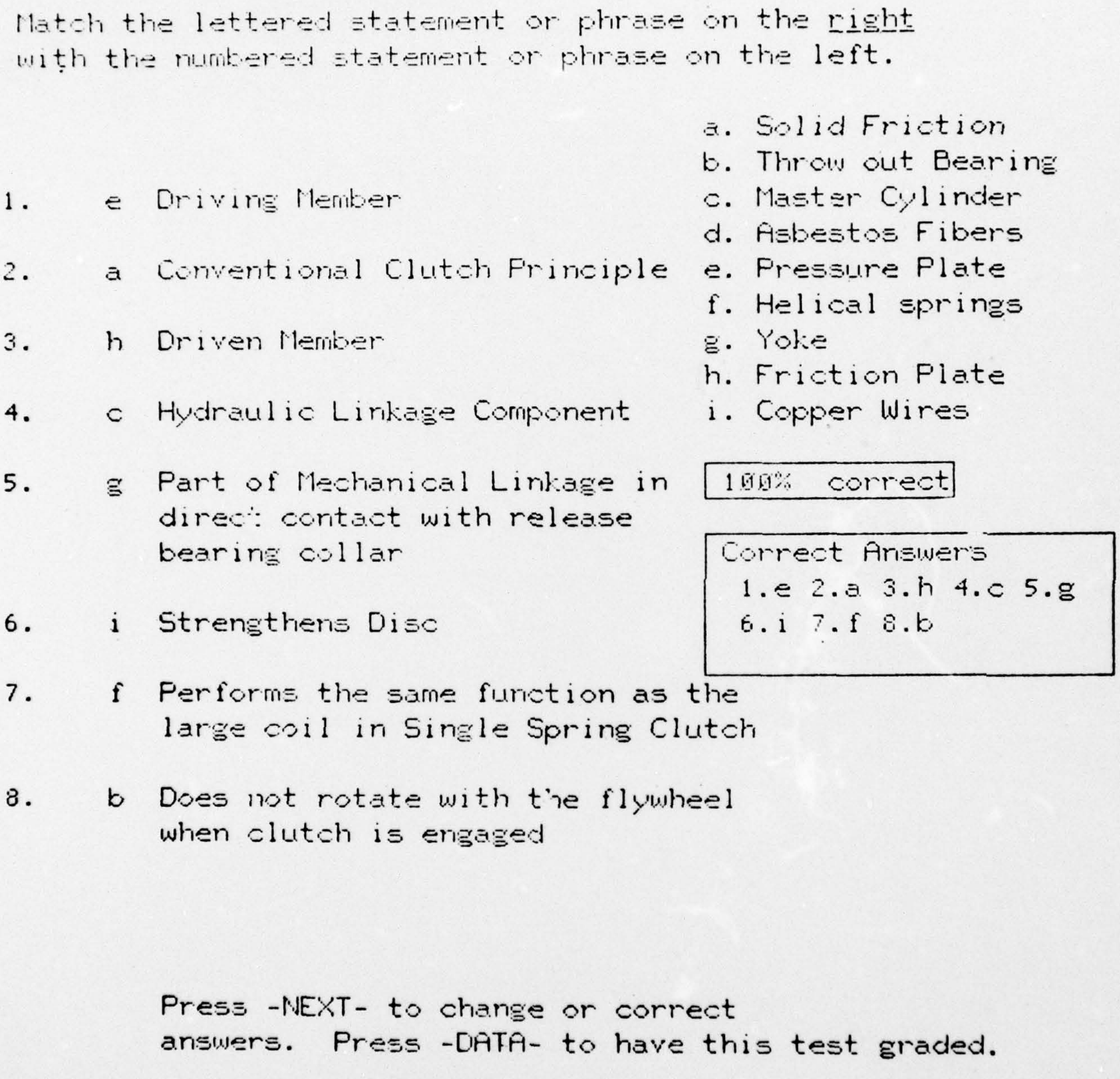
7. f Performs the same function as the large coil in Single Spring Clutch

8. b Does not rotate with the flywheel when clutch is engaged

a. Solid Friction
b. Throw out Bearing
c. Master Cylinder
d. Asbestos Fibers
e. Pressure Plate
f. Helical springs
g. Yoke
h. Friction Plate
i. Copper Wires

Press -NEXT- to change or correct answers. Press -DATA- to have this test graded.

Frame 60



Match the lettered statement or phrase on the right with the numbered statement or phrase on the left.

a. Solid Friction
b. Throw out Bearing
c. Master Cylinder
d. Asbestos Fibers
e. Pressure Plate
f. Helical springs
g. Yoke
h. Friction Plate
i. Copper Wires

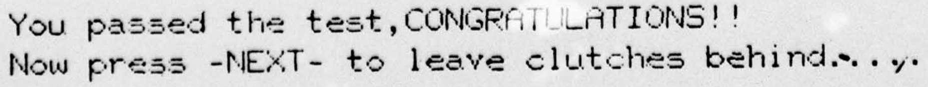
1. e Driving Member
2. a Conventional Clutch Principle
3. h Driven Member
4. c Hydraulic Linkage Component
5. g Part of Mechanical Linkage in direct contact with release bearing collar
6. i Strengthens Disc
7. f Performs the same function as the large coil in Single Spring Clutch
8. b Does not rotate with the flywheel when clutch is engaged

100% correct

Correct Answers
1.e 2.a 3.h 4.c 5.g
6.i 7.f 8.b

Press -NEXT- to change or correct answers. Press -DATA- to have this test graded.

Frame 61



You passed the test,CONGRATULATIONS!!
Now press -NEXT- to leave clutches behind....

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