Chapter 6
ROLE OF COMPUTERS IN TEAM TRAINING: THE AIRCRAFT MAINTENANCE ENVIRONMENT EXAMPLE

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6.1 INTRODUCTION

In order for the Federal Aviation Administration (FAA) to provide the public with a continuing safe, reliable air transportation system, it is important to have a sound aircraft maintenance system.1 The maintenance system is a complex one with many interrelated human and machine components. The linchpin of this system, however, is the human. Recognizing this, the FAA (under the auspices of the National Plan for Aviation Human Factors) has pursued human factors research.1,2 In the maintenance arena this research has focused on the aircraft maintenance technician (AMT).3,4,5 Since it is difficult to eliminate errors altogether, continuing emphasis must be placed on developing interventions to make the maintenance procedures more reliable and/or more error tolerant. In response to this need, this research looked at the role of team training and specifically that of advanced technology for team training in enhancing team performance.

6.2 BACKGROUND

Task analyses of aircraft inspection and maintenance activities have revealed the aircraft inspection and maintenance system to be complex -- requiring above average coordination, communication and cooperation between inspectors, maintenance personnel, supervisors and various other subsystems (planning, stores, and shop) to be effective and efficient.1,2,6,7 A large portion of work is accomplished through teamwork. The challenge is to work autonomously but still be a part of the team. In a typical maintenance environment, the inspector first looks for defects and reports them. The maintenance personnel then repair the reported defects and work with the original inspector or the buy-back inspector to ensure that the job meets predefined standards. During the entire process, the inspectors and maintenance technicians work with their colleagues from the same shift and the next shift as well as personnel from planning, stores, etc., as part of a larger team to ensure that the task gets completed.1 Thus, in a typical maintenance environment, the technician has to learn to be a team member, communicating and coordinating the activities with other technicians and inspectors. Although the advantages of teamwork are widely recognized in the airline industry, the work culture assigns responsibility for faulty work to individual AMTs rather than to the teams on which they work.8 The reasons for this could be the individual licensing process and personal liability, both of which often result in AMTs and their supervisors being less willing to share their knowledge and work across shifts with less experienced or less skilled colleagues. The problem is further compounded since the more experienced inspectors and mechanics are retiring and being replaced by a much younger and less experienced workforce. Not only do the new AMTs lack knowledge or skills of the far more experienced AMTs they are replacing, but also they are not trained to work as a team member.

The earlier problem of the development of individual AMT skills has been continually addressed by FAA. For example, FAR Part 66 (new AMTs certification requirements, not officially established in NPRM stage) specifically addresses the significant technological advancements that have taken place in the aviation industry and the advancements in training and instructional methods that have arisen in the past decade. The FAA, through the Office of Aviation Medicine, has also funded efforts for the development of advanced training tools to train the AMTs of the future.[1,2,9] These prototype training systems (e.g., Boeing 767 Environmental Control System [ECS] tutor and multimedia System for Training Aviation Regulations - STAR) will be available to the A&P schools. It is anticipated that the application of these training technologies on a large scale will help reduce the gap between current AMT skills and those needed for the maintenance of advanced systems.

However, the AMTs joining today's workforce are lacking in team skills. The Aircraft Maintenance Technology Schools (AMTS) provide the necessary technical skills for students to receive both their airframe and power plant certificates (A&P License). The curriculum for AMTS is specified in the Code of Federal Regulations, and presently does not address any instruction on teamwork skills. In fact, the current technical school environment encourages students to compete, and as a result, the AMTs are often ill-prepared for cooperative work. To prepare student AMTs for the workplace, new ways have to be found to build students' technological, interpersonal and socio-technical competence by incorporating team training and communication skills into their curriculum. Furthermore, the importance of teams has also been emphasized in the National Plan for Aviation in Human Factors where both the aircraft industry and government groups agree that additional research needs to be conducted to evaluate teamwork in the aircraft maintenance/inspection environment.[1,2,10] Recent work has examined the effects of team training when applied to students at an Aircraft Maintenance Technology School. Using a previously designed framework for the study of team training in the aircraft maintenance environment, Gramopadhye et al. found a positive correlation between team skills training and the improvement of team performance and overall task performance in an aircraft maintenance situation.[11] In addition, the study concluded that student AMTs need to be provided with team skills instruction to prepare them for the teamwork tasks found in the aircraft maintenance environment. However, the study did not address issues related to the appropriateness of the training delivery system. The question that begs to be answered is: What is the best method to present team skills training?

With computer-based technology becoming cheaper, the future will bring an increased application of advanced technology to training. Over the past decade, instructional technologists have provided numerous technology-based training devices with the promise of improved efficiency and effectiveness. Examples of such technology include computer simulation, interactive video discs and other derivatives of computer based application,[12] several of which have been employed for diagnostic maintenance training.[4,12,13] Furthermore, multimedia has assisted in teaching difficult and complex skills.[14] Layton stated that the domain of aircraft maintenance is rapidly becoming the focus of computer-based training (CBT) aids.[15] With the use of desktop computers with multimedia packages, new maintenance job aids have been developed to teach technical skills to maintenance technicians. AMTs may learn a variety of skills from CBT that range from scheduling preventive maintenance to applying expert systems for fault diagnosis and repair. Lufthansa Airlines believes so strongly in CBT that they have instituted CBT with video overlays to update the technical skills of their maintenance technicians.[16] Andrew et al., also describes various multimedia technologies that have been effective in simulating combat situations for team training in the military.[17] Because of the advantages offered, computer-based training may have a role to play in team training in the aircraft maintenance environment. It is important, therefore, to examine the effectiveness and applicability of computer-based multimedia team training for aircraft maintenance technicians. To date, however, no one has examined the role of the advanced technology, specifically computer-based multimedia presentation, for team skills training for aircraft maintenance technicians. The express purpose of this research was to address this knowledge gap, and to determine the best methodology to improve team training for aircraft maintenance technicians.

6.3 RESEARCH OBJECTIVES

The general objective of this research was to understand the role of team training and specifically that of computers for team training. As part of this effort, a computer-based team training software -- the Aircraft Maintenance Team Training (AMTT) software -- was developed and a controlled study was conducted to evaluate the effectiveness of computers for team training.18 The study evaluated the transfer effects of computer-based team training and addressed usability issues related to using computers for team training. In addition to the above general objectives, the research also tested the following hypotheses using the controlled study.

1. Does there exist any difference in the performance of the AMT teams when training is delivered through traditional instructor-based training (IBT) versus computer-based training (CBT-AMTT) format?
2. Is the effectiveness of a specific training delivery system sensitive to task type?
3. Do AMT teams which exhibit superior team performance also demonstrate superior task performance?

6.4 COMPUTER-BASED TEAM TRAINING - THE AIRCRAFT MAINTENANCE TEAM TRAINING (AMTT) SOFTWARE

The efforts to develop a computer-based team training software for aircraft maintenance technicians (AMT) started in September 1994. The earlier phase of the work investigated the usefulness of team training for aircraft maintenance technicians, and developed a framework for understanding the role of teams and teamwork in the aircraft maintenance environment.18,19 Furthermore, this study identified opportunities for incorporating team training within the A&P school curriculum. The results of a controlled study conducted to evaluate the effectiveness of team training were encouraging as to the potential of improving AMT team performance and overall task performance.20 Drawing from the results of this previous research, a computer-based team training software -- Aircraft Maintenance Team Training Software (AMTT) -- was developed.

To ensure that the software addressed the needs of the aviation community, the designers worked in close cooperation with a major aircraft maintenance/repair/overhauling facility and an A&P school. The development of AMTT was based on the classical iterative software/instruction development methodology.21 The requirements of the aircraft maintenance environment guided the development of the software program, which was centered on human (AMT) requirements and evolved through appropriate stages of specification, story-boarding, prototyping, development, and testing.

6.4.1 Layout of the AMTT Software

Specifically designed for training aircraft maintenance technicians in basic team skills, AMTT uses a multimedia presentational approach with interaction opportunities between the user and the computer. The multimedia presentation includes: full motion videos, which provide real life examples of proper and improper team behavior, photographs and animation, that illustrate difficult concepts, and voice recordings coupled with visual presentations of the main contextual material. Since the software was developed as a training and research tool, the software facilitates the collection of pre-training and post-training performance data.

AMTT is divided into four major programs: Team Skills Instructional Program, Instructor's Program, Printing Program and the Supplemental Program. Figure 6.1 shows the overall layout of the AMTT software. While the Team Skills Program and the Supplemental Program have been designed for use by the aircraft maintenance technician undergoing team training, the remaining two programs are for use by the instructor/supervisor. An AMT interacting with the AMTT software, first, uses the Team Skills Instructional program which initially provides an introduction to the software. Following this step and introduction to the software, the AMT is provided with instruction on basic team skills through four team skills sub-modules: communication, leadership, decision making, and interpersonal relationship. These sub-modules not only emphasize and cover generic material related to these skills but also relate the importance and use of the specific skills within the aircraft maintenance environment. On completion of the team skills modules, the information is summarized in the team skills overview module. At this stage, the AMT is ready to use the Task Simulation module, which allows the AMT to apply the skills acquired in the previous four team skills modules within an aircraft maintenance situation. The simulation enables the instructor to test the AMT's knowledge on teams and ability to identify team related problems. In addition to the four basic team skills module, AMTT also provides the AMT with a supplemental program. The supplemental program consists of two separate supplemental modules: the critical path method and interactive decision making. The objective of the supplemental modules is to provide users with hands-on experience in the use of the specific decision making tools in a simulated team environment. It is anticipated that this interactive experience will enhance learning and the use of the above-mentioned tools in the real world environment. Since the software was developed as both a training and research tool, the software facilitates the collection of pre-training and post-training performance data. The instructor can access and analyze user performance data using the instructor's program. The printing program is an additional utility provided to the instructor to print the various screens in each of the team skills modules and present the information in an alternate instructional format.

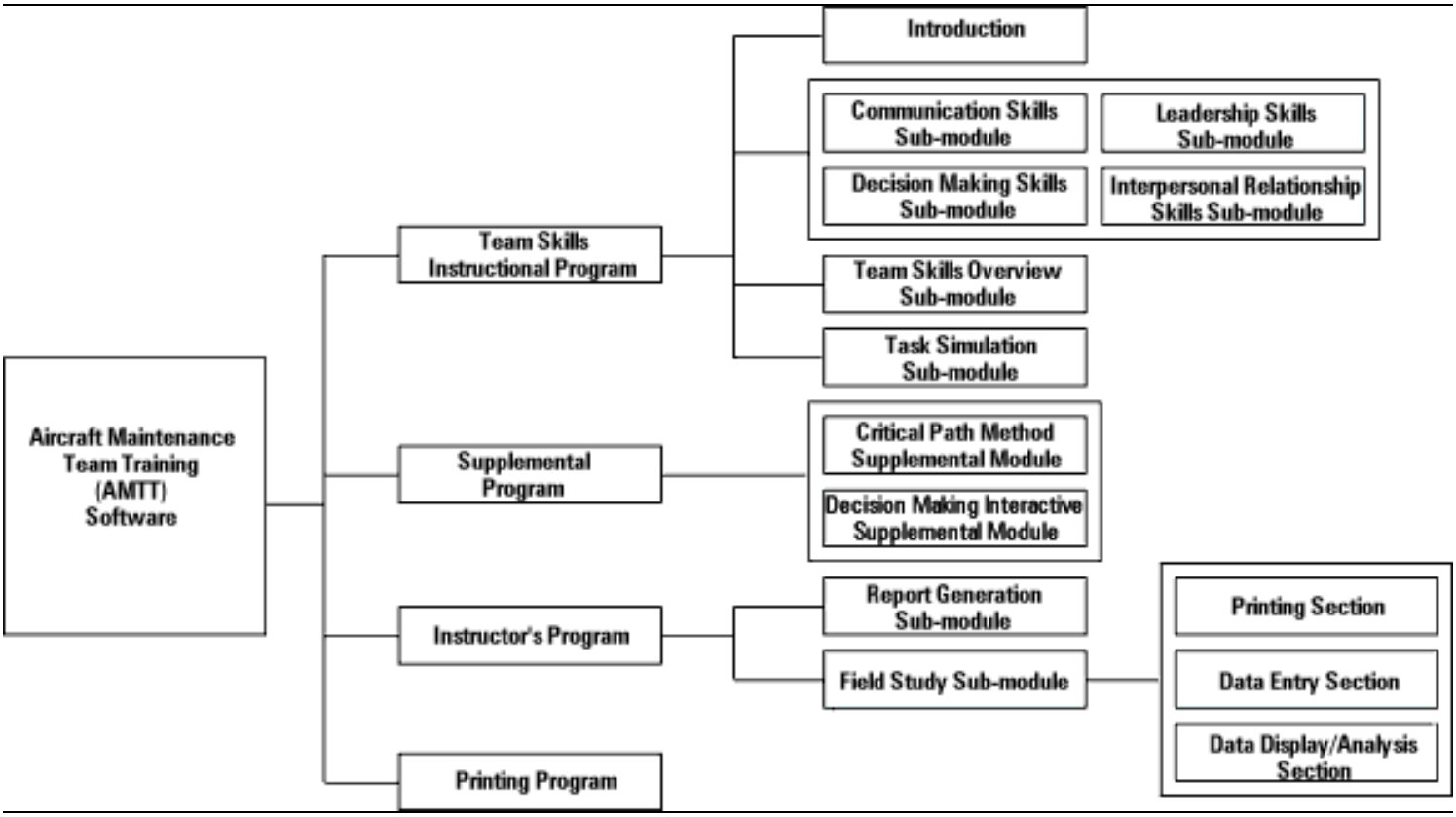

Figure 6.1 Layout of the Aircraft Maintenance Team Training (AMTT) Software

6.5 METHODOLOGY

A controlled study was conducted to evaluate the effectiveness of advanced technology for team training. the following section describes the test site, participants, equipment, and experimental procedures used in this study.

6.5.1 Test Site

The controlled study was conducted at the Aircraft Maintenance Technology Center of Greenville Technical College (GTC). The center houses both classrooms for A&P training and a fully equipped hangar for conducting aircraft maintenance and repair. The classrooms at the Aircraft Maintenance Technology Center provide seating for 20 students. Each classroom is equipped with a 25-inch color television, video player, overhead projector, white and black boards, and a lectern. In addition, the classrooms are equipped with four Pentium 75 MHz computers and 15-inch color monitors (1024 X 768 resolution) installed with multimedia packages.

6.5.2 Test Subjects

The subjects for this study consisted of 12 students from the aircraft maintenance technology center and 24 licensed A&P mechanics from a local aircraft maintenance facility. The subjects were compensated for their participation. The 36 subjects were randomly assigned to two groups such that each group had equal numbers of subjects from the aircraft maintenance technology program and maintenance facility, respectively.

Group IBT - Instructor-based Training: received team training instruction through traditional instructor-based training (IBT), and

Group CBT - Computer-based Training: received team training instruction through multimedia computer-based training (CBT) software (AMTT software).

6.5.3 Equipment

Table 6.1 provides a list of the equipment used in the controlled study. To keep the two training delivery systems as similar as possible, the video clips used in the IBT were identical to the video clips used in the CBT. In addition, the transparencies used in the IBT were screen dumps from the screen images presented in the CBT.

Table 6.1 Equipment used

Research Phase	Equipment

Instruction Phase	**Overhead projector with transparencies**
Instructor-based Training (IBT)	**Television with video player**
	White board
	Lectern
	Video
	Miscellaneous paper and pencils
Instruction Phase **Computer-based Training (CBT)**	**Four Pentium 75 MHz computers with full multimedia package**
	Aircraft Maintenance Team Training (AMTT) software
Evaluation Phase	**Two King Air 90A twin engine turboprop aircraft**
	Tow tug
	Tow bar
	One set of low platform scales for weighing
	Circuit tester
	Miscellaneous hand tools (e.g. wrenches, screwdrivers, level, string, etc.)

6.5.4 Experimental Procedure

The study was divided into two phases: the instructional and evaluation phases.

Instructional Phase

Team Training

Subjects in the IBT group were trained on team concepts using a traditional instructor-based training delivery system, while those in the CBT group received similar training on a computer using the AMTT software. Every effort was made to maintain a constant curriculum and presentation sequence for both the groups. The only difference in the training between the two groups was the delivery system. The team skills training focused on the following four separate skills: communication, decision making, interpersonal relationship, and leadership. It should be noted that in the instructional phase, team training was provided to individuals.

Data Collection

Before training, each subject completed a demographics report (Section 6.11.1). The subject's perception on each team skill (communication, decision making, interpersonal relationships and leadership), before and after training was measured using the Team Skills Verbal Protocol Report (Section 6.11.2). The report used elements from Crew Resource Management/Technical Operations Questionnaire (CRM/TOQ), the modified Taggart's questionnaire,22 Taylor's questionnaire,23 and the Critical Team Behavior Form (CTBF).24 Similarly, changes in subject's team skills knowledge was measured using a 20-question multiple choice Knowledge Test administered before and after training (Section 6.11.3).

At the conclusion of training all subjects completed a two-part usability report (Section 6.11.4). The report collected subjective satisfaction ratings on the training delivery system using a seven-point Likert scale, where seven indicated strongly agree and one indicated strongly disagree. The first part of the usability report, referred to as the General Report, addressed issues relevant to both training delivery systems, and was completed by subjects in both the groups. The General Report addressed usability issues related to content, mechanics of presentation, format, and usefulness. The second part of the usability report was training delivery system specific, and addressed usability issues related to presentation and format. It was completed by subjects in the respective groups.

Evaluation Phase

The teams were not formed until the evaluation phase. The phase examined the transfer effects of team training (IBT and CBT) on AMT performance. After completion of individual training in the instructional phase, subjects in each group were randomly assigned to six three-member teams. Following the assignments, the teams were tasked with performing two tasks representative of normal aircraft maintenance.

Task 1 Routine maintenance task -- determining the center of gravity of an aircraft.

Task 2 Non-routine maintenance task -- trouble shooting an electrical problem on an aircraft.

The specific tasks were selected after detailed discussions with instructors, mechanics and training personnel at the A&P School and the maintenance facility. The order in which the tasks were performed was balanced within each group so that three teams performed the routine task followed by the non-routine task, while the order was reversed for the remaining three teams. The tasks are described in greater detail below.

Routine Maintenance (RM) Task

As part of the routine maintenance task, each team was tasked with determining the center of gravity of a King Air 90A aircraft. This is a normal routine maintenance activity which is conducted periodically on all aircraft. This task was selected since it requires a team effort to execute. To reflect a true maintenance environment, work cards were supplied to the teams which provided general procedural instructions. For evaluation purposes, the routine maintenance task was subdivided into four major subtasks:

Subtask 1.1 - Towing

Subtask 1.2 - Setup

Subtask 1.3 - Weighing and calculating

Subtask 1.4 - Roll out.

Weighing an aircraft to determine the center of gravity requires that the aircraft be located in a level and enclosed area (hanger) with all doors and windows closed. This is to prevent the movement of air over the wings which may cause the scales to misread the true weight of the aircraft. The aircraft was positioned outside the hanger on the runway apron. As a result, the team's first task (Subtask 1.1) was to tow the aircraft into the hanger. This task required that one person drive the towing tug while the other two team members walk at the wing tips to prevent accidental damage to the plane. This task was considered to start upon receipt of the work cards explaining the procedure, and was deemed finished when the aircraft was positioned and secured in the hanger.

The setup for weighing (Subtask 1.2) started the moment Subtask 1.1 ended, and required the team to secure the platform scales from the storeroom, to position the scales in front of the landing gears, and to roll the aircraft onto the scales. This procedure required one person to drive the towing tug, another team member to ride the brakes in the cockpit, and the third team member to monitor the movement of the aircraft in order to prevent accidental damage to the aircraft. Positioning the chocks for and aft of the wheels, as well as riding the breaks was critical for the safety of the aircraft and the maintenance personal during the setup procedure. This subtask was considered complete when the breaks were set, the chocks were in place, and the tow bar was disconnected from the aircraft.

The weighing and calculating task (Subtask 1.3) started at the conclusion of Subtask 1.2. Prior to reading the scales, the team members followed the procedures given in the work cards requiring that all excess equipment and material be removed, that the plane be leveled, and that all panels and doors be closed. The leveling of the aircraft was accomplished by adjusting the air pressure in the wheels. Once all the steps listed in the work cards were accomplished, the scales were read to obtain the weight of the aircraft. This task was considered complete when the team submitted their calculations to the evaluators. Since it was not necessary for the aircraft to remain on the scales during the calculations, Subtask 1.4 was typically initiated and completed before Subtask 1.3 was completed. The time to complete Subtask 1.4 was subtracted from the overall time taken for Subtask 1.3 in order to obtain a true measure of the completion time for Subtask 1.3.

Roll out (Subtask 1.4) was the final task performed by the team. This subtask started when the team initiated the reconnection of the tow bar to the aircraft, and was deemed finished when the aircraft was moved completely off the scales and parked properly (wheels chocked), and the scales and miscellaneous equipment were put away. As with the set up (Subtask 1.2), this procedure required a team effort with one person driving the tug, a second person riding the breaks and a third person monitoring the aircraft's movement.

Non-routine Maintenance (NM) Task

The second task was a non-routine maintenance task that involved trouble-shooting an electrical problem. To ensure consistency throughout the experiment, each team was read a narrative from a pilot's log that described the problem with the nose landing gear warning light (Section 6.11.5). According to the pilot's log, on final approach to the airport the nose landing gear warning light indicated that the nose landing gear was not down and locked when in fact it was. It is interesting to note, that this is not an untypical problem faced by pilots. The narrative was then left with the team so that they could refer to it as needed. The team had to diagnose the problem, identify/find the problem, and rectify the problem within a one-hour time period. This was an open-ended problem and, therefore, no guidance (i.e., work cards) was provided.

To make this non-routine maintenance problem more challenging, it was subdivided into three separate but overlapping problems. To create the first problem, the circuit breaker for the landing gear lights was placed in the "off" position. If the team managed to solve this first problem, they were still faced with a landing gear warning light that would not function. A second problem was created by placing a burned out bulb in the landing gear light socket. Solving this second problem, the team would continue to face a warning light that would not function. For the third problem, the wire connecting the down and locked switch on the landing gear to the landing gear warning light was disconnected. The disconnection was made inside an electrical junction box located within the nose landing gear wheel well. This third problem was not as obvious as the first two problems, and necessitated the use of wiring diagrams located in the maintenance manual.

Data Collection

As the teams performed the routine and non-routine tasks, their performance on the tasks was evaluated by three independent evaluators on measures of: accuracy, safety, and speed. In addition, at the conclusion of the routine and non-routine maintenance tasks, the evaluators and each individual subject completed a report evaluating their team on the application of various team skills (communication, decision making, interpersonal relationships, and leadership).

Task Performance Evaluation

Routine Maintenance (RM) Task

Accuracy	Number of errors or number of times the team's procedure differed from the work card. Number of time an improper tool was used. Number of times that the equipment was handled incorrectly.
Safety	Number of times the safety of the aircraft was in jeopardy. Number of times the safety of an individual was in jeopardy.
Speed	Time to complete the subtask (in minutes). Percent of task completed within allowed time.

Non-routine Maintenance (NM) Task

Accuracy	Was the problem diagnosed correctly? Did the team locate the problem? Did the team fix the problem?
Speed	Time taken to diagnose the problem. Time taken to locate the problem. Time taken to fix the problem. Total time.
Safety	Number of time the safety of the aircraft was in jeopardy. Number of time the safety of an individual was in jeopardy.

Instructor's Evaluation

Upon completion of the routine and non-routine maintenance tasks, the evaluators completed a verbal protocol report evaluating the teams on various team performance measures (communication, decision making, interpersonal relationships and leadership skills). The instructors evaluated each team on the application of team skills using a seven point Likert scale (Section 6.11.6). The score for each team was obtained by averaging the scores provided by the three evaluators.

Self Evaluation

Upon the completion of the RM and NM tasks, all subjects completed a verbal protocol report that was identical to the instructor's report. This allowed the individual team members to rate the performance of the team on the application of team skills (communication, decision making, interpersonal relationships and leadership).

Scenarios

A team that works together for three hours in a controlled study will not face all the situations that could occur in a real world maintenance environment. To assist in evaluating the performance of teams on both the routine maintenance and non-routine maintenance tasks, certain events which are typical of the aircraft maintenance environment were artificially created (Section 6.11.7). These artificial events (scenarios) forced the teams to employ the team skills and provided a basis for evaluation.

6.6 RESULTS

This section presents the results obtained from the instructional and evaluation phases of the study. Statistical Analysis Software (SAS) was used to analyze the data obtained for the different measures.

6.6.1 Instructional Phase

To measure the effect of team training on a subject's perception of team skills, the responses on the Team Skills Perception report were analyzed using an analyses of variance. Separate aggregate scores were obtained for each individual skills component after ensuring that it was appropriate to group the scores on individual responses into an aggregate measure.25 The ANOVAs (analysis of variance) showed a significant Trial effect for communication [$F(1,34) = 9.37$, $p < 0.05$] and leadership skills [$F(1,34) = 10.44$, $p < 0.05$]. However, the main effect of Trial was not significant for interpersonal relationship and decision making skills. The analysis did not reveal any significant Group x Trial interaction effect or Group effect for any of the team skills.

Similar ANOVAs were conducted on the pre- and post-team skills knowledge test scores to measure the effect of training. The ANOVAs showed a significant Trial effect for communication [$F(1,34) = $, $p < 0.001$], decision making [$F(1,34) = 112.10$, $p < 0.001$], interpersonal relationships [$F(1,34) = 42.1$, $p < 0.001$] and leadership [$F(1,34) = 14.36$, $p < 0.001$]. The Group x Trial interaction effect and the main effect of Group were not significant. Both the groups showed an increase in the post-training scores.

The subject's responses on the usability reports were analyzed to measure user satisfaction with the training delivery system. Aggregate scores were obtained for each usability category after ensuring that it was appropriate to group the scores on individual responses into an aggregate measure.25 Separate ANOVAs were conducted for each usability category (general categories: content, mechanics, layout, usefulness; delivery system specific categories: presentation, format). The analyses of variance conducted on the general part of the usability questionnaire did not reveal any significant differences between the groups on each of the four general usability categories. A two-tailed t-test was used to compare the actual mean scores versus expected mean scores (3.5) on delivery system specific issues. The tests revealed that the subjects rated both training programs significantly high on presentation and format related issues.

6.6.2 Evaluation Phase

The subjects and instructors evaluated the teams on their application of team skills. Aggregate scores were obtained for each individual skill measure after ensuring that it was appropriate to group the individual responses into an aggregate score. ANOVAs conducted on the aggregated self evaluation scores for communication, decision making, interpersonal relationships, and leadership did not reveal any significant differences between the IBT and CBT trained teams for both the routine and non-routine maintenance tasks. A similar result was also observed on the instructors' evaluation of the teams on the various team skills measures.

ANOVAs conducted on the accuracy measures for the routine maintenance task as a whole did not reveal any significant differences between the IBT and CBT trained groups. Separate ANOVAs were conducted for individual subtasks. The ANOVA showed a significant group effect for subtask 1.1 ($F(1,10) = 4.96$, $p < 0.05$). Similar ANOVA conducted for the non-routine task did not reveal any significant differences between CBT- and IBT-trained groups. Analysis of safety scores for the routine and non-routine maintenance task revealed that both the teams had equal number of safety violations. Separate ANOVAs were conducted on individual speed measures for the routine and non-routine maintenance task. The ANOVAs did not reveal any significant group effect.

Correlation analysis performed on the various measures showed a positive correlation between the post training knowledge test scores and the time to complete the maintenance tasks ($r = 0.4683$, $p < 0.05$), between accuracy measure and the use of communication skills ($r = 0.4322$, $p < 0.01$), decision making skills ($r = 0.341$, $p < 0.05$) and interpersonal relationship skills ($r = 0.4661$, $p < 0.0042$). Similarly, correlation analysis of safety scores revealed that the teams which had higher communication, decision-making, leadership, and interpersonal relationship scores had significantly fewer safety violations
($r = -0.5702$, $p < 0.001$; $r = -0.8062$, $p < 0.0001$; $r = -0.5312$, $p < 0.0009$; $r = -0.4719$, $p < 0.0112$).

6.7 DISCUSSION

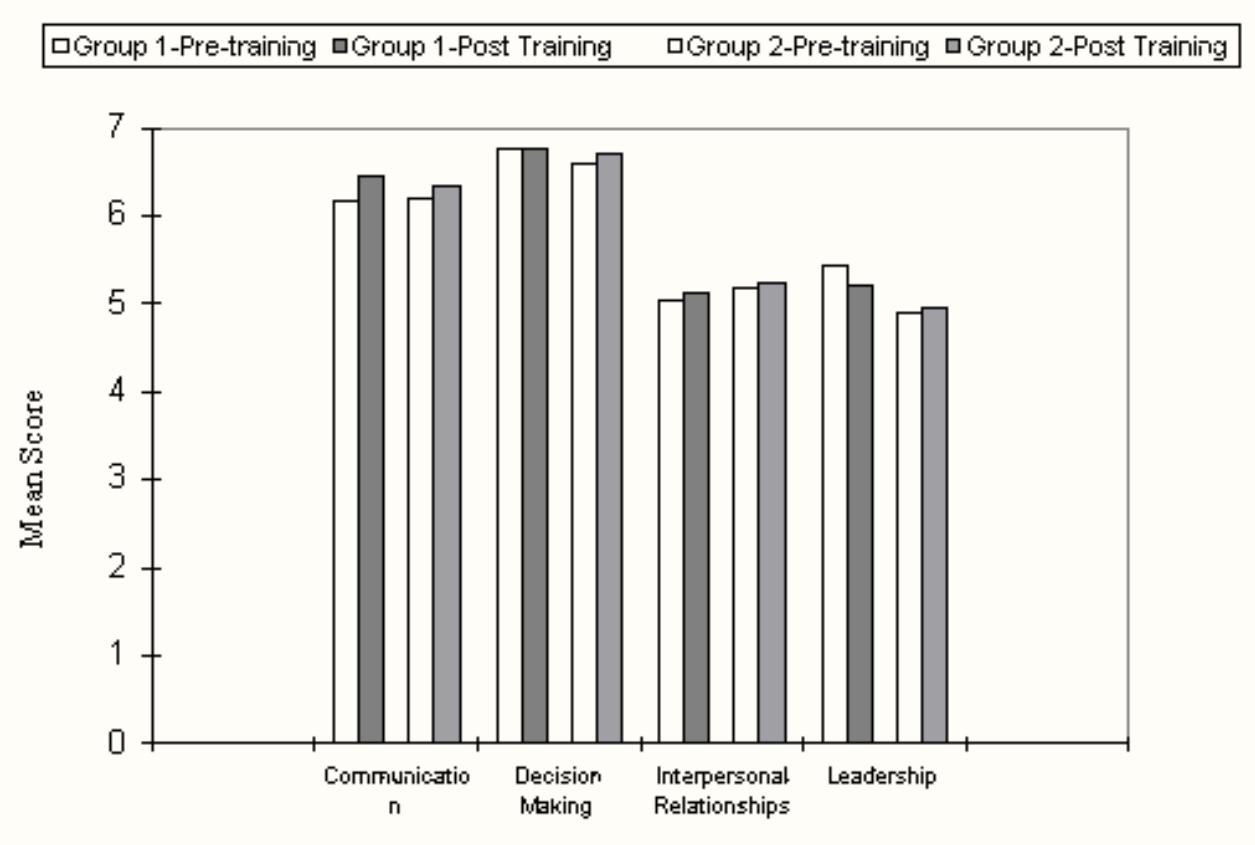

Figure 6.2 Comparison of Team Skills Perception Pre- and Post Training for Groups 1 and 2

The analyses of the pre- and post-training perception questionnaires showed that the training delivery system had comparable effects on the subject's perception of team skills. It was interesting to note that the subject's overall (pre- and post-training) perception of interpersonal relationships and leadership skills were much lower than those for communication and decision making skills (Figure 6.2). The subjects that made up the test Groups consisted of either students or maintenance technicians, and as such were not composed of crew leads or supervisors. It can be hypothesized that nonsupervisory technicians do not recognize the importance of leadership and interpersonal relationship skills. This lack of concern for leadership skills was first noted by Taylor.7 In a survey of ten U.S. commercial transport aviation maintenance facilities, Taylor found a lack of leadership skills in maintenance foremen. In addition, work currently being conducted under a grant from the FAA Office of Aviation Medicine has identified a need for leadership skills training for lead mechanics and maintenance foremen.26

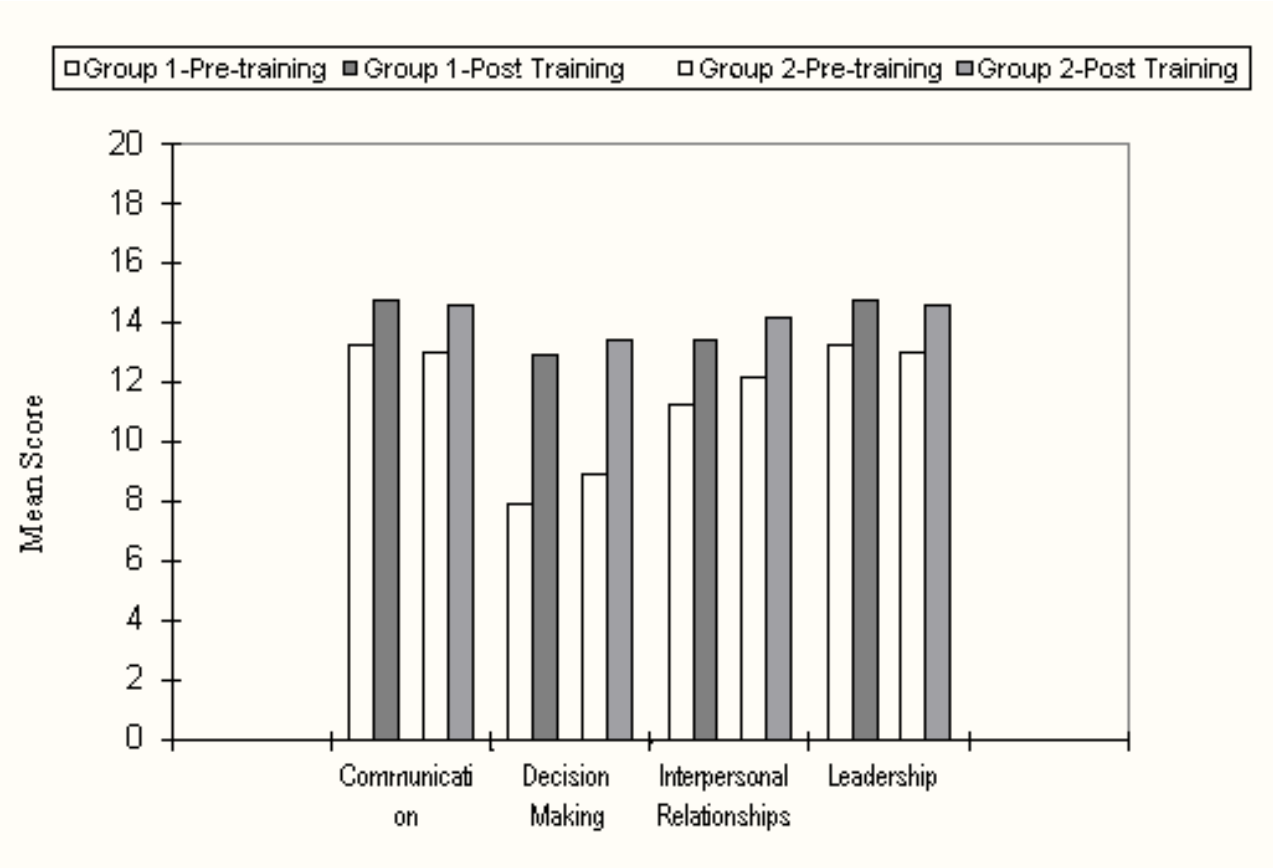

Figure 6.3 Comparison of Team Skills Knowledge Tests Pre- and Post Training for Groups 1 and 2

Both the IBT and CBT groups showed a significant increase in the post-training knowledge test scores (Figure 6.3). The highest increase in score was observed for the decision making skill (Group IBT: 64 percent, Group CBT: 50.1 percent), followed by interpersonal relationship (Group IBT: 19.1 percent, Group CBT: 16.4 percent), and almost an equal increase in scores for communication (Group IBT: 11.3 percent, Group CBT: 12 percent) and leadership skills (Group IBT: 11.3 percent, Group CBT: 12 percent). The fact that both groups showed comparable increases in test scores probably indicates the effectiveness of both methods of delivering team training. The results are consistent with those of other researchers who have found similar results in improving team skills by training. Taylor et al., conducted a crew resource management (CRM) training program for aircraft maintenance personnel and found that maintenance performance measures increased after training. 27 Also, in a study to improve teamwork in engineering design education, Ivaturi found that team training instruction enhances student's knowledge of team skills.19

Traditionally, team training has been delivered in a classroom environment by role playing, games, simulations, etc.17,28 Thus, the conventional approach has been highly interactive wherein the trainees and trainers interact at different levels throughout the training process. The fact that the CBT (specifically, the AMTT software) was able to achieve the same scores as IBT (an equally well designed instructor-based team training program) bodes well for the role of computers in imparting team skills knowledge. At this point, it should be mentioned that the IBT portion of the team training program had the same content as the CBT portion and the only difference was in the method of delivery. This shows that given the equivalent content of the two team training programs, a well designed interactive computer-based team training program can be as effective as a traditional instructor-based team training program.

The development of the AMTT followed an iterative design process so that the problems with the software were identified and corrected before implementation. The cycle of design, test, measure, and redesign was repeated numerous times in the development process.21 Thus, the AMTT software was developed after understanding the needs of the AMT, talking with experts from Lockheed Martin and Greenville Technical College, following a process of iterative design and development, and eventually resorting to detailed user testing (with instructors, supervisors and AMTs). The usability and knowledge test scores clearly indicate that the resulting product was one which was well received by the users and one that helped increase their knowledge on the teamwork skills. Figure 6.4 shows the results of the general usability questionnaire with mean scores on four separate usability issues. These results are encouraging since they indicate that the users were equally satisfied with both training programs. Chandler found similar results using a media rich computer software (System Training for Aviation Regulations - STAR) to teach federal aviation regulations (FARs) to A&P students.29 In her study, the subjects reported a high degree of satisfaction with interactive stories and true-to-life situations presented through CBT. Comparable satisfaction levels between users of hypermedia and paper-based team training programs were also noted by Ivaturi.19

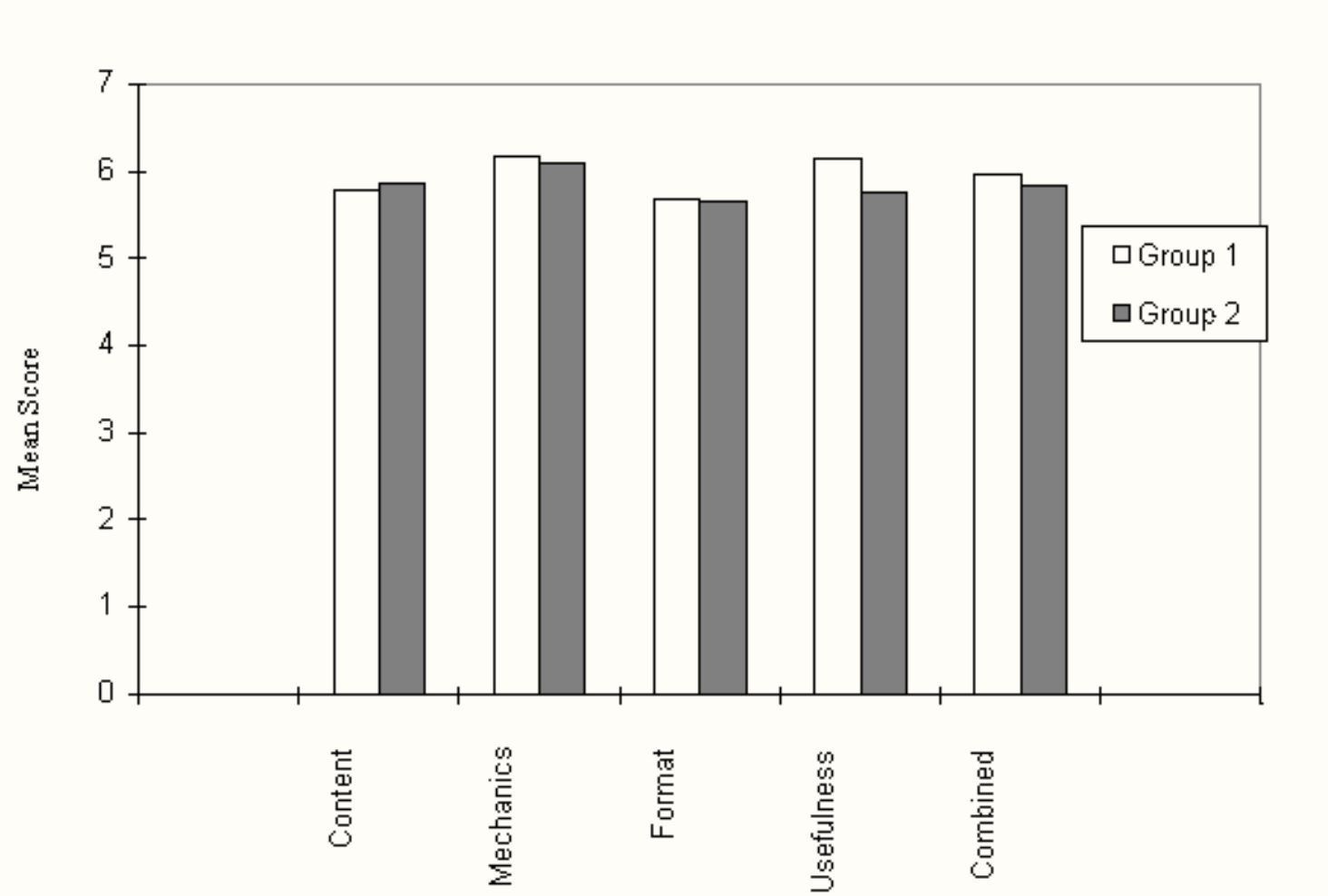

Figure 6.4 Comparison of Usability Scores for Groups 1 and 2 on Training Delivery Issues

The self evaluation scores on each team skill category were similar for both the groups on the routine and non-routine maintenance tasks. The results indicate that the effect of both the training programs on the teams perception of their application of team skills are comparable. Similarly, instructor's evaluation on the application of team skills was comparable for both the routine and non-routine maintenance tasks. It is interesting to note that for each skill category in the routine and non-routine maintenance tasks, the instructors were conservative in their ratings compared to the subjects' ratings. A similar result was noted by Glickman et al., in a study examining the development of team skills over time.24 In their study, the instructors ratings were consistently lower than the rating given by the team leader.

Analysis of accuracy scores on the routine maintenance task revealed that the total number of errors were the same for each Group (10 each). Most of the errors were due to the fact that the team's procedures differed from those specified in the work cards. Table 6.2 gives a breakdown of the typical errors made by the teams while performing the routine maintenance task. Accuracy for the non-routine maintenance task was measured by whether or not the teams correctly diagnosed the problem (Yes or No), located the problem (Yes or No) and fixed the problem (Yes or No). All 12 teams diagnosed, located, and fixed Problems 1 and 2. Only two teams (T1 and T6) could not locate and fix Problem 3 within the allocated time. Statistically, there were no significant differences between the Groups, indicating that the training delivery system had no effect on the accuracy measures. A positive correlation was observed between the accuracy and the use of communication skills, decision making skills, and interpersonal relationship skills. These findings are consistent with other studies on the effects of communication and decision making on team performance. In a study of the Team Evolution and Maturation model, Morgan, Salas and Glickman found that as a team's performance improves, the perception of the team members concerning communication and coordination increases.30 Also, in a study to investigate whether teamwork process measures are associated with outcome measure, Brannick et al., found that team effectiveness was positively associated with decision making and communication skills.31

Table 6.2 Typical Accuracy Errors that Occurred During the Routine Maintenance Task

Subtask	Typical Errors that Occurred
Subtask 1.1 - towing	• Failed to check oil and to drain toilet waste water system • Failed to close hanger doors
Subtask 1.2 - set up	• Failed to place all control surfaces in neutral position • Failed to close passenger door
Subtask 1.3 - weighing and calculating	• Failed to measure from the main wing spar • Made incorrect measurement from the wheel center line to reference datum
Subtask 1.4 - roll out	• Failed to properly place chocks • Failed to return scales to storage

An obvious revelation after analyzing the accuracy scores for the routine and non-routine maintenance tasks was the overall low number of errors for both the Groups. The high accuracy scores achieved by the teams can probably be explained within the Speed Accuracy Tradeoff (SATO) context.32 Training delivered at A&P schools and through various training departments focuses on accuracy, emphasizing the need to minimize errors since these can be catastrophic (e.g., the case of a Continental commuter airlines, Continental Express, that flew without the tail deicing boot properly attached, or the United DC-10 whose engine failed, severing control hydraulic lines and causing a crash at Sioux City). This perception of accuracy obviously seemed to transfer to the performance of the teams for both the RM and NM tasks.

Both the Groups had almost the same number of safety violations for the routine and non-routine maintenance tasks. The majority of the safety violations occurred for the RM task. Table 6.3 provides a list of typical safety violations that occurred during the routine and non-routine maintenance tasks. The lack of safety violations during the non-routine maintenance task could possibly be an artifact of the task. The NM task was essentially a problem-solving task. Therefore, the task was more of a cognitive task unlike the routine maintenance task which was a highly procedural and manual task (movement of the aircraft into the hangar, positioning the aircraft, and rolling the aircraft onto and off of the scales). Hence, the opportunities for safety violations were much greater for the RM task compared to the NM task. Although safety violations were reported for RM and NM tasks, the overall number of incidences were much lower than those that are typically reported in the "real world" aircraft maintenance environment. 33,34 The existing study was performed in a clean, quiet, and simulated hanger environment. There were no other AMTs working on the aircraft at the same time, thereby minimizing work interruptions and work flow. On an actual hangar floor, there are multiple skill groups (avionics, hydraulics, maintenance) with multiple crews working on a single aircraft. It is a highly complex and dynamic environment wherein an individual AMT must not only work with his own team members, but also must communicate and coordinate with other crews, supervisors, inspectors, etc. Thus, the work of a team is not only dependent on the intra-team factors, but also inter-team factors. In addition, there are other factors which are obviously present: environmental factors (e.g., poor noise and lighting conditions), organizational factors (e.g., gate pressure, late night shift), and subject factors (e.g., part-time workers, shift workers), which were missing in the current study, and possibly contribute to the greater number of safety violations. Similarly, the results of the statistical test did not reveal any significant differences between the IBT and CBT trained teams on overall task completion times for the routine and non-routine maintenance tasks.

Table 6.3 Typical Safety Violations that Occurred During the Routine and Non-routine Maintenance Tasks

Tasks	Typical Safety Violations
Routine Maintenance Tasks:	
Subtask 1.1 (towing)	• **Removed wheel chocks prior to connecting towing tug** • **Failed to walk with the aircraft while towing it to the hanger**

Subtask 1.2 (roll up)	• **Failed to place chocks fore and aft of the scales** • **Failed to properly set parking brakes**
Subtask 1.3 (weighing and calculating)	• **No safety violations**
Subtask 1.4 (roll out)	• **No safety violations**
Non-routine Maintenance Tasks:	
Problem 1 (circuit breaker)	• No safety violations
Problem 2 (burned out bulb)	• No safety violations
Problem 3 (disconnected wire)	• Caused damage to junction box • Replaced wire without first checking wiring diagram in the maintenance manual

6.8 CONCLUSIONS AND FUTURE EXTENSIONS

Having discussed the results from the analysis and evaluation phases of the study, the following conclusion can be drawn from the study.

- There were no significant differences between IBT and CBT in terms of user satisfaction. Both the training delivery systems reported a high level of user satisfaction on the general and delivery specific portions of the usability questionnaire. Analysis of the general usability questionnaire on specific issues such as content, mechanics, format, and usefulness did not reveal any significant differences between the two training delivery systems. It was encouraging to find that AMTs were able to interact and use the AMTT software after minimal instructions on basic computer operations.

- Team training enhanced the knowledge of individuals on team skills. However, the type of training delivery system did not have a significant effect on the individual's ability to acquire team skills knowledge and apply the knowledge acquired. Both the systems were comparable in terms of their ability to deliver team skills knowledge.

- Teams which exhibited superior team behavior also exhibited superior performance on a select set of task performance measures. The correlation analysis showed that the results approached significance for a large number of variables.

- Many times CBTs fail because software designers fail to design interfaces and systems that the users can understand. The problem can be alleviated by resorting to a user-centered design approach which uses an iterative process of design, test, measure, modify, and retest. This procedure was used in the development of the AMTT software, and as such a user friendly product was produced. The study used subjects with limited computer experience, yet they were able to interact with the AMTT software without assistance.

- After analyzing the results for both the CBT and IBT teams, the results are unequivocal. CBT (i.e., AMTT) was as effective in delivering team training instruction as IBT. Finally, the iterative design methodology employed in this study proved to be useful in designing an effective computer-based team training software. The above results have obvious ramifications for the use of AMTT for team training in the aircraft maintenance environment. In addition to being as effective as existing instructor-based team training methodologies, use of AMTT for team training has other obvious advantages:

    1. Standardization: AMTT provides a systematic and consistent curriculum. Aircraft maintenance instructors at various facilities use their own unique training strategies (lectures, classroom discussions, video examples, etc.). In addition, some maintenance instructors who are technically competent may not have sufficient team skills knowledge to train AMTs on teamwork. The AMTT software provides a standardized and systematic team skills training program which aircraft maintenance instructors (at certified repair stations, airline companies, general aviation stations, and A&P schools) can use to provide team skills training.

    2. Adaptability: Traditionally, maintenance training has been accomplished via on-the-job training or classroom training, both of which are manpower intensive. It requires careful scheduling of personnel or encumbers others in the training process. AMTT is adaptive, self paced, and can be done at convenient times when trainees are available and need only involve the person being trained.

    3. Record Keeping: The record-keeping capabilities of AMTT track the student's progress. This information can be used by the instructor/supervisor to design remedial training.

    4. Cost effectiveness: Team training using AMTT can be cost effective because: (1) It can be delivered on-site, thus eliminating travel expenses for the trainer and the trainee. (2) It can minimize down time by providing training at times that are convenient to the trainee and the company's work schedule. In larger organizations, AMTT can be delivered to many people at multiple sites thus proving to be cost effective.

    5. Use of advanced technology: Many facilities (e.g., A&P Schools and fixed based general aviation facilities) do not have access to larger aircraft. The AMTT software provides team skills training against the backdrop of maintaining a DC-9. Therefore, the trainees not only acquire knowledge and skills on teamwork, but also gain an understanding of the importance of teamwork in the maintenance of wide-bodied aircraft.

Based on the results of this study, it is clear that team training needs to be integrated into the existing curriculum of the A&P school as well as the continuing education programs of licensed AMTs. This can be achieved by using multimedia computer-based team training programs (such as AMTT) which focus on both generic and context specific (i.e., aircraft maintenance environment specific) team skills. In addition, we envision the following extensions to the current work:

- A larger study needs to be conducted which will look at the effects of team training in the real world. Furthermore, the study should encompass a wider variety of maintenance tasks (line maintenance, base maintenance, component shops, and support shops) involving various repairs and maintenance facilities ranging from large airlines through fixed based operators associated with general aviation.

- The current study evaluated team performance by measuring changes in outcome measures (accuracy, safety and speed) and team performance variables (self evaluations and instructor's evaluations). This could be viewed as a simplistic way of modeling the team process wherein the changes in the inputs (training programs) are mapped onto changes in the outputs. Although the data obtained from this study provided valuable insights into the team process, we still do not know what changes took place in terms of task process measures (e.g., changes in the mental model, number of dead ends in trouble shooting a problem, etc.) that had an impact on the outcome measures. Hence, it would be worthwhile to extend the current study so as to look at team process measures, task process measures, and outcome measures as teams perform a series of aircraft maintenance related team tasks.

- The current study looked at the immediate effects of team training, but did not examine the long term retention of team skills. A study is needed to examine whether team skills degrade over time, and if so, what interventions (e.g., retraining or remedial training) should be applied to reverse this trend.

- In the current study, knowledge on team skills was delivered to individuals. Future research should examine the possibility of creating a multimedia computer-based team training software program which would deliver training to teams rather than to individuals. The future version of the AMTT software should expand the individualized team skills training to significantly larger teams with team roles being performed either by the human or the computer.

- The current study demonstrated the effectiveness of interactive multimedia computer-based team training. As newer interactive computer technology becomes more readily available, there will be new opportunities for research.

1. Over time team training environments will become more real and possibly more fun. Development of 3D game environments would allow individual or multiple users to acquire and practice teamwork skills in a real world mode. Current research has used games such as Gunship(tm) and Microsoft Flight Simulator to teach and test teamwork skills,[35] but new software programs can be developed which would allow a team of individuals to build a city, explore a new world or troubleshoot an aircraft in flight. Further research is needed to test the suitability of the newer technology with respect to the current CBT and the traditional IBT.

2. The next obvious step is to incorporate new technology into team training programs. One such futuristic tool which is available today is virtual reality. Virtual reality can enhance learning by allowing the user to "walk through" the environment, examine objects from various perspectives, and to interact with the environment. A study should be conducted that would examine the effectiveness of using virtual reality in developing high fidelity computer-based team training programs.

3. Future versions of the AMTT software should provide for expanded communication with full use of networked computers and/or internet. AMTs could work with their colleagues from different sites and apply team skills in solving maintenance-related problems.

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6.11 APPENDICES

6.11.1 Appendix A - Consent Form

INFORMED CONSENT STATEMENT FOR
TEAMWORK, TEAM TRAINING AND TEAM PERFORMANCE:
AIRCRAFT MAINTENANCE ENVIRONMENT

INFORMATION

You have been invited to participate in a research study entitled Teamwork, Team Training and Team Performance: Aircraft Maintenance Environment. If you agree to participate, you will be one of thirty-six subjects who will be participating in the study. You will be participating both individually and on a team.

There are two distinct stages to this research. In the first stage, you will be asked to be one of two groups: one group will receive team training in a traditional classroom format, and the other group will receive training from a computer-based multimedia team training tutorial. Both training delivery systems will provide you the same information.

Prior to any instruction, you will be asked to fill out some personal demographic information. ALL INFORMATION WILL BE STRICTLY CONFIDENTIAL.

You will also be asked to complete a short questionnaire and multiple choice test both before and after each instructional unit. The scores on your test and your opinions about the topic will not be revealed to anyone other than yourself (upon request) and the investigators conducting this research: David Kraus and Anand Gramopadhye.

At the conclusion of all instruction you will be asked to fill out a questionnaire giving us your opinion of the training.

ESTIMATED TIME FOR STAGE 1 = 3 HOURS

In the second stage of this research, you will be assigned to a three member team. As a team you will need to complete two aircraft maintenance tasks: a routine maintenance task and a non-routine maintenance task. Major equipment will be supplied, but you may need to use your own tools. After completion of each task you will need to complete a short questionnaire giving us your opinion of how well your team performed.

ESTIMATED TIME FOR STAGE 2 = 3 HOURS

You will be paid $5.00/hour for your time. Payment will be upon completion of the testing.

For those of you receiving training from the computer, there may be feelings of frustration. It will be extremely helpful if you tell us about these times so that we may correct any problems. Please remember, that any frustration you feel is due to the difficulties in the software and not because you have done anything wrong. We can only test two teams at a time during the second stage. Therefore:

AFTER COMPLETING STAGE 2 OF THIS RESEARCH

PLEASE DO NOT INFORM THOSE WHO HAVE YET TO DO THE TASKS
WHAT THE TASKS ARE OR
ANY PROBLEMS YOU MAY HAVE HAD

CONSENT

I have been given the opportunity to ask questions about this study; answers to questions (if any) have been satisfactory.

The information in the study records will be kept confidential and will be made available only to persons conducting the study unless I specifically give permission in writing to do otherwise. In any results of this study

that are published, I will not be identified.

I will receive $5.00 per hour to a maximum of 6 hours ($30.00) even though the actual time spent in receiving instructions and performing tasks may vary.

In consideration of all of the above, I give my consent to participate in this research study. I understand that I may drop out of this study at any point if I so choose.

I acknowledge receipt of a copy of this informed consent statement.

SIGNATURE OF SUBJECT_____

DATE_____

SIGNATURE OF WITNESS_____

SIGNATURE OF INVESTIGATOR_____

6.11.2 Appendix B - Team Skills Verbal Protocol Report

Perception Questions on Communication

1. Good communication and team coordination are as important as technical proficiency for aircraft safety and operational effectiveness.

Very strongly disagree	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Very strongly agree**

2. Crew leaders and supervisors should encourage questions during work and in special situations

Very strongly disagree	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Very strongly agree**

3. The start of shift team meeting is important for safety and effective team management

Very strongly disagree	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Very strongly agree**

4. Knowing the correct technical terminology is critical for effective communication

Very strongly disagree	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Very strongly agree**

5. Proper team communication should always be unidirectional and progress from the crew chief down to the team members.

Very strongly disagree	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Very strongly agree**

6. If a person is not able to perform the job properly, he should ask for help from the team members

Very strongly disagree **1** **2** **3** **4** **5** **6** **7** **Very strongly agree**

7. Positive feedback is more important than negative feedback.

Very strongly disagree **1** **2** **3** **4** **5** **6** **7** **Very strongly agree**

8. Team members should give unsolicited advice to each other on how to do a job.

Very strongly disagree **1** **2** **3** **4** **5** **6** **7** **Very strongly agree**

9. It is equally important to know how to give feedback as well as to receive feedback.

Very strongly disagree **1** **2** **3** **4** **5** **6** **7** **Very strongly agree**

10. Feedback is necessary for improving team performance.

Very strongly disagree **1** **2** **3** **4** **5** **6** **7** **Very strongly agree**

Perception Questions on Decision Making

1. Team members should not question the decisions or actions of the crew leader or supervisor except when they feel that the action could effect the safety of the operation

Very strongly disagree **1** **2** **3** **4** **5** **6** **7** **Very strongly agree**

2. In a team situation the work goals and priorities have to be agreed upon by all team members.

Very strongly disagree **1** **2** **3** **4** **5** **6** **7** **Very strongly agree**

3. All team members should contribute to the team decisions

Very strongly disagree **1** **2** **3** **4** **5** **6** **7** **Very strongly agree**

4. In making decisions in a team it is important that all members participate

Very strongly disagree **1** **2** **3** **4** **5** **6** **7** **Very strongly agree**

5. If there exists a conflict it should be resolved by the team leaders.

Very strongly disagree **1** **2** **3** **4** **5** **6** **7** **Very strongly agree**

6. Team members should actively support the goals and objectives of the organization (Costs, quality and service).

Very strongly disagree **1** **2** **3** **4** **5** **6** **7** **Very strongly agree**

7. If a team member disagrees with the decisions of the team they should voice their opinions.

Very strongly disagree **1** **2** **3** **4** **5** **6** **7** **Very strongly agree**

8. Voting and than using the majority is the best way to make team decisions.

Very strongly disagree **1** **2** **3** **4** **5** **6** **7** **Very strongly agree**

9. Teams have no need to make decisions. They should work together as directed by the crew lead.

Very strongly disagree **1** **2** **3** **4** **5** **6** **7** **Very strongly agree**

10. Brainstorming is an effective ideas generation technique.

Very strongly disagree **1** **2** **3** **4** **5** **6** **7** **Very strongly agree**

Perception Questions on Interpersonal Relationships

1. Team members should avoid disagreeing with others because conflicts could create tension and reduce team effectiveness.

Very strongly disagree **1** **2** **3** **4** **5** **6** **7** **Very strongly agree**

2. One should be aware of and sensitive to the personal problems of other team members.

Very strongly disagree **1** **2** **3** **4** **5** **6** **7** **Very strongly agree**

3. For a team to work effectively it requires every team member to rake into account the personalities of the other team members.

Very strongly disagree **1** **2** **3** **4** **5** **6** **7** **Very strongly agree**

4. Since individuals do not function as effectively under high stress conditions, team coordination is more important in emergency or abnormal situations

Very strongly disagree **1** **2** **3** **4** **5** **6** **7** **Very strongly agree**

5. A member of crew leader who is truly professional will not bring his personal problems on the job.

Very strongly disagree **1** **2** **3** **4** **5** **6** **7** **Very strongly agree**

6. The team members should help resolve a team members personal problem if it affects the job.

Very strongly disagree **1** **2** **3** **4** **5** **6** **7** **Very strongly agree**

7. Team members can reduce problems relating to interpersonal relationships by not interfering with the jobs of other team members.

Very strongly disagree **1** **2** **3** **4** **5** **6** **7** **Very strongly agree**

8. Problems mainly due to interpersonal relationships are management problems and the management needs to address them to help the team.

Very strongly disagree **1** **2** **3** **4** **5** **6** **7** **Very strongly agree**

9. If there is one member who adversely affects the working of the team, that person should be isolated from the team.

Very strongly disagree **1** **2** **3** **4** **5** **6** **7** **Very strongly agree**

10. Having good interpersonal relationship skills are important to the success of the team.

Very strongly disagree **1** **2** **3** **4** **5** **6** **7** **Very strongly agree**

Perception Questions on Leadership

1. The crew leader or supervisor should take hands on control and make all decisions in emergency or non-standard situations.

Very strongly disagree **1** **2** **3** **4** **5** **6** **7** **Very strongly agree**

2. Team members should not question the decisions or actions of the crew leader or supervisor except when they threaten the safety of the operation.

Very strongly disagree **1** **2** **3** **4** **5** **6** **7** **Very strongly agree**

3. Under no circumstances should a sub-ordinate assume control of the project.

Very strongly disagree	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Very strongly agree**

4. The responsibilities of the crew leader vary across situations

Very strongly disagree	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Very strongly agree**

5. Overall successful team management is primarily a function of the crew leader or supervisor's technical proficiency.

Very strongly disagree	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Very strongly agree**

6. For a team leader to have the respect of his team members he should be technically proficient in all aspects of the work.

Very strongly disagree	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Very strongly agree**

7. The crew leader or supervisor should verbalize plans or actions and should be sure that the information is understood and acknowledged by the team members.

Very strongly disagree	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Very strongly agree**

8. T team leader should complete the tasks for his team member if he doesn't know how to complete it.

Very strongly disagree	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Very strongly agree**

9. Knowledge on how to hold a meeting is an important skill of a leader.

Very strongly disagree	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Very strongly agree**

10. Unlike technical skills, leadership skills are easily learned and used.

Very strongly disagree	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Very strongly agree**

6.11.3 Appendix C - Team Skills Knowledge Tests

Table C-1
Multiple Choice Test on Communication

1. Your crew chief is talking to the team and when he says something significant and you nod your head in agreement...
   A. It displays a lack of desire to communicate.
   B. You are communicating with body language.
   C. You should keep very still so as to not confuse the speaker
   D. You should remain quiet since verbal and non-verbal communication do not mix.

2. Which of the following is the proper sequence of the communication process?
   A. Transmitter, audience, feedback and speaker.

B. Speaker, paper, reader and feedback
C. Transmitter, receive, audience and message.
D. Speaker, message, listener and feedback.

3. A message that a speaker wishes to verbally communicate may be distorted by any of the following EXCEPT...
A. Background noise.
B. His attitude to the listener.
C. Terminology that is used.
D. The printing cost.

4. Suppose you are presenting some technical information to your team, and you notice that a team member is indicating with his facial expression that he doesn't understand wheat you are saying. You should...
A. Stop for a moment and ask if you are making yourself clear.
B. Continue on because he will eventually understand.
C. He should be ignored since any interruption of your presentation would be rude.
D. You should stop your presentation to answer his question but only if he requests it.

5. Which of the following is true?
A. Listening is not considered a true form of communication.
B. We communicate most often by writing
C. Feedback is typically not immediate in written communication
D. Communication by body language is only done by the listener as he responds to the speaker.

6. Which of the following statements concerning active listening is true?
A. In active listening you should actively consider what you are going to say next while the speaker is talking.
B. Active listening is disruptive and should be avoided.
C. Part of active listening is giving feedback to the speaker on what was just said.
D. Active listening is listening while you are involved in an activity.

7. You are presenting an idea you have to your team. One of your team members is sitting with his ankles crossed, his arms crossed and is looking at the floor. Which of the following concerning this person is true?
A. He really likes your idea but is waiting patiently for you to finish so he can add a thought.
B. He doesn't agree with your idea but is being polite by not interrupting.
C. He is impatient and does not care one way or the other what your idea is.
D. He is probably indicating that he wants to speak next.

8. When the supervisor summarized what he said and then asked several team members questions, he was...
A. Grading the team members.
B. Using an investigative management technique.
C. Was using reverse psychology to get his team to work harder.
D. Looking for feedback to see if he got his message across.

9. All of the following are communication EXCEPT...
A. Reading a circular
B. Thinking of ways to improve performance
C. Giving a fellow team member a "Thumbs up" sign
D. Listening to announcements

10. In the communication process, the transfer link or mode...
A. Should be written

B. Is spoken
C. Can be spoken, written, or visual.
D. Does no include visual.

11. In the communication process, feedback...
A. Shortcuts the path between encoding and decoding
B. Does no show up during verbal communication
C. Is electronically passive
D. Is used to clarify ideas, intent and concepts

12. All of the following may cause your message to be changed or distorted EXCEPT...
A. Circulars used
B. Terminology used
C. Tone of voice
D. Background noise

13. Which of the following concerning feedback is true?
A. Is only a problem in electronic communication.
B. Should be written down
C. Should be positive as well as negative
D. Is not a consideration for job performance

14. Which of the following is NOT a proper guideline for written communication?
A. Write so that only the most experienced reader will understand.
B. Proof read any document you write.
C. Be clear, concise and correct.
D. Write legibly.

15. Which of the following is a form of verbal communication?
A. A bulletin
B. A class presentation
C. Nodding your head
D. Smashing your fist on a table because you are mad.

16. Of a circular, bulletin and non-routine work card, which is a type of written communication?
A. The circular and the bulletin only.
B. The non-routine work card only.
C. All are examples of written communication
D. None are examples or written communication.

17. Feedback is important in job performance because...
A. It is used by management for grading
B. It allows you to correct or improve your work.
C. It is part of your performance evaluation.
D. It goes on you permanent record.

18. Effective listening techniques include...
A. Stopping a person as soon as you disagree, so that you can systematically make your points.
B. Formulate your next point while a speaker is talking.
C. Assume an attentive position.

D. Always take notes.

19. In this video, Ron...
A. Is using an active listening technique.
B. Is performing interactive management
C. Should not have spoken since it disrupts John's train of thought.
D. Failed to use body language.

20. The non-routine work card shown in the picture has created a problem for the reader because...
A. Of poor English
B. Of poor handwriting
C. Of incorrect information
D. Insufficient information

Table C-2
Multiple Choice Test on Decision Making

1. With reference to the video, what is the first thing that this team must do?
A. Define the problem as a single question.
B. Brainstorm ideas.
C. List reasons why the existing process won't work.
D. Do a critical path analysis.

2. Which of the following is an example of a well defined problem that this team might develop?
A. What management practices and training rolls need to be implemented to alleviate this problem.
B. How can we get the parts to the mechanics in a timely manner?
C. List the present problems.
D. What are the overall objectives of this company, and how might those objectives be changed to accommodate changes in the supply department?

3. Which of the following procedures should this team use to generate ideas to improve the process?
A. Controlled convergence technique
B. Evaluation by voting
C. Selective elimination
D. Brainstorming

4. Which of the following is the second step in the decision making process?
A. Prioritizing
B. Problem definition
C. Generation of ideas
D. Coordination with supervisors

5. In brainstorming...
A. You should accept ideas that are generated without discussion or reaction
B. You should immediately drop ideas that the majority vote to eliminate
C. You should never combine ideas
D. The team leader should limit the number of ideas to simplify voting.

6. With reference to the video, what decision making tool is this team employing?
A. Multivoting

B. Voting
C. Nominal group technique
D. Consensus

7. In the idea generation stage of decision making...
A. You reject all poor or ridiculous ideas right away to save time
B. Each idea should be discussed in detail as it is presented
C. Piggy-backing or hitch-hiking your ideas onto someone else's ideas is encouraged
D. You should use personal experiences to reject ideas that have failed in the past

8. After a list of ideas have been generated, your team should progress to the third stage in the decision making process. This step is...
A. Prioritizing
B. Coordinating
C. Mechanizing
D. Supervising

9. Which of the following tools would you use to prioritize the list of ideas the team develops to improve the process?
A. Consensus
B. Voting
C. Multivoting
D. Management by tolerances

10. If your team comes to a solution by unanimous vote, then what was the decision tool that was used?
A. Consensus
B. Voting
C. Multivoting
D. Nominal group technique

11. With reference to the above video, what decision making tool is this team using?
A. Multivoting
B. Voting
C. Nominal group technique
D. consensus

12. Why would we want to use a majority voting procedure as a 'decision making' technique?
A. Because it is good for handling complex situations
B. Because voting never produces bad feelings
C. Because it builds self-esteem
D. Because it is a rapid decision making technique.

13. In the multivoting decision making technique...
A. You need to vote the same way each time to maintain consistency
B. You prioritize your votes
C. You cast you votes in any manner you choose
D. The number of votes you get is set at 4 per person

14. The silent generation of ideas...
A. Reflects poor communication skills
B. Should be done before idea presentation

C. Is an alternative to brainstorming
D. Is used at the conclusion of meetings

15. Which of the following statements is correct?
A. Having a well defined decision making procedure is helpful to a team.
B. Once a team is finished brainstorming, they will have a consensus as to a solution.
C. Multivoting is a sub category of inspection.
D. Of all team skills, decision making is the most important.

16. With reference to the video, what should the team leader so at this point
A. The team leader should close the meeting and report 'No ideas generated' to the supervisor.
B. The team leader should keep presenting his own ideas in the hope that the others will get started.
C. The team leader should use his authority to make them respond.
D. The team leader should back up and start with the silent generation of ideas.

17. With reference to the video, what should the team leader do at this point?
A. Do more silent generation of ideas allowing more time - possibly days
B. Back up to the initial problem and discuss it thoroughly since there is probably some misunderstanding
C. You must keep going round robin until someone gives an ideas to report. Someone has to say something.
D. Stop. It is now time to report 'No ideas generated' to the supervisor.

18. With respect to the video, what should the team leader so at this point?
A. Nothing. This is the type of interaction that you are seeking for eliminating poor ideas and keeping good ideas.
B. Redirect the focus of the team to another problem that needs to be solved.
C. Reprimand the team members for criticizing and evaluating
D. Stop the evaluation by reminding team members of the brainstorming rules.

19. With reference to the video, in this situation, the team leader...
A. May make changes on a suggestion if the contributor agrees.
B. Is within his power to make any alterations.
C. Should make alterations to a suggestion only if the majority of the team members agree.
D. Should never change what the contributor says.

20. When the team is discussing the various ideas generated during brainstorming, the team leader should...
A. Uses his discretion to shorten the list of ideas for his team.
B. Should only eliminate ideas and not combine ideas
C. Should eliminate or combine ideas only with the permission of the contributor and other team members
D. Leave the list alone. Do no make changes.

Table C-3
Multiple Choice Test on Interpersonal Relationships

1. Which of the following statements concerning successful teams is true?
A. Successful teams never have interpersonal relationship problems.
B. Successful teams consist of people with similar experience, background and opinions.
C. Since teams are temporary, successful teams must ignore personal differences and avoid all conflict.
D. Successful teams realize personal differences can add to the strength of the team.

2. In general, teams should...
A. Avoid uncontrolled tension when dealing with conflict

B. Encourage conflict between team members
C. Not avoid conflict or tension since it helps to ensure a free exchange of ideas
D. Realize that open conflicts are always constructive

3. Team members must learn to...
A. Respect other team members and consider their opinions
B. Avoid objectionable remarks
C. Be open to new ideas
D. All of the above

4. Team members learn to work together...
A. Very easily since they are working on a common goal
B. Through extensive training and close supervision by trainers
C. With the help of a specially trained manager
D. Through several stages of development

5. The "Forming" or "first" stage of a team's growth is best characterized by which of the following statements?
A. There is excitement, optimism and some anxiety.
B. There are arguments among team members, competition and "choosing sides."
C. There is significant involvement by top management because this stage is so critical.
D. Forming is characterized by the large number of forms to be filled during this stage.

6. The "Storming" stage is considered which stage of a team's growth?
A. First
B. Second
C. Third
D. Fourth

7. Which of the following statements regarding the "Storming stage" of team growth is true?
A. Successful teams typically by-pass this stage of team growth because of the conflict.
B. During this "Storming stage," it is vital that management becomes involved.
C. During this state, more energy is spent in learning about one another than in accomplishing goals.
D. Storming occurs primarily in long established teams.

8. Which of the following statements regarding the "Norming stage" of team growth is true?
A. This is the last and fourth stage
B. During this stage, team members are more friendly and confident in each other
C. It is at this stage that management becomes involved in each team aspect
D. Most conflicts occur during this stage

9. Ground rules are used to:
A. Determine procedures for running a team meeting
B. Set up processes for documenting team activities
C. Establishing acceptable behavior
D. Establishing acceptable behavior and standard operation procedures

10. Gatekeeping is often included in ground rules, and refers to:
A. The function of controlling tropics to be discussed
B. Methods to achieve balance participation by members
C. The team leader closing sown a discussion so that decisions can be made

D. Monitoring attendance and replacing members who have shown disinterest by not attending meeting on a regular basis

11. Which of the following statements about team meeting is the most correct?
A. Team meetings are important, but they are not treated as high priority work
B. Emphasis on attending meetings on time is a distracting carry-over from more formal behavioral requirements
C. Team, meeting should start and stop on time
D. Meetings should be extended if meaningful progress is made

12. Interpersonal problems can be solved:
A. By establishing ground rules
B. with a combination of ground rules and team leader actions
C. By reminding member of their responsibilities
D. By returning disruptive members to their own organization

13. Overbearing team members:
A. Limit discussion and free exchange of ideas
B. Will evaluate each idea and reject ideas that "will not work"
C. May criticize ideas from others
D. All of the above

14. Members with dominating personalities:
A. Try to control team meetings
B. Like to hear themselves talk
C. Have no tolerance for other opinions
D. All of the above

15. If a member is reluctant to participate, it could mean that:
A. The member is uncomfortable in the meeting
B. The member is distracted by personal problems
C. May not care about team participation
D. All of the above

16. Impatient members may be:
A. Trying to help the team leader keep the meeting on schedule by relaxing the atmosphere
B. Trying to push activities to achieve personal goals
C. Able to handle information faster than other team members
D. Trying to get more ideas exposed within the limited time

17. A negative member should be:
A. Generally ignored and given time only for positive comments
B. Permitted to "talk it out" and then asked to withhold all other negative comments
C. Quickly removed from the meeting for a one-on-one discussion with the team leader
D. Asked to listen, withhold comments, and to meet with the team leader in a future private meeting.

18. An indifferent team member:
A. Is the same as a negative participant, and should be handled the same way
B. Should be ignored since their attitude is disruptive
C. May be encouraged to participate through the use of open ended questions
D. Should be removed from the team and returned to their own organization

19. When you have team members who feud or constantly argue with one another, you should:
   A. Encourage the feuding since open conflicts are always constructive
   B. Push them to some agreement for managing their differences without disrupting the group
   C. Immediately notify higher management so that they might take action to stop the feuding
   D. Stop the meeting immediately, and get the adversaries to discuss the issues. Offer to facilitate the discussion

20. Interpersonal relationships in team environments:
   A. Become more personal by recognize differences in rank or authority
   B. Become more personal and lines of authority remain intact
   C. Are more open to public view
   D. Are built on trust and mutual respect

Table C-4
Multiple Choice Test on Leadership

1. Characteristics of a team oriented company are...
   A. Focus on functions, efficiency , emphasis on process and strong management control
   B. Profit centered, proficient operations, process control and strong leadership
   C. Employee centered, emphasis on process and consistent quality
   D. Employee centered, emphasis on process and consistent quality and customer driven

2. Teams are beneficial to employees because they:
   A. Give employees a feeling of belonging
   B. Make it easier for employees to learn from the supervisor
   C. Allow for the team members to participate in decisions; improve morale
   D. Require employees to learn new skills

3. Teams are beneficial to the company because...
   A. The company can take advantage of employee's experience and knowledge
   B. They help the image of the company and in attracting highly skilled employees
   C. They are a good marketing tool
   D. They spread out responsibility for errors

4. Participative leadership can be best characterized as:
   A. Directing teams as to specifics
   B. Managing activities of employees
   C. Coordinating team activities
   D. Solving employee's problems

5. Team leadership skills can be:
   A. Learned through experience
   B. Learned through specialized training
   C. Learned Through Specialized training and experience
   D. Passed on from father to son

6. Leadership skills can include all of the following EXCEPT:
   A. Coordination
   B. Report generation
   C. Training

D. Dealing with interpersonal relationships

7. Which of the following statements concerning leadership styles is true?
   A. Transition to a team leadership style takes time and effort
   B. The supervisory leadership style takes time and effort
   C. Leadership is learned only through specialized training
   D. Passed on from father to son

8. A team leader will periodically hold meetings. When meeting, a good leader will:
   A. Make sure the room is set up like a classroom in order to make presentations easier
   B. Mentally develop and keep an agenda to follow
   C. Encourage participation by requiring everyone to take notes
   D. Be concerned about the meeting room environment

9. Decisions should be made by:
   A. Experts in planning and engineering organizations
   B. Team leaders in conjunction with technical notes and experts from engineering
   C. Team members on the floor, based on their expertise
   D. By the team only when forced to do so by management

10. Consensus building means that:
   A. You agree to go along this time if the group will agree with you next time
   B. Everyone agrees to support the selected solution alternative
   C. More than a simple majority is needed to make the decision but not everyone needs to agree
   D. Selected alternatives should reflect guidance received from management

11. The primary concept in team decision making is to:
   A. Make the best decision possible in the shortest time and go back to work - no one will remember where the solution came from if it turns out to be wrong
   B. Make maximum use of past experience and stay away from new or innovative ideas - there is too much risk
   C. Generate ideas, evaluate the ideas and then select the best alternative
   D. Generate ideas, form recommendations and then forward to management for a decision

12. Team meetings should be held:
   A. Periodically to remind members that they belong to a team
   B. Whenever or as frequently as management will provide the time form the job
   C. When there is a need - it has a purpose - and will not become a social period
   D. When the team leader is being pressed by management and he needs more hands to prepare something for them

13. The following is an example of a closed ended question.
   A. John, what are your thoughts about Peter's suggestion?
   B. How would you improve the process
   C. Do you think that this is the best way?
   D. Why do you think that this will work?

14. Constructive feedback is:
   A. Listening and focusing your attention on the speaker
   B. Drawing out the speaker by challenging his comments or by asking the sources of the information being furnished
   C. Providing positive comments (feedback) - turning mistakes and error into learning experiences.
   D. Telling workers how to do a task correctly to make them more efficient

15. Which of the following statements concerning feedback in general is correct?
   A. Give both positive and negative feedback.
   B. Constructive feedback should emphasize the negative and should be given to redirect and/or improve performance.
   C. Avoid negative feedback since it lowers self-esteem and reduces team performance.
   D. New team teaching techniques encourage the elimination of negative feedback - provide only positive feedback.

16. To get your message across to team members:
   A. Plan to tell them the main point at least three different ways and then summarize.
   B. Keep your message concise - use simple language - and check for understanding.
   C. Make a concise statement - they are smart and do not need repeated explanations.
   D. Make a short statement and open discussions for clarifying questions.

17. Should you always check discussions for understanding?
   A. No - you don't want to insult team members or imply that they are slow learners.
   B. Yes - it will help ensure that there is a common understanding.
   C. No - give team members a chance to follow instructions - if mistakes are made, use the learning experience - if no mistakes are made, it will build confidence.
   D. Yes - it will give team members time to think about what was said and make the meeting more meaningful.

18. All the following are ways to encourage participation in a meeting EXCEPT:
   A. Show attentiveness with voice and facial expression
   B. Have presentations done by specialists
   C. Use open ended questions
   D. Use silence

19. As a team leader you are concerned with the training of your team members. Besides this, you:
   A. Are responsible for record keeping of training received by your team
   B. Should regularly hold written and practical tests
   C. Encourage your team members to take advantage of training that is offered
   D. Conduct certification reviews

20. A team member has a personal problem and is disrupting work. As a team leader you should:
   A. Talk to him on a one-on-one basis - let him know that you care.
   B. Trade was stories with him to make him believe that he is very lucky - his experience could have been worse.
   C. Ask him to take time off until he can solve the problem - safety may become a major problem.
   D. Ask him to leave his problems outside of the job - it is distracting - reduces productivity - may cause a safety hazard. Tell him you are interested.

6.11.4 Appendix D - Usability Questionnaires

Table D-1
General Questions

Instructions

The following statements are to be used to evaluate the training delivery system. The following seven point scale is used:

1	2	3	4	5	6	7

Very Strongly **Neutral** **Very Strongly**
Disagree Agree

Contents

The amount of information presented was adequate.

1 **2** **3** **4** **5** **6** **7**

Very Strongly **Neutral** **Very Strongly**
Disagree Agree

The subjects were thoroughly covered.

1 **2** **3** **4** **5** **6** **7**

Very Strongly **Neutral** **Very Strongly**
Disagree Agree

The information presented was understandable.

1 **2** **3** **4** **5** **6** **7**

Very Strongly **Neutral** **Very Strongly**
Disagree Agree

Mechanics

The videos were helpful in understanding the concepts presented.

1 **2** **3** **4** **5** **6** **7**

Very Strongly **Neutral** **Very Strongly**
Disagree Agree

The short questions presented during instruction, were helpful in reinforcing what you learned.

1 **2** **3** **4** **5** **6** **7**

Very Strongly **Neutral** **Very Strongly**
Disagree Agree

The language used by the speaker was understandable.

1 **2** **3** **4** **5** **6** **7**

Very Strongly **Neutral** **Very Strongly**
Disagree Agree

Presentation format

The screens / overheads were understandable.

1 **2** **3** **4** **5** **6** **7**

Very Strongly **Neutral** **Very Strongly**
Disagree Agree

The information presented flowed smoothly.

1 **2** **3** **4** **5** **6** **7**

Very Strongly **Neutral** **Very Strongly**
Disagree Agree

The presentation was interesting.

1	2	3	4	5	6	7
Very Strongly Disagree		**Neutral**		Agree	**Very Strongly**	

Usefulness

The knowledge gained from each of the following modules was useful.

Communication module

1	2	3	4	5	6	7
Very Strongly Disagree		**Neutral**		Agree	**Very Strongly**	

Decision making module

1	2	3	4	5	6	7
Very Strongly Disagree		**Neutral**		Agree	**Very Strongly**	

Interpersonal relationship module

1	2	3	4	5	6	7
Very Strongly Disagree		**Neutral**		Agree	**Very Strongly**	

Leadership module

1	2	3	4	5	6	7
Very Strongly Disagree		**Neutral**		Agree	**Very Strongly**	

Table D-2
Usability Questionnaire for
Computer-based Training (CBT)

Instructions

The following statements are to be used to evaluate the training delivery system. The following seven point scale is used:

1	2	3	4	5	6	7
Very Strongly Disagree		**Neutral**		Agree	**Very Strongly**	

Presentation

The voice over helped in understanding the material.

1	2	3	4	5	6	7
Very Strongly Disagree		**Neutral**		Agree	**Very Strongly**	

The tutorial was easy to use.

1	2	3	4	5	6	7
Very Strongly Disagree		**Neutral** Agree	**Very Strongly**			

It was easy to navigate through the tutorial.

1	2	3	4	5	6	7
Very Strongly Disagree		**Neutral** Agree	**Very Strongly**			

Format

The colors used on the screen were pleasing.

1	2	3	4	5	6	7
Very Strongly Disagree		**Neutral** Agree	**Very Strongly**			

The buttons on the screen were easy to understand.

1	2	3	4	5	6	7
Very Strongly Disagree		**Neutral** Agree	**Very Strongly**			

The delays while the computer worked did not frustrate you.

1	2	3	4	5	6	7
Very Strongly Disagree		**Neutral** Agree	**Very Strongly**			

You were satisfied with the interaction with the computer.

1	2	3	4	5	6	7
Very Strongly Disagree		**Neutral** Agree	**Very Strongly**			

The tutorial was effectiveness in providing instruction.

1	2	3	4	5	6	7
Very Strongly Disagree		**Neutral** Agree	**Very Strongly**			

Table D-3
Usability Questionnaire for
Instructor-based Training (IBT)

Instructions

The following statements are to be used to evaluate the training delivery system. The following seven point scale is used:

1	2	3	4	5	6	7
Very Strongly Disagree		**Neutral** Agree	**Very Strongly**			

Presentation

The instructor was effective in presenting the material.

1	2	3	4	5	6	7
Very Strongly Disagree		**Neutral**		Agree		**Very Strongly**

The presentation was interesting.

1	2	3	4	5	6	7
Very Strongly Disagree		**Neutral**		Agree		**Very Strongly**

The instructor talked at an acceptable pace.

1	2	3	4	5	6	7
Very Strongly Disagree		**Neutral**		Agree		**Very Strongly**

Format

The videos were easy to see.

1	2	3	4	5	6	7
Very Strongly Disagree		**Neutral**		Agree		**Very Strongly**

The overhead projections were easy to see.

1	2	3	4	5	6	7
Very Strongly Disagree		**Neutral**		Agree		**Very Strongly**

The instructor interacted well with the students.

1	2	3	4	5	6	7
Very Strongly Disagree		**Neutral**		Agree		**Very Strongly**

The instructor was easy to understand.

1	2	3	4	5	6	7
Very Strongly Disagree		**Neutral**		Agree		**Very Strongly**

I was satisfied with the effectiveness of this classroom training.

1	2	3	4	5	6	7
Very Strongly Disagree		**Neutral**		Agree		**Very Strongly**

6.11.5 Appendix E - Narrative of Problem for Non-routine Maintenance Task

I was flying in from Chicago, and on my way here I had flown through some bad weather. There was a storm with rain and lightening, but I was never hit by anything. There was also a lot of turbulence. As I approached the Greenville Airport, I lowered my landing gear, but the nose gear light showed that I had a failure. I panicked!! I radioed the tower of my situation, and they alerted their crash crew. As I flew by the tower, they said that the landing gears were down, but they couldn't tell if they were locked or not. I had to take a chance. It was really tense for a while, but I landed safely. An inspection of the gears showed that they were in fact locked down. I don't know what is wrong with the landing gear light, but I need it repaired within the next hour.

Suggested procedure:

1. Research
   System configuration

2. Trouble shoot
   a. Preliminary
   b. In-depth

3. Correct problem

4. Verify correction - swing gear if necessary

5. Maintenance record update

6. Clean up

6.11.6 Appendix F - Instructor's/Self Evaluation Report

Table F-1
Communication

1. Team members used proper terminology when communicating either verbally or written.

1	2	3	4	5	6	7
Very Strongly Disagree		Neutral		Very Strongly Agree		

2. Team members asked for clarification on a communication that was unclear.

1	2	3	4	5	6	7
Very Strongly Disagree		Neutral		Very Strongly Agree		

3. Team member called attention to mistake made by another team member without being negative.

1	2	3	4	5	6	7
Very Strongly Disagree		Neutral		Very Strongly Agree		

4. During a shift change, discussions were held at the location of the specified work.

1	2	3	4	5	6	7
Very Strongly Disagree		Neutral		Very Strongly Agree		

5. Team members actively listened to fellow members.

1	2	3	4	5	6	7
Very Strongly		Neutral		Very Strongly		

Disagree Agree

6. Non-routine work cards were filled out properly.

1	2	3	4	5	6	7
Very Strongly Disagree		Neutral		Very Strongly Agree		

7. Overall, the team communicated effectively.

1	2	3	4	5	6	7
Very Strongly Disagree		Neutral		Very Strongly Agree		

Table F-2
Decision Making

1. The team leader solicited input from team members

1	2	3	4	5	6	7
Very Strongly Disagree		Neutral		Very Strongly Agree		

2. As a problem was presented to the team as a whole, it was well defined so that everyone understood.

1	2	3	4	5	6	7
Very Strongly Disagree		Neutral		Very Strongly Agree		

3. When discussing a problem, all team members participated in the discussion.

1	2	3	4	5	6	7
Very Strongly Disagree		Neutral		Very Strongly Agree		

4. The team made their decisions in an effective manner.

1	2	3	4	5	6	7
Very Strongly Disagree		Neutral		Very Strongly Agree		

5. Team members carried out solutions/decisions with commitment and pride.

1	2	3	4	5	6	7
Very Strongly Disagree		Neutral		Very Strongly Agree		

6. Team members effectively used external sources of information to help make decisions.

1	2	3	4	5	6	7
Very Strongly Disagree		Neutral		Very Strongly Agree		

7. Decision making tools (i.e. brainstorming, consensus, etc.) where effectively used.

1	2	3	4	5	6	7
Very Strongly Disagree		Neutral		Very Strongly Agree		

Table F-3
Interpersonal Relationships

1. When asked for help, team members willingly and openly provided assistance.

1	2	3	4	5	6	7
Very Strongly Disagree		Neutral		Very Strongly Agree		

2. The group worked well as a team.

1	2	3	4	5	6	7
Very Strongly Disagree		Neutral		Very Strongly Agree		

3. Team members had a positive attitude about their work.

1	2	3	4	5	6	7
Very Strongly Disagree		Neutral		Very Strongly Agree		

4. Team members remained focused on their work.

1	2	3	4	5	6	7
Very Strongly Disagree		Neutral		Very Strongly Agree		

5. Team members encouraged and supported one another.

1	2	3	4	5	6	7
Very Strongly Disagree		Neutral		Very Strongly Agree		

6. Team members gave unsolicited and unnecessary advice to one another.

1	2	3	4	5	6	7
Very Strongly Disagree		Neutral		Very Strongly Agree		

7. Team members did not relate well to one another.

1	2	3	4	5	6	7
Very Strongly Disagree		Neutral		Very Strongly Agree		

Table F-4
Leadership

1. The leader failed to verified if information he provided was understood by all recipients.

1	2	3	4	5	6	7
Very Strongly Disagree		Neutral		Very Strongly Agree		

2. The team leader accepted ideas and contributions from team members.

1	2	3	4	5	6	7
Very Strongly Disagree		Neutral		Very Strongly Agree		

3. Team leader coordinated gathering of information in an effective manner.

1	2	3	4	5	6	7
Very Strongly Disagree		Neutral		Very Strongly Agree		

4. Leader reviewed procedures and assignments with team prior to a task requiring teamwork.

1	2	3	4	5	6	7
Very Strongly Disagree		Neutral		Very Strongly Agree		

5. The team leader dealt effectively with questions asked by team members.

1	2	3	4	5	6	7
Very Strongly Disagree		Neutral		Very Strongly Agree		

6. The team leader fostered cooperation within the team

1	2	3	4	5	6	7
Very Strongly Disagree		Neutral		Very Strongly Agree		

7. The team leader dealt effectively in inter-team cooperation/negotiation.

1	2	3	4	5	6	7
Very Strongly Disagree		Neutral		Very Strongly Agree		

6.11.7 Appendix G - Scenarios Used to Create Artificial Situations

1. Shift change

Approximately one-half hour into the RM task, the team will be told that that their work shift will end in 15 minutes. The team will need to prepare a non-routine work card to pass their work onto the next team. After the turnover, they will

return to their work.

2. Loss of personnel
   fifteen minutes into the NM task, a team member will be selected at random and will be removed from the team for fifteen minutes.

3. Equipment not immediately available
   The platform scales will be withheld from the team for ten minutes. The team will have to coordinate with supplies to determine when the scales will be available.

4. Extra weight in plane
   The work cards specify that all extraneous equipment be removed from the plane before weighing. Two large piece of equipment will be placed in different part of the plane.

5. Shared equipment
   Only one tow tug is available and must be shared by the two teams as they perform their tasks.

6. Towing of aircraft
   Both planes will be located outside the hanger on the runway apron. Only one plane at a time can safely be moved into the hanger. Teams must coordinate movements.

7. Flaps down
   The flaps on both planes will be in a down position. These flaps must be brought to level before work can proceed on plane.

8. Missing work cards
   The fifth and sixth work card will not be provided to the team conducting the RM task unless they notify their supervisor (Instructor) that it is missing.

9. Interruption
   During the NM task, a visitor will stop by plane and spend five minutes asking questions about their work.