Team Training for the Aircraft Maintenance Technician: The Aircraft Maintenance Team Training (AMTT) Software

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ABSTRACT

Previous research on civil aircraft inspection and maintenance has shown the important role teamwork plays in completing aircraft inspection/maintenance tasks. Hence, it is necessary to develop team training tools for aircraft maintenance technicians (AMT) to enhance team skills and team performance within the aircraft inspection/maintenance environment. In response to this need, this paper describes the development of a computer-based multimedia team training tool, the Aircraft Maintenance Team Training (AMTT) software.

BACKGROUND

Recent FAA reports on human factors in aviation maintenance (Shepherd, 1991, FAA, 1993) have recognized the importance of training. Training for aircraft maintenance and inspection systems has essentially aimed to improve individual skills. This training has ranged from improving diagnostic skills for aircraft maintenance training (Johnson, 1990) to acquiring and enhancing visual inspection skills to improve airframe structural inspection (Latorella et al., 1992; Gramopadhye et al., 1993). A large effort in the past has concentrated on developing individual skills of AMTs; however, very little effort has been placed on developing team skills.

The task analysis of aircraft inspection and maintenance activities (Shepherd, 1991) has revealed the aircraft inspection/maintenance system to be complex, requiring above average coordination, communication and cooperation between inspectors, maintenance personnel, supervisors and various other sub systems (planning, stores, and shops) to be effective and efficient. A large number of activities of a maintenance technician or an inspector necessitates teamwork and can be performed more effectively and efficiently in a team. Though the advantages of teamwork are widely recognized (Hackman, 1990) in the airline industry the work culture assigns responsibility for faulty work on individual AMTs rather than on the teams in which they work. 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 they are also 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, the newly established FAR Part 66 (new AMTs certification requirements) 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. These advanced tools include intelligent tutoring systems, embedded training, etc. which will be available to A & P training schools. It is anticipated that the application of these new training technologies will help reduce the gap between current AMT skills and those needed for the maintenance of advanced systems.

NEED FOR TEAM TRAINING

A large portion of inspector and maintenance technician work is accomplished through teamwork. The challenge is to work autonomously but still be a part of the team. In a typical maintenance environment, first, the inspector 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 (FAA, 1993). 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. However, the AMTs joining today's workforce are lacking in team skills. The current A & P school curriculum often encourages students to compete against one another, and often AMTs are not fully prepared for co-operative work in the future. 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. Additionally, the importance of teams has been emphasized in the National Plan for Aviation in Human Factors (FAA, 1993), where both the industry and government groups agreed

that additional research needs to be conducted to evaluate teamwork in the aircraft inspection/ maintenance environment. As part of an effort focused on teams in the aircraft maintenance environment, the current study achieved the following: - developed a framework to understand the role of teamwork and team training in the aircraft maintenance environment, - conducted a controlled study to evaluate the effectiveness of team training with AMTs from an A & P school, and - developed a computer based team training software entitled "Aircraft Maintenance Team Training" (AMTT).

FRAMEWORK AND CONTROLLED STUDY OF TEAM TRAINING IN THE AIRCRAFT MAINTENANCE ENVIRONMENT

Drawing from the task analysis of aircraft inspection and maintenance operations (Drury, 1990; Shepherd, 1991), site visits to the repair facilities, observations with training personnel and A & P school instructors, and a detailed review of the various team models, a framework for team training was developed. This framework, serving as the first step in understanding teamwork in aircraft inspection and maintenance operations, illustrates the interaction between internal factors, external factors, the team process, training strategies and outcome measures. The framework assisted in the development of a team training program (Gramopadhye et al., 1995). Then, the effectiveness of this program in enhancing team skills was tested in a controlled study conducted with student AMTs from an A & P school. The framework and the results of the study have been reported extensively in Ivaturi et al. (1995), Gramopadhye, et al. (1995). The results of this study were encouraging as to the potential of team training in improving team performance and overall task performance. The results showed that AMT teams which underwent team training exhibited a larger percentage of team behaviors related to successful team performance as compared to teams with no training. Having developed a framework and demonstrated the effectiveness of team training, it is clear that student AMTs need to be provided with training and tools which they can use to enhance team skills and prepare them for cooperative environment in the future. Since advanced technology may have a role to play in developing team training tools, specifically computer-based team training tools, evaluation is needed.

ADVANCED TECHNOLOGY APPLIED TO TEAM TRAINING -- THE AIRCRAFT MAINTENANCE TEAM TRAINING (AMTT) SOFTWARE

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 applications (Johnson, 1990), several of which have been employed in maintenance training (Johnson, 1990, Johnson et al., 1992; Shepherd, 1992). Furthermore, multimedia has assisted in teaching difficult and complex skills (Gordon, 1994). Andrews et al. (1992) also describe various multimedia technologies that have been effective in simulating combat situations for team training in the military. Because of the advantages offered, computer-based training may have a role to play in team training in the aircraft maintenance environment. As part of the effort which examines the application of advanced technology to team training, a computer based team training software--Aircraft Maintenance Team Training Software (AMTT) was developed.

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 animations 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, a database program was developed to collect demographic information as well as pre and post performance data.

SPECIFICATIONS

AMTT was programmed in Microsoft Visual Basic and runs in the Microsoft Windows environment. AMTT uses the 486 DX2 66 MHz platform, with a 15 inch SVGA monitor, 16 MB RAM, 2 MB video RAM, MCI compatible sound card, and a multispeed CD.

DEVELOPMENT

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 (Lockheed Martin Aeromod Centers, Inc.) and an A & P school (Greenville Technology--Aircraft Maintenance Technology Program). 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.

STRUCTURE OF THE AMTT SOFTWARE

AMTT is divided into three major programs: Team Skills Instructional program, Instructor's Program and Printing Program.

Team Skills Instructional Program.

The team skills instructional program consists of the following modules: introduction, team skills, team skills overview, task simulation and the critical path method (supplemental) module.

Introduction module: The objective of the introduction module is fourfold. First, it provides the user with definitions of terms and concepts found throughout the software. Team and teamwork are both defined and described, and the types of teams normally found in the aircraft maintenance environment are illustrated. Second, the importance of teamwork and the resulting effects on performance are detailed for the user. Third, the user is introduced to the organization and layout of the tutorial. Finally, the introduction acquires demographic information about the user.

Team skills module: Team skills factors or skills dimensions have been identified and defined by a number of authors (Cannon-Bowers, et al. 1993, Glickman, et al., 1987; Nieva, et al., 1978). Gramopadhye, et al. (1995) and Kraus et al. (1996) describe the six team skills factors that are relevant specifically to the aircraft maintenance environment Training material relevant to the above skills was developed and the different skill dimensions were combined to form four separate sub-modules--Communication sub-module, Decision making sub-module, Interpersonal Relationships sub-module and Leadership sub-module. (Figure 13-1) shows a prototypical layout of the team skills module. The right side of the screen is dedicated to key points being discussed in the voice-over, while the left side of the screen provides supporting material. This supporting material comes in a variety of formats which include, but are not limited to, animations, videos, photographs, diagrams and flow charts. Buttons on the command line at the bottom of the screen can be clicked on to exit, advance, back-up, stop and replay audio, replay of video and access the navigational map. On-line help is also available and is structured similar to Microsoft Help A window is also provided which provides the user information on whichever object the mouse is residing. Each of the team skills sub-modules has a similar structure. The sub-modules start with a questionnaire wherein users ranks ten subject related questions on a seven point Likert scale. The objective of this questionnaire is to collect user's perception on specific team skills prior to training. The questionnaire is followed by a short test that is intended to measure the user's current knowledge on the subject matter. On completion of the test, the user is presented with the instructional material. The tutorial material is broken down by major topics. After each topic, a test is presented to the user before proceeding to the next topic. These embedded tests serve two purposes: first, it serves as a check to verify that the user has understood the material just presented, and second, it serves to reinforce what the user has just learned. The same questionnaire and test question asked at the beginning of the module are posed to the user at the end. This was done to measure the effect, if any, the subject material had on the users' understanding of the material and changes in user's perception related to the specific team skill.

Figure 13-1: Team Skills Module

Team skills overview module: In a short 10-15 minute slide show presentation, the team skills overview module was designed to capsulate all the general information provided in the four sub-modules of the team skills instructional module.

Task simulation module: The task simulation module was designed to allow the users to apply the skills learned in the team skills instructional module in an aircraft maintenance situation. To accomplish this, a virtual aircraft maintenance environment was created with a virtual team of seven technicians (one crew lead and six crew members). The virtual team had three consecutive tasks which required a team effort. These tasks were: testing the extension and retraction of the landing gears, jacking down the plane, and finally, towing the aircraft to another location. A narrative was provided about the crew and their efforts to complete these teamwork tasks. Problems which involved team skills arose in the normal course of work, and the user, acting as a consultant, was queried as to the correct course of action. To simulate real life, wrong answers were carried forward to a potentially disastrous end. False problems or situations were introduced to determine if the user recognized when situations were progressing within bounds. (Figure 13-2) shows a prototypical screen of the task simulation module. To assist the user in understanding the story line, photographs of the team members working together were presented on the left side of the screen. Data concerning the number of correct and incorrect decisions made by the user was stored in the database for analysis.

Figure 13-2: Task Simulation Module

Critical Path Method (supplemental) module: Teamwork often leads to making decisions concerning how to perform or improve future work. Decision making, however, does not end with achieving agreement with all the team members. Decisions must be converted into an action plan. The Critical Path Method (CPM) Supplemental Module was developed to teach the user the most common method of scheduling and analyzing a team process (Paulson, 1995). After the user is introduced to the background and capabilities of CPM, the module proceeds to instruct the user on how to construct CPM diagrams using the activity-on-node approach. Users are tasked with calculating the critical path of several networks to enhance the learning experience. CPM networks answer "what if" type of questions to help determine the impact of a decision before implementation. The impact of changes are taught with a series of "what if" exercises to help clarify the process, to practice calculating critical paths, and to demonstrate how the critical path may become altered due to minor changes in resources. The supplemental module concludes with a practical exercise in which the user observes an aircraft towing task.

Instructor's Program

The instructor's program facilitates the collection and analysis of data on each user. It consists of two main modules: the report generation module and the field study module. The report generation module allows the instructor to retrieve, analyze and print performance data for all users as they complete the various sub-modules within the team skills instructional program. The field study module was designed to enable the instructor to print the questionnaires and use them to collect field data. Data obtained can be entered and further analyzed using this module.

Printing Program

In a situation wherein computer support is lacking, it may become necessary to present the information in an alternate format. The printing program was designed specifically to provide the instructor with the resources and structure necessary to print the different screens in the team skills instructional modules and sub-modules.

FUTURE PLANS

The next phase of this project will involve testing and evaluation. The software will be tested for robustness. Recommendations forthcoming from this testing will be incorporated to enhance the software. The evaluation phase will analyze the utility of computer-based team training in the aircraft maintenance environment. A detailed experimental protocol will be developed and the evaluation will be based on an experimental design using an experimental treatment group and a control group. The above phases will be conducted in cooperation with an A & P certified school, aircraft maintenance facility and a partner airline.

CONCLUSIONS

The paper has described ongoing research and development related to the application of team training in the aircraft maintenance environment. The research demonstrates the current application of advanced multimedia technology in developing a team training software for training aviation maintenance technicians in team based skills. Subsequent phases of this research will evaluate the utility of AMTT in an operational setting. Training team skills of AMTs is critical to ensure successful team performance in the aircraft inspection/maintenance environment. In the future, as the composition of the AMT workforce changes, team training will become more critical. In such an environment, computer-based team training coupled with technical instructors will provide an effective training solution.

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