Internet-Based Training System for Preparing Professionals in Aviation Maintenance

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Abstract

This paper presents a new integrated media on-line training system designed to train aviation maintenance professionals. The rationale for this NSF sponsored project is to enable aviation maintenance instructors and learners derive maximum benefits from state-of-art computer technologies through the creation of a groundbreaking, proactive learning tool for this profession. Three modules addressing landing gear operation, turbine engine and aircraft stability comprises the aviation maintenance training on line system. We believe that this new learning system will address the needs of the aviation industry worldwide, and enable a shorter cycle time in training aircraft maintenance technicians thereby reducing overall training costs for the industry as a whole. Although our system is primarily designed to prepare professionals, it may also be used to advertise general engineering or aeronautical engineering as a career choice for middle and high school students. As more and more young people become computer literate early on in their lives, integrated media tools will be highly beneficial in attracting talented students to explore the field of aviation science and technology.

Introduction

The first author has conducted research in virtual reality and developed multi-media products for engineering and technology for over fifteen years. Selected examples of previously developed virtual reality products and their impact in enhancing the learning environment have appeared in other publications [1, 2, 3, 4]. An overview of related research and the development of related instructional software may also be accessed over the Internet at http://www.ceet.niu.edu/faculty/song. The purpose of this paper is to describe the working of a series of interactive computer-based learning modules for training and continuing education of aviation maintenance technicians. This instructional system will reduce overall costs of training while improving the efficiency and effectiveness. A striking feature of this newly developed integrated media system is its accessibility and use over the Internet. Integrated media implies the use of hypermedia and interactive multimedia as well as the presentation of lectures in a textual format [5]. The financial incentive to embark on this ambitious project was made possible through a National Science Foundation grant no. 9950088 awarded in 1999 [6].

The on-line training system for aviation maintenance is a collaborative project involving three major institutions based in the Northern Illinois region namely, Northern Illinois University, Rock Valley College and the Rockford School District. This partnership provides the technical expertise and infra-structure required to successfully design, develop and field-test what we visualize as a novel and comprehensive training system of the future. The overall goals of the project are:

- Develop three interactive multimedia simulation training modules
- Field-test the modules and conduct assessment studies
- Disseminate the program via the Internet to selected aviation maintenance programs nationwide and conduct further assessment studies.

Overview of the system

The aviation maintenance technician on line training system comprises of three interactive, integrated media, stand alone simulation modules addressing:

(a) Landing gear
(b) Turbine engine
(c) Weight and balance (stability)

An integrated media approach enables the linkage of text, sound, video, and graphics via the computer in such a manner that learners may access information in practically any random sequence on a real time basis. The developmental phases of the project are currently in progress per our original plan and upon completion the modules may be accessed via the Internet by authorized institutions involved in the training and continuing education of aviation maintenance technicians. The landing gear module will be elaborated here; the turbine engine and stability modules will be covered only very briefly.

Landing Gear Training

The landing gear module includes three specific, sequential sub-modules associated with landing gear training, (1) circuit simulation, (2) circuit trouble shooting and (3) circuit repair.

(1) Circuit simulation

The circuit simulation sub-module enables trainees to explore the power, control and warning circuits related to the landing gear mechanism operations during take-off and landing modes. The demo version may be viewed at http://www.ceet.niu.edu/faculty/song. A schematic circuit encompassing the power, control, and warning components is prominently displayed on the screen. In addition, an animated aircraft provides a visual representation of how circuit actions influence the flying machine as a whole. Industry standard symbols are employed in the schematics and the activation of actual components is communicated to the trainee through highlighting of the corresponding symbols. The operations occur on a real-time basis and the trainee can build association between changes in the circuit elements and how they influence flight. Trainees may explore the circuit during take-off, landing gear up (stowed position), landing gear down (approaching ground), and landing situations by simply clicking the control buttons present on the computer screen. These buttons also facilitate a quick replay of the animation if desired. The circuit may also be explored to visualize scenarios corresponding to starting of the engine, plane taxiing down a runway, ascending, cruising, and descending portions of the flight without particular attention to the landing gear mechanism.

(2) Circuit troubleshooting

A simulated continuity tester enables trainees to perform troubleshooting exercises on the landing gear circuit. Continuity of circuit elements or the lack of it is communicated through both audio and visual cues. Operational problems are posed as pilot reports presented through a digital video that can be viewed on the computer monitor. This feature simulates the real world scenario where pilots and technicians often communicate on a personal basis. Trainees then proceed to conduct tests on the system to isolate the cause of the problem. While they are at work, a digital clock tracks and prominently displays the amount of time spent during this process. The placement of probes (one red and one black corresponding to positive and negative terminals) at different points on the circuit is accomplished through serial clicking of a mouse button. A red display on a simulated multi-meter along with a silent audio conveys incorrect analysis or discontinuity (also work in progress); and a green signal accompanied by an audio tone implies correct isolation of cause and continuity of the circuit. Once trainees isolate the source of the problem correctly, they receive a congratulatory message and are granted access to repairing actions.

(3) Circuit repair

This sub-module allows trainees to select appropriate replacement components to correct the problems discovered during the troubleshooting phase. Although this stage is much less involved than the previous phase of diagnosis, it provides a fulfilling experience to the trainees because they are actually able to repair the circuit and have the landing gear operate per design intent. In actual practice, technicians will have to often work with expensive and hard-to-locate parts and often a choice based on judgment are essential. The virtual system simulates this situation by providing the technician with an array of part choices for replacement. As trainees proceed with their repair, part and labor costs are continuously monitored and reported on the screen. The objective of the competent trainee would of course be to fix the problem in the shortest time with a minimum number of required parts. Clearly, trainees may examine several what-if scenarios even if they were to arrive at the optimum solution very quickly. In many ways they are able to construct new knowledge and internalize several other concepts that go much beyond the original scope of the problem. Thus, users are highly likely to formulate new problems on their own and discover potential solutions to these as well. Thus, the idea of recursive education comes into play and further enhances learning and retention [3].

The Turbine Engine Module

This module simulates a Pratt and Whitney PT-6 turboprop engine installed on a Beechcraft King Air 65-90. The engine features complete manual starting, therefore students must follow a rigid algorithm to complete a normal start. This module enables trainees to understand the importance of following a checklist of procedures for correct starting while also maintaining a close watch on the instrumentation panels to successfully start the engine and avoid damage. While this simulation is in progress, three distinct areas may be recognized on the computer screen and they are (1) checklists of starting procedure, (2) engine controls and instrumentation and (3) feedback window. Students who have practiced simulation training will find it easier to start an actual engine and complete the task much quicker because of prior knowledge of the procedure.

An important emphasis in this module is the use of real world sounds to convey proper operation or malfunction. Actual sounds made by a master relay, fuel valve, boost pump, and starter were digitized to recreate the simulation, and sound cues follow actions such as switch activation, or turning the starter on or off. Yet another feature involves the incorporation of random branching into the circuitry which enables the creation of new scenarios during different starts until all possible options of the simulation are exhausted. When fully complete the system will simulate a normal start, a hung start due to incorrect positioning of the prop lever, and no start due to an improperly configured fuel valve or boost pump. Potentially possible situations of no oil pressure, low fuel pressure, high exhaust gases temperature, and high idling RPM will also be featured.

Weight and Balance Module

This module addresses the important issue of aircraft stability. The influence of distribution of weights, mainly equipment, passengers and effects is simulated in this module. Trainees are exposed to the physical and mathematical concepts that are involved in estimating weights and computing the center of gravity of the aircraft. An A-10 military ground attack plane and a Canadair Challenger commercial jet are both featured in the weight and balance computations; students can readily see how the fundamental principles apply equally well to airplanes that are significantly different in terms of design and intended function. By pointing and clicking a mouse button, the trainee may vary the seating arrangements of passengers and luggage, and the corresponding center of gravity calculations are completed on a real time basis. The simulation will also enable students to reevaluate the center of gravity following a major equipment replacement, or after the introduction and removal of ballast weights. An evaluation of the effects of extreme loading conditions on stability with particular emphasis on the fore and aft distributions will also be enabled.

Advantages of the Training System

The idea of an integrated media system for on-line training of aviation maintenance technicians is novel in several ways. To date, there is no similar product being marketed, either commercial or non-commercial. Several distinctive competencies of the learning modules make it particularly attractive for training the new aviation technician and also providing continuing education to qualified aviation technicians in today's rapidly changing technological society.

It is a common misconception that virtual reality is the poor person's approach to experience actual reality. Contrary to this belief, VR can sometimes provide much more than actual reality albeit in a more cost-effective manner. An example from our landing gear system module would best illustrate this point. In actual reality, a trainee pilot learning how to land an aircraft safely can manipulate the controls from the cockpit but the trainee will be unable to see the physical effect of her/his actions, such as the landing gear mechanism becoming active, and the wheels spinning into position. In order to witness the latter, the trainee should be willing to give up the controls. Using our virtual reality based landing gear circuit simulation model, a pilot trainee can simultaneously operate the controls, view the effects of his/her actions on the physical elements of the operating circuit, and the corresponding actions taken by the actual working mechanism. This is one of several potential cases where our learning system can provide a much more comprehensive learning experience than actual reality.

The environment promotes "enhanced reality" by facilitating learner interaction and manipulation. Trainees can examine what-if situations on a real time basis, that is, they can perform diagnosis on faulty circuits, implement remedial measures and then see the effects of their actions instantly on screen. Clearly, trainees may examine several what-if scenarios even if they were to arrive at the optimum solution very quickly. In many ways they are able to construct new knowledge and internalize several other concepts that go much beyond the original scope of the problem. Students and trainees are highly likely to formulate new problems on their own and discover potential solutions to these as well. This is the idea of recursive education at play, where learners themselves become teachers as they continue to be engaged with the process, and this eventually enhances the quality of learning and retention [3]. Realism is embedded in the system through high quality sound and imaging techniques used in the production process.

Instructional systems based on VR have the ability to romance, excite and create a sense of awe among learners [3]. As Reid & Sykes observed, traditional instructional methods usually provide for passive learning; on the contrary, properly designed VR instruction fosters active learning [7]. The simulation of an active learning environment continues to be the most fundamental criterion in the development of our instructional regimen. The digital culture that is pervading our society has given birth to the third knowledge revolution or otherwise known as the age of transactional learning. Besides closing the divide between two groups of people historically famous as instructors and students, consider what Carl Raschke said of transactional learning, "In the short haul, the revolution at our door is about computers, browsers, connectivity with telecom systems, Web sites, Internet relay chat, and learning with laptops instead of textbooks. In the long haul, it is about the dissolution of structures and the true freedom of the mind, a freedom that was impossible in the age of education." (p.17) [8]

Traditional method of learning depends on person-to-person communication, that is, instructor-learner and less often learner-instructor. Due to the inherent nature of this process, there is substantial room for distraction on the part of either the learner or the instructor due to personality issues. By depicting neutral, pure, and professional video images or cartoon characters in VR media ("abstract reality"), this system minimizes or even eliminates potential distractions that impede learning. Abstraction, as defined in the *American Heritage Dictionary* implies consideration without reference to specific examples or objects [4].

The concept of personification again according to the *American Heritage Dictionary* is a person or thing typifying a certain quality or idea; an embodiment or exemplification; and the artistic representation of an abstract quality or idea as a person. An example of personification in the AMTOL system is a relay communicating with a pump or electric motor as if it were a human being. The specific advantages as applied to learning are that trainees are likely to find things easier to understand and remember what they saw and heard more intensely when compared to legacy methods of teaching [4].

Research has shown that VR can be an effective method of learning even for children at grade four levels, yet it is imperative that all systems it embraces be user friendly. Learners are more likely to enjoy the experience and immerse themselves in a lesson if the user interface is intuitive and easy to navigate [9]. One definite advantage of the virtual medium is the absence of safety issues that may involve potential fluid leaks, explosions or toxic emissions [3]. Safety concerns will no doubt be important in future real operations; however VR spares the trainees and instructors from having to learn all aspects of safety before actually experiencing some of the technical intricacies. This feature is also important in the case of a recruiter looking for a medium that can provide for visual communication and experiential methods to attract talented middle and high school students to aviation maintenance or aeronautical engineering.

Like flexible manufacturing systems in the later part of the twentieth century, flexible learning systems will be required to accommodate the rapid changes that are poised to rule modern technology in the 21st century[10]. With on line training, instructors and trainees are no longer required to be present at the same place at the same time. Trainees can have access to this learning tool anytime and at any place that can accommodate a personal computer. Also, each student can potentially plan on learning when they are best ready.

This on-line system makes use of the concept of adaptive testing [3]. The system makes a judgement of the users ability level based on prior response (in terms of correctness and the amount of time taken) and adjusts the level of difficulty while posing the next problem. Flexibility is also implied in that a skilled student may be able to analyze a specific faulty circuit in a few iterations and a novice might take many more attempts to be successful. Another feature that lends itself to flexibility is the ease with which the integrated media can be redesigned to accommodate changes in aviation maintenance technology. Using on-line training would provide instructors the incentive to stay current with technology and this would eventually benefit the trainees because unlike the case with the traditional model, students will not have to endure outdated information until instructors become familiar with the technological changes.

With the on-line training system, the only capital resource required is the computer and access to the Internet; students and instructors can enjoy the luxury of being able to recreate parts of or the entire simulation, examine and solve a problem from different angles, and engage in creative experimentation. All this can be accomplished with virtually no operational costs. Often when operating expensive equipment or handling costly tooling or instruments, students and instructors tend to be overcautious because of fear of damage and this can negatively impact learning. Virtual reality tools do not pose this barrier and so users are psychologically more poised to approach learning with a spirit of adventure. Yet another potential long term cost benefit is associated with changes that constantly occur in aircraft design and hence aviation maintenance. It will be relatively easier, faster and less expensive to update an on-line training system for all intended audience as opposed to training several hundred instructors using traditional methods and expect them to subsequently pass this on to their trainees.

Concluding Remarks

Virtual universities and classrooms are growing in numbers all over the world. These are also times when progressive employers are providing their affiliates with personal computers for e-learning. It is a fact that electronic and computer-based technologies have increased the possibilities for learning, rendered the concept of learn anywhere, anytime practical and also radically changed the methods that were once traditional among trainers and managers as applied to continuing education [11].

Our aviation maintenance technician training on-line system is a carefully planned instructional package intended to delight both trainers and students. Much emphasis has been placed on designing a virtual reality based system that simulates real world scenarios to the maximum extent possible. As our modules are based on the premise that people learn by doing (active learning), retention rates exceeding 90% are realistic [12]. The product development team has researched proven learning theories, considered available technologies, and analyzed future trends in education and training in conceptualizing and developing the on-line training system.

Although our on line training system can not totally replace on the job training for aviation maintenance technicians, it can eliminate the need for several phases of conventional training. The use of Internet training will significantly reduce the amount of time required in actual on the job training thus greatly reducing costs. By design and conception, our virtual reality modules provide a much more comprehensive learning system, thus paving the way for more effective training. Future systematic investigations from field studies are expected to confirm the influence and effectiveness of our instructional regimen.

A significant part of product development is complete at this time. However, some work is still in progress. The landing gear training modules may be currently accessed via the Internet at http://www.ceet.niu.edu/faculty/song. At this point, the first author entertains proposals from interested educators who wish to volunteer to field test our training system at their institutions. Compensation is available for selected educators. Interested parties should contact Dr. Song via e-mail at song@ceet.niu.edu or by calling him at (815)-753-1345.

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