Interactive Web-Based Training System at Tinker AFB: Environmental Engineering, and C-135 Aircraft Maintenance Instruction

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Abstract

This paper describes the incorporation of three-dimensional components with other media elements in the interactive web-based training projects for both military and civilian personnel at Tinker Air Force Base. The projects include training material for both Environmental Engineering and C-135 Aircraft Maintenance Instruction. This learning system incorporates web-based technology including the ability to track and monitor the user. Statistical data on the user’s progress such as the actual time spent, and number of times visited on any assigned topic is collected for administrative purposes of the sponsoring organization. A significant advantage of using the web is the availability of a wide range of media that can be implemented effectively for presentation. Information delivery is done by integrating a variety of multimedia components such as videos, animations, sounds and simulations with the standard text and graphics. The opportunity for the user to explore and learn effectively through an investigative process is provided using these technologies.

The purpose of the Environmental Engineering project is to train and guide the Air Force Base personnel, including both technicians and engineers, to comply with the standard requirements of various NESHAP (National Emission Standard for Hazardous Air Pollutants) and environmental regulations. The project is categorized into modules, where each module is dedicated to a regulation applied at Tinker AFB. Each module consists of several individual lessons, and then each lesson is further subdivided into objectives, which is the basic learning block. At the end of an objective there are activities designed to evaluate the user’s understanding the material.

The C-135 Aircraft Maintenance Instruction project gives detail instructions on the correct maintenance procedures for the pressurization on the KC-135 series aircraft. The project also has a similar learning system structure to that of Environmental Engineering. The main difference is that each module represents the main technical maintenance tasks required for the KC-135. An unique feature of this project is the incorporation of three-dimensional visualization in the learning environment. Three-dimensional animations and simulations are developed to depict the actual situation of the maintenance procedure.
1. Introduction

Society has seen rapid industrial growth due in part to the technology advancements in the past decade. Companies are re-structuring the labor force to retain specific skills that will be an advantage for future development. This budget conscious economy, governed by a volatile and dynamic market, has forced organizations to focus more on efficient training methods. Industries that adopt strategies to train their personnel just in time to have a competitive edge are in this Internet driven economy (Le Beau, 2000). One of the strategies adopted is to improve staff competency.

Staff competency is the building block of a successful organization (Latino, 1999). Development of technical skills and knowledge is a basic requirement for “corporate survival.” There are several critical issues that need to be considered when planning the implementation of a training program so that the organization benefits both on a long-term and short-term basis. The factors affecting the development of training strategies depend on organizational objectives that range from compliance and productivity improvement to executive training for keeping up with the latest technologies and procedures. Although traditional training is designed to provide a strategic advantage, the ability of the worker to cope up with speed is a major problem that needs to be resolved.

Learning and working are two very conflicting activities. Humans’ stereotypical working behavior is a major factor in employee resistance to change and learning. However, when training is available at the employee’s own pace with no constraints in material and time, training becomes more effective because he/she will have the flexibility and privacy to experiment and learn without any embarrassment associated with traditional classroom learning.

In order to be cost effective, organizations have shifted their focus towards non-traditional methods, such as web-based training, to provide user-oriented systems that cope with the demands of just-in-time training (Imparato, 2000). Current trends in training integrate technologies to provide participant a constructive, virtual environment for intensive training (Stokes, 2001).

The concept of web-based training is being widely adopted both in profit and non-profit organizations. Tinker Air Force Base, a non-profit governmental agency has also adopted this method of training, to increase the proficiency of its personnel in complying with environmental engineering regulations, and improving the efficiency to perform various aircraft maintenance operations. The high security and confidentiality of information has forced Tinker to locate training within the base. In order to resolve the high security issue, Internet is used as a tool to deliver the training. By using the Internet as the delivery medium the impact of secondary components such as convenient scheduling, active participation, attendance, participation, and time, that affect the organization of training sessions are also minimized.

This paper describes the development of an interactive web-based training system incorporating the capabilities of different Internet technologies to provide a cohesive, independent and self-contained environment that can aid in learning for both military and civilian personnel at Tinker.
Air Force Base. This system includes training material for environmental engineering and aircraft maintenance instruction.

The purpose of the Environmental Engineering project is to train and guide the Air Force Base personnel to comply with the standard requirements of various NESHAP (National Emission Standard for Hazardous Air Pollutants) and environmental regulations. Understanding and complying with NESHAP is fundamental for any person that performs duties on any air base in the US. The C-135 Aircraft Maintenance Instruction project gives detailed instructions on the correct maintenance procedures for the pressurization on the KC-135 series aircraft.

Engineering knowledge and technical skill are necessary for project compliance and routine activities. The specific need to train personnel to comply with regulations placed this project at center stage at Tinker AFB. Training can be used to improve efficiency and attain specific technical skills. This training is focused in guiding both engineers and technicians to become more proficient, and attain the objectives of their projects by complying with the technical aspects.

The learning system developed and implemented for Tinker AFB by the authors, uses various web-based technologies to provide a platform for training. One advantage of using the Internet is the capability to track and monitor users from remote locations within and outside the base. Statistical information on the user’s progress, such as actual time spent and number of times visited on any assigned topic, are monitored and recorded in an online database. The information tracked is used for two purposes. First, it is used to assist the students to learn better by making their own assessments. Second, it is made available to administrators and supervisors for review and evaluation. An additional advantage of tracking such information is that it provides data regarding the usability of the system over a period of time.

In order to understand the details about designing this learning system intensely, a brief overview of the various topics involved in NESHAP and C-135 is given. As the training system is categorized into modules, the structure of the learning system is explained. Next the website organization, functional operation of the lessons, information tracking and the built in administrative capabilities are discussed.

In continuity with the learning system design, the technology aspects of the actual learning environment are described. This includes the explanation of the integration techniques used to incorporate the media components in the environment. Then design tools and web delivery technologies are described. This section discusses which applications are used in the development, and explains the benefit to developers in using them. In the last section, an assessment of the effectiveness of the training system is presented to support the usefulness of this training project. Finally, the conclusion section provides a summary of the web-based training systems.
2. Topics Covered in the Training Lessons

The learning system includes a variety of training material for both environmental engineering and aircraft maintenance instruction. They are divided into topics refer to each main material covered in order to increase the learning progress of the user.

There are several NESHAP requirements and environmental regulations involved in the Environmental Engineering training. To support these requirements and regulations extensively, this project is categorized into modules, where each module is devoted to a regulation applied at Tinker AFB. There are six regulations covered. The Tinker AFB Aerospace NESHAP module provides an overview of Aerospace NESHAP along with maintenance, responsibility for compliance, cleaning operations, and painting procedures. The Tinker AFB Introduction to the Clean Air Act module provides an introduction to the act including results of air pollution, direct outcomes of air pollution, and how we can limit air pollution. The Tinker AFB Halogenated Solvent NESHAP provides an introduction to Halogenated Solvent NESHAP along with operations, maintenance requirements, and responsibility for compliance. The Tinker AFB Chrome Electroplating NESHAP module provides an introduction to Chrome Electroplating NESHAP including maintenance, operations requirements, and responsibility for compliance. The Pollution Prevention module provides an introduction to the pollution prevention process, and focuses on compliance through pollution prevention. The Solid Waste Management module provides introduction to and overview of Solid Waste Management including discussions about existing program and potential improvements, applicable rules and regulations.

Inside the C-135 Aircraft Maintenance Instruction project, there are a number of maintenance procedures for the pressurization of the C-135 series aircraft. The project is categorized into modules to support this various procedures, where each module is devoted to each individual procedure required for maintaining the pressurization. There are four procedures covered. The Cabin Pressure Control System Familiarization module provides information about component description, system operations, and test equipment required. The Fuselage Pressure Testing module covers three required steps for proof test including preparations, procedures, and post procedures. The Cabin Pressurization module describes operational checkout preparations, precautions, and procedures. The Cabin Pressure Control System Malfunction Analysis module discusses about analysis procedures for cabin pressure control system malfunction.

3. Learning System Structure

In order to manage and organize the materials efficiently, a modular and hierarchical structure is incorporated in designing the learning system. The structure is designed in close relationship to that of an academic curriculum. Each level can be compared relatively to a traditional education system. Four levels are maintained to hierarchically structure the contents. The breakdown structure is organized into modules, lessons, objectives, and frames as illustrated in Figure 3.1.

Each project is categorized into modules, where each module is dedicated to only one topic. Each module consists of several individual lessons, and then each lesson is subdivided into objectives, which is the basic learning block.
Figure 3.1: Organization of modules, lessons and objectives

The contents in the objective are displayed in separate frames. Each frame includes at least two media components. Though each frame displayed specific content, they are made self-contained in a single environment for an objective. This allows the user to learn the material in pieces and then move on to the next concept. Furthermore, if the user stops at a given frame, it is best to have the user start back at the beginning of that objective so that the concept in that objective can be reviewed at one time.

4. Web Site Organization

In order to evaluate the effectiveness of this training system via the Internet, http://tinker.ou.edu hosted at the University of Oklahoma is dedicated as the delivery website. Each project can be accessed by selecting one of the topic areas provided. Currently there are two topic areas; the first is Environmental Engineering area, and the second is the C-135 Aircraft Maintenance Instruction area. The system is made flexible to support expandability to add additional topics without difficulty. In order to restrict distribution material and protect confidentiality of information, a secure system with a login is implemented. Tinker can activate a “guest” account if they wish to allow others access to the material.

The login procedure is the primary permission-checking tool to access and enter the system. An active user has to enter their username and password that is set up by the administrator. This
identification allows the system to track and record the progress of each user. The guest account is not included in any report for Tinker personnel. The system administrator has the ability to turn off the guest account option and lock out the system from the general public.

Once the user enters the system successfully, checks are done with the database to confirm the identity of the user, to determine their privileges and identify what lessons need to be completed. Not all lessons are open to all users. This allows Tinker to selectively target employees for specific training. Next, the installation status of browser plug-ins is automatically checked and the user is given a status report if any additional plug-ins are required. The system uses QuickTime and Shockwave (Director and Flash) media that require browser plug-ins before viewing the lessons.

In order to access a lesson, the navigation level inside the system is divided into various levels to match the organization of the modules (Figure 3.1). This process is designed to aid in information and content presentation, and guides the user through the system conveniently and productively. The various stages in navigation are discussed briefly in the following paragraphs.

The first navigation level is the personalized page that appears after login. There are two menus provided at this level as shown in Figure 4.1a. The options in the top menu vary based on the type of user and are discussed in detail later. The menu on the left provides option for the user to navigate between modules by pulling down the dropdown menu. The individual lessons are inside the modules as shown in Figure 4.1b.

Figure 4.1a and 4.1b: Main page and Lesson selection page

The order of the lessons depends on the type of user and is controlled by the system administrator. Only those lessons assigned to the user are displayed and added to the left menu. The lesson numbers also are different between user groups due to the variation in content.

After a lesson is clicked, a list of objectives in that lesson is displayed in the middle of the page as shown in Figure 4.2. The left menu bar is still available to choose another lesson if needed.
The check marks next to the objectives indicate if the objective has been viewed and completed. Any completed objective can be reviewed but new objectives must be taken in order. The Start button takes the user to the start of the first objective that has not been completed. If it is the first time in a given lesson, the Start button will begin at the first objective. This mechanism is implemented so that users are forced to go through the material in a linear process. All objectives must be done in order, but completed objectives can be reviewed in any order.

The actual delivery of lesson content is done in a new browser window that is opened when the Start button is clicked. The new window has all browser functions turned off so that the user can only use the buttons provided inside the lesson frame to navigate. This allows the system to monitor where the user is at and what is being completed. The main browser window is still active for the user to access help, profile, progress, reference, and terminology sections. An example of a new lesson window is shown in Figure 4.3.

At anytime inside the main browser on the top menu option, support features to check progress, modify profile, acquire help, and view terminologies used are provided for all the users by popping up on a separate browser window as shown in the Figure 4.4. At this stage, for users with administrative capabilities an additional link is provided on the top menu of the interface to access the management features.
5. Lesson Operation

The primary focus of this learning system is to educate and make the user understand their responsibilities. To assist in this goal, it is important that the actual lesson navigation is simple. The level of control must also provide the option for the user to review present content or any completed topic while in a given objective.

To focus the user’s attention on the learning material, a simple navigation system that can provide the required level of control is implemented. Three main functional navigation buttons are provided for the user to control the operation of the lesson. They are the forward, repeat and backward buttons. The navigation is located on the bottom right corner inside each lesson screen so that they do not interface with the presentation material. So that the user must view the contents inside each objective at least once before proceeding to the next concept, the forward navigation is made dependent on the sound that explains the concepts in the frame. Users wait until the sound is completed before the forward button is activated. This attribute restricts the user to quickly move through the lesson without listening and viewing the content. An example of lesson frame, which also illustrates the basic user controls, is shown in Figure 5.1.

In addition to the forward button, there is a back and repeat button. The repeat button is located in the middle of those forward and backward buttons because its functionality lies between the
other two features. The repeat button is incorporated to provide the user with the option to review the material inside that particular frame again before proceeding. There are additional controls for administrators and it will be discussed more in section 7.

To evaluate and provide feedback to the user and administrator, most objectives have two questions or activities at the end that require action by the user. An example of a question frame is shown in Figure 5.2a. The questions cover the basic concepts that the user should have learned throughout that particular objective. After an answer has been submitted, the system presents feedback to the user that suggests what is correct if the wrong answer was chosen or gives a congratulation message with a summary statement. Figure 5.2b shows an example of feedback screen.

![Figure 5.2a and 5.2b: Typical evaluation question and question feedback frames](image)

Besides the typical question, there are various simulation activities throughout the lessons. These activities require the user to participate by doing something, such as matching statements, solving puzzles, etc. An example activity is shown in Figure 5.3.

![Figure 5.3: Example of activity (Tic-Tac-Toe)](image)

At the end of the lesson, the last screen will congratulate the user for completing the lesson and also report how many questions or activities were completed successfully throughout the lesson. The own user’s progress can be viewed at any time by the progress link at the top menu bar in
the main browser window. This feature will give all results for all lessons and all objectives assigned. Figure 4.4 shows an example of this user’s progress screen.

6. Server-side Database and User Tracking

To support the administrative section, all relevant user information is tracked and recorded in a database. The data tracking is done only at the completion of each objective and sent to the database. By only accessing the online database at the end of each objective, the frequency of interaction with the server is minimized. This results in a more responsive system when there are a large number of users. The information tracking provides the feature for the user to leave at any point and return exactly to the next incomplete objective.

Another functional use of the database is to regulate administrative privileges depending on the level of the user. The user is classified into three levels: administrator, manager, and basic user. Managers are given partial administrative capabilities to supervise small user groups. The difference between administrators and managers are, administrators have full control of the entire website, while managers only control a group of users.

7. Administrative System

A web-based administrative system is integrated to allow administrators to monitor users and supervise the overall system through a web-based interface. This system facilitates only administrative user account to access, add, modify, delete, edit user information, set up user groups, manage lessons, and report user progress.

Administrative functions are separated from the main training system and are accessed through a special link in the top menu bar that only appears for administrator and manager accounts. Inside this administrator page (Figure 7.1), the left menu bar of the administrative page provides links to modify profile information, system preferences, manage group, manage department, user progress and guest user access information. Each individual feature is discussed in detail briefly as follows.

Figure 7.1: Administrator main page
The Profile is similar to the one available for basic users where personal information is displayed. Additional capability to modify personal information and system settings is provided for administrator. The Preferences is a listing of features that the administrator can use to change system attributes. It can be used to activate or deactivate preferences such as email notification of lesson completion, and Guest account access at any time. The User Progress is incorporated to provide administrative type of users with the option of previewing the performance based on individual users, groups, and departments. The progress information can be organized to support the administrator in analyzing and evaluating the progress in a multi-faceted way.

The Manage Group section allows the lesson assignment for the different groups of users accessing the system. A group can be set up in numerous ways as the requirements vary based on the working background such as wiper, painter, etc. Each individual user can also be assigned additional lessons if needed. The Manage Department provides managerial users with the options to add, delete, and edit manager accounts. A manager account is like a basic user, except the manager can add, delete, and edit user into his/her department. Each department has only one group attached to it so that the lessons can be defined. The Manage User supports in registering new users in the system by entering basic information create an identity. This information allows user to be assigned by identifying them with a group and department. The Manage Guest is designed to provide the administrators with the option to decide what lesson content can be accessible to unauthorized guest users entering the system. This feature is the same as Manage User, except it only applies to the guest accounts and this type of account does not appear on any progress report and would not interfere with Tinker user account type.

8. Technology Aspects of the Lessons

A significant advantage of using the web is the availability of a wide range of media that can be used effectively for presentation. Information delivery is done by integrating a variety of multimedia components such as videos, animations, sounds, and simulations with the standard text and graphics. These electronic media types are combined to match nicely with many of the aspects of technical training. The opportunity for the user to explore and learn effectively through an investigative process is provided using these technologies.

As technical and engineering training required a high level of interactivity, a double stage container system is used in delivering the information. The first level container is the Internet browser. The browser is used because of its ability to interface the client within the World Wide Web with a simple connection.

The main difficulty with any web-based delivery is the creation of content material with a simple navigation system with a small file size. In order to maximize the benefits of electronic media a secondary container, Shockwave, was used. The technology and techniques discussed in this section explain how the media was actually implemented in the lessons.

Text is used to provide brief instruction or summaries of concepts in a frame, so that the user is not over loaded and tired with too much content. An instructional tone, emphasizing information is used to keep the user’s attention.
Graphics are used in the system to enhance the learning experience through visual motivation, which is very helpful to show technical aspects and complex concepts of the training. Animation is used to introduce the topic and explain basic principles that are relevant to the user. Animation is used to take advantage and focus the user’s attention to support a stimulated learning process. Animation is used to stage story-like presentations, show processes, and also explain complicated concepts that need to be represented over a period of time. Figure 8.1a is the example of animation.

Simulation is used periodically to bring life to many of the basic concepts, and illustrate technical aspects by providing the user hands-on-training through an interactive exploration process along with the presentation material. Simple user-friendly games such as matching, Tic-tac-toe, Jeopardy, and engineering-based simulations are created to keep the user active, excited, and interested in the learning process. These activities are monitored to provide feedback in the learning process. Figure 8.1b shows the example of simulation.

![Figure 8.1a and 8.1b: Examples of animation and simulation](image)

Sound is important to enhance the learning opportunities to the learner. Sound is used in the system for two purposes; first as a narration, and then to give feedback to a user’s response in simulations. Sound narration is used in every frame to underline ideas and concepts presented as text or graphics. The sound summarizes and explains the textual content in the frame.

Video is used to illustrate examples from the actual working environment to give a practical approach towards training. Figure 8.3 shows the example of this technology.
Figure 8.3: Incorporation of Video Element

*Three-Dimensional Visualization* is used to help users better understand C-135 aircraft maintenance and instruction. This allows the developing a wide spectrum of three-dimensional productions, ranging from simple text handling to interactive product demonstrations to complete complex game environments, which include animation and simulation. Figures 8.4a and 8.4b show the example of three-dimensional animation and simulation respectively.

![Figure 8.3: Incorporation of Video Element](image)

**Figures 8.4a and 8.4b:** Example of three-dimensional animation and simulation

9. Design Tools and Web Delivery

There is a wide range of authoring tools used to develop this project. This section discusses those various main design tools used to create the entire web based training system. The reasons and benefits of selecting and using these application tools are explained.

The container of this project used to deliver the training content is developed through *Macromedia Director*. Director is chosen because of its programming, authoring, streaming and compression capabilities. Director also supports the programming capability called as *Lingo* scripting language. Another advantage using latest version of Director is the capabilities to support three-dimensional graphics. This allows delivery of high-performance three-dimensional visualization to the Internet world. The three-dimensional objects can be created and controlled using Lingo without any additional computer language or program required.
A vector-based animation tool, which is used to develop high quality animations, and compress the high-resolution photographs and clip-art images, is developed using Macromedia Flash. The compatibility of Shockwave player to run Flash Shockwave files, and the wide availability of Flash Shockwave player plug-ins greatly influenced in selection of Flash as the animation tool.

Video compression is completed through Media Cleaner to develop streaming video elements in the system. Media Cleaner is used because of various compression and streaming technologies available help in experimenting with different methods quickly.

To develop graphics and optimize the high-resolution photographs, Adobe Photoshop is used. This pixel-based environment is chosen because of the ability to edit high-resolution images easily. As a large number of audio files needed to be manipulated efficiently, Sound Forge is used because of its ability to simply cut, copy, and paste sound based on the requirements made the dividing of the main source files for each frame an easy process.

The database system is managed using Microsoft SQL Server, which suits well for web-server-based database with its simple-to-use interface. SQL Server is designed to serve as the database system for Windows 2000, which is the operating system for this training system. SQL Server database is the ultimate solution for the system to provide for the great number of users. SQL Server has a capability to support the great volume of concurrently connected users in data processing effectively.

10. Assessment

In order to assess the effectiveness of the system, the progress of the project has been reported and presented on a frequent basis to comply with the requirements of the Tinker. Reviews, comments, feedback and suggestions from Tinker on any related features such as the lesson contents, system operation, system features, and organization are done after each module is developed. This process assists in developing the system to conform as per requirements specified by Tinker.

In the Spring of 2002, after Tinker AFB takes delivery of the system, there will be test conducted on actual users to evaluate the learning effectiveness. The results of these tests will be presented at the ASEE conference in June, 2002.

Currently this system is hosted at the University of Oklahoma. The complete system will be hosted inside the base for only air force personnel. The option to allow the outside world to access is left to Tinker consideration. The change of location of the learning system can be done easily by shifting the current server physically to the base. By changing the host name, IP address for the server, and connecting a database to the system completes the installation process of the web-based training system.

11. Conclusion

The web-based training systems for Environmental Engineering and C-135 Aircraft Maintenance Instruction were developed for Tinker Air Force base to support a participative intensive
learning. The objective for the Environmental Engineering modules is to train and guide the Air Force Base personnel to comply with the standard requirements of various NESHAP (National Emission Standard for Hazardous Air Pollutants) and environmental regulations. Meanwhile, the objective for C-135 Aircraft Maintenance Instruction is to train and guide the Air Force Base personnel to perform the required procedures in maintaining the pressurization on the C-135 series aircraft correctly. The major difference between these two systems is the lesson content. The aircraft maintenance training incorporates three-dimensional visualization features. A web compatible database was designed and integrated into the training system to support online information tracking and management. A hierarchical organization structure was designed to ease the system management.

The system is comprised of three main segments, the lessons, the administrative system, and the database. The course content is separated into six modules or topics. The modules are then subdivided into lessons that contain objectives, which focus on specific training material. Each lesson has text, graphics, video, animations, simulations, and sound integrated to deliver the course content. At the end of each objective, the user is requested to answer questions related to the material reviewed, the results are recorded in the database.

The delivery of the lessons and tracking of the user progress are controlled using a database. All information is stored within the database and is critical to the delivery of the lessons. The database is maintained and edited through the administrative web pages. An administrative section allows administrators and managers to set up user accounts, manage the lessons, create user groups, and report on user progress. All administrative programs are web-server based and can be operated through any web browser.

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