12.0 REDUCING FAR ERRORS THROUGH STAR

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INTRODUCTION

Federal Aviation Regulations (FARs) are legal documents written precisely to define the regulations pertaining to aviation. Below is an example of a typical paragraph found within the FARs.

> "(a) A certificated mechanic may perform or supervise the maintenance, preventive maintenance or alteration of an aircraft or appliance, or a part thereof, for which he is rated (but excluding major repairs to, and major alterations of, propellers, and any repair to, or alteration of, instruments), and may perform additional duties in accordance with § 65.85, 65.87, and 65.95. However, he may not supervise the maintenance, preventive maintenance, or alteration of, or approve and return to service, any aircraft or appliance, or part thereof, for which he is rated unless he has satisfactorily performed the work concerned at an earlier date....."[1]

Given this type of legal writing it is not easy for most people to extract the intent of a regulation. In addition, information relevant to a task is often distributed across many parts of the FARs. Because of this extensive cross referencing between FAR sections, it is not always obvious where one needs to look to get a complete sense of a regulation. Errors resulting from non-compliance with the regulations are due to personnel not understanding the functional purpose of the FARs nor the role they play in ensuring compliance with these regulations. In short, personnel lack the "big picture" of how the FARs govern the daily operations of aviation maintenance.

STAR is designed to help aviation personnel acquire the big picture. This is accomplished by incorporating multimedia-rich presentations and storytelling techniques within several different learning environments. Two versions of the STAR program are described in this paper. The first version, called STAR-AMT, is designed to be an instructional companion to the FAA's course on Aviation Maintenance Regulations for Aviation Maintenance Technicians (AMT). The second version, called STAR-ASI, is designed as an on-the-job training aid for Aviation Safety Inspectors (ASI). A description of how these multimedia-rich presentations and storytelling techniques have been incorporated in each of the learning environments is presented along with a summary of an evaluation of the STAR-AMT program conducted in November 1995.

STAR-AMT

Philosophy And Approach

Learning in Context

Part of the difficulty in teaching the FARs is that AMT students perceive the subject to be very dry. Indeed, some of the tasks expected of the students can be pretty tedious. However, there are many opportunities to convey the complexity and subtlety of the information in interesting ways. "War stories" from AMTs currently out in the field are one way to make the material more interesting and meaningful to the student. Stories are well suited for capturing tacit instructional knowledge, because storytelling is a more natural way for people to convey ill-specified practices.[2]

Another way to make the material more meaningful is to immerse the students in situations that confront them with "real world" decisions related to their jobs. By placing the application of the FARs in context, students have a much better chance of constructing for themselves a scheme for how the FARs operate functionally in aviation.[3] When students are given the opportunity to learn in context, the concepts are acquired more rapidly, durably and are more easily transferred to new situations.[4] Both "storytelling" and "situated learning" place the information to be learned in contexts that the student can more easily relate to and remember.

Media-Rich Presentations

Media-rich presentations are a third approach to making the subject of the FARs more interesting. Multimedia has other pedagogical advantages as well. According to Park and Hannafin, multiple, related representations improve both encoding and retrieval.5 Learning improves as the number of complementary stimuli used to represent learning content increases. For example, when concepts are encoded in both verbal and visual forms, they are retained in memory longer and are more easily accessed, because the two types of information complement each other in the activation, representation, and development of related information.6 Thus, complimentary information presented through multiple types of media is most favorable for conceptual retention.

Multiple Vantage Points to Complex Information

When teaching subtle information such as aviation regulations, there are advantages to providing students with many vantage points to the same body of information. Experiencing complex material repeatedly under different circumstances provides multiple opportunities to gain a deep understanding of the subject.7 Each vantage point not only covers different aspects of the same material, but also reinforces different kinds of study skills. In this way, students are not only provided with multiple ways of viewing the information, but also with multiple opportunities to learn. In addition, information conveyed through one learning environment may best fit one student's style of learning, while the other learning environments fit other people's learning styles. Thus more people benefit when multiple approaches to the subject are taken.

STAR-AMT offers several different categories of learning environments: overviews, scenarios, challenges, and resources. Each category contains one or more learning modules for students to explore. Overviews show students how FARs are organized, how different parts are related to each other, and who is responsible for what aspects of those regulations. Scenarios are interactive stories that place students into a true-to-life situation where the regulations are often subtle. Challenges require students to exercise certain skills they will need to develop in order to efficiently search the regulations and understand what they find. Resources are comprehension aids such as a glossary. These aids provide "as needed information" that can be explored in their own right or used in conjunction with other, more formal learning environments. Each learning environment could be a stand-alone application. Together they provide multiple vantage points for students to arrive at a deeper understanding of aviation regulations.

The Learning Environments

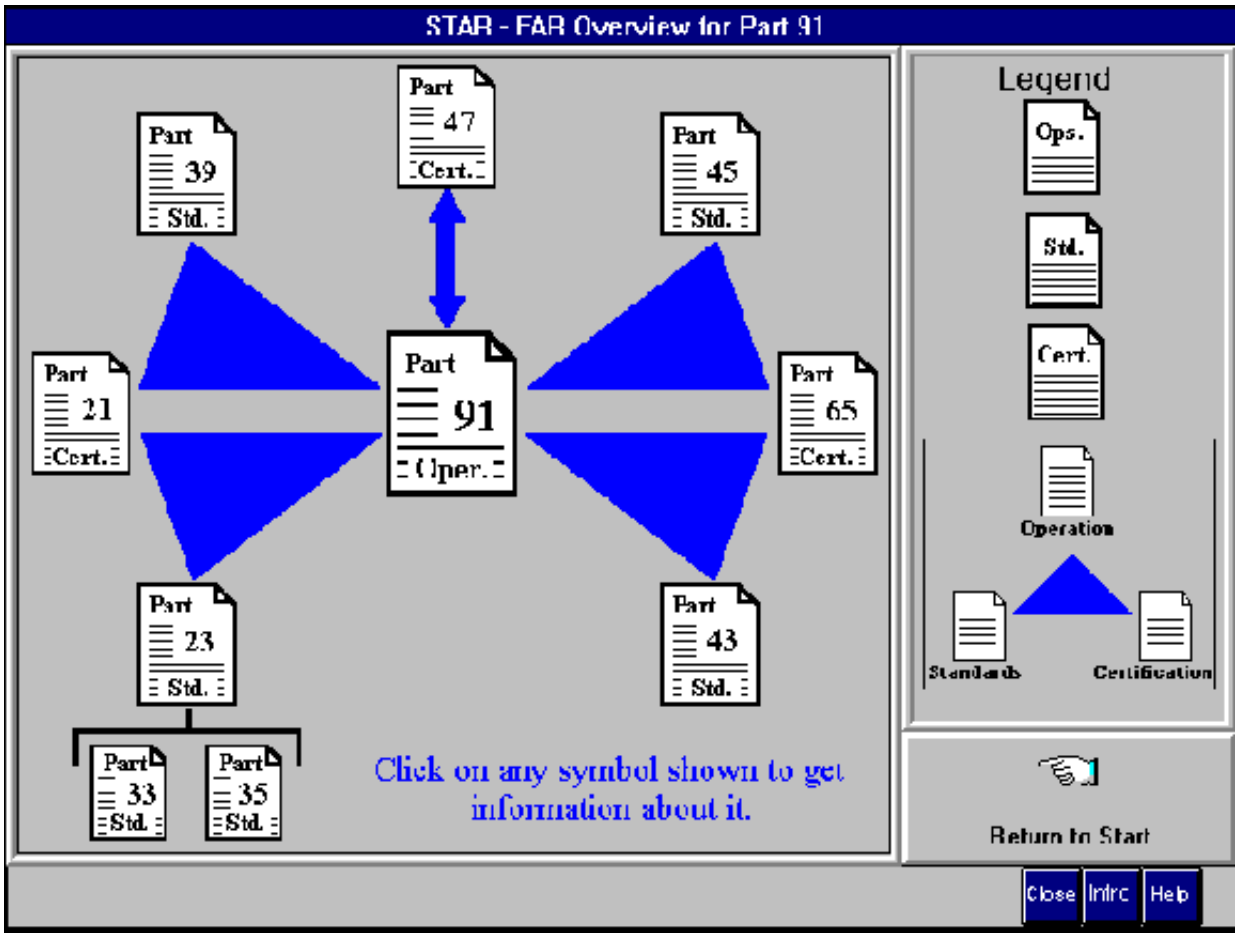

Figure 12.1 Overview

Though the users have control over their exploration of STAR-AMT, there is a logical progression for moving through the curriculum. Overviews give students the overall structure of the FARs and are best viewed first. Scenarios anchor students in real world situations,8 and Challenges are designed to provide students with a self-testing mechanism for assessing their knowledge of the material, as well as to promote the integration of material covered in the other learning environments. Resources are designed to augment and support the other training activities. Each learning environment is described below.

Overviews

Overviews are intended to show students how FARs are organized, how different parts are related to each other, and who is responsible for what aspects of those regulations (Figure 12.1). Students are presented with a graphical scheme for how the FARs most relevant to their work are related to one another. Included in this scheme is a general description of each FAR part, what type of regulation it embodies, and how these different types of regulations interact with each other. General concepts are presented first followed by a specific example. Relationships between concepts are then highlighted. Each concept is presented through an audio narration with textual complement. As each new piece of the overview is presented, it flashes to indicate to the student that this is the next relevant concept. Students may observe the sequential building of the conceptual graph or they may explore different portions of the graph independent of any order.

Scenarios

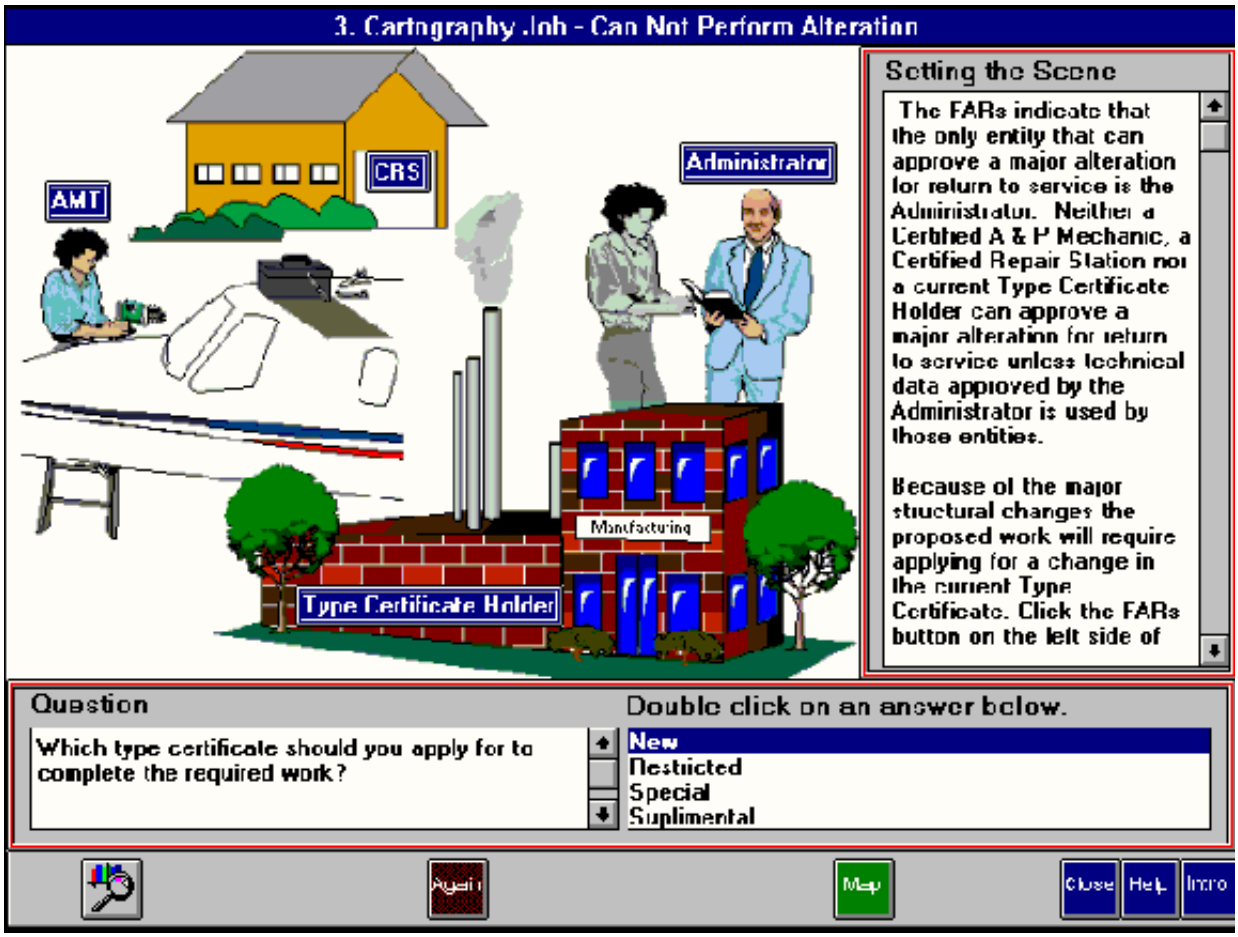

Figure 12.2 Scenario

Scenarios are essentially interactive stories (Figure 12.2). In the opening scene of each scenario, students are presented an unclear situation where several actions are possible. They are asked a question about what they should do and are presented with several actions that they could take. Each scene is portrayed through a graphic picture or photograph and the new situation is told through text and narration. The graphic picture sets the visual scene and the narration tells the story.

Once a student chooses an answer, a new scene in the scenario is presented. The new scene reveals, through commentary and animation, the consequences of the action chosen and the rationale for why the student should or should not have made that choice. Students are then asked a new question and presented with new options until they reach the end of that story line in the scenario. Students may access a map to help them orient and navigate through the scenario. As a student moves from one scene to the next, the map updates to reflect the student's progress.

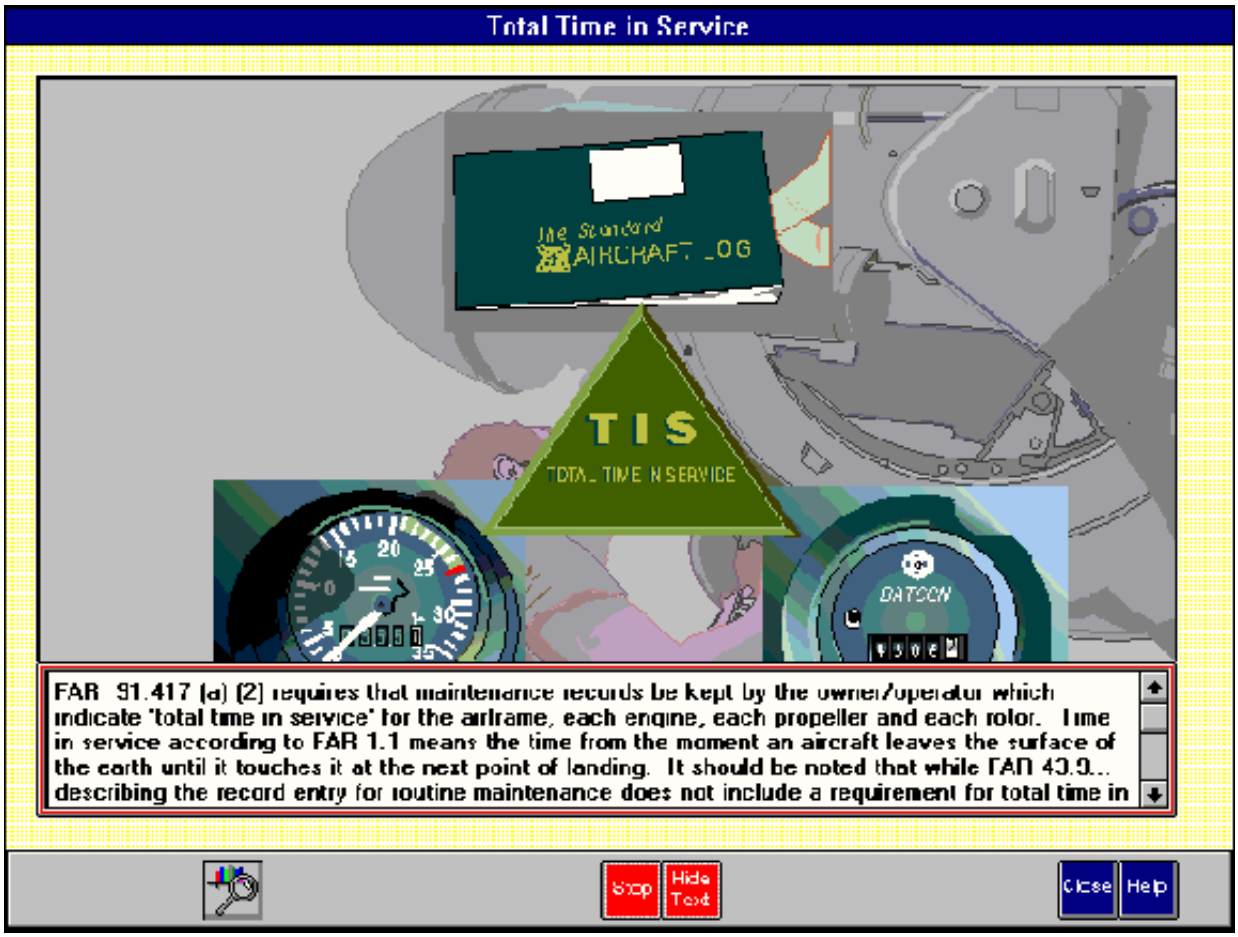

Figure 12.3 Informational Media

Associated with each individual scene is supporting informational media (Figure 12.3). This supporting media augments students' understanding of the scene by providing commentary about the FARs or background to general aviation concepts. The informational media is intended to fill in students' understanding of the current situation. Students are encouraged to explore the additional information provided within each scene. Some of the information could influence their subsequent decisions with respect to the question they are about to answer. Other information is provided to round-out their general knowledge of the subject.

Resources

Resources are comprehension aids such as a glossary. These aids provide as-needed information that can be explored in its own right or used in conjunction with other, more formal learning environments. There are three modules in the resource learning environment. The document browser is designed to provide searching and viewing documents in their entirety. It has full-text searching capabilities both within and among documents. The glossary defines and exemplifies commonly found terms in the FARs. Associated with each term are exemplars of how the term is used in a FAR passage, as well as how the term is commonly used in the field. Where appropriate, graphics are provided that enhance the meaning of the term. Informational Media are multimedia presentations designed to supplement the STAR-AMT learning environments with related concepts and commentary about the FARs and aviation.

Challenges

Challenges are designed to provide students with a self testing mechanism for assessing their knowledge of the material as well as to promote the integration of material covered in the other learning environments. Challenges can vary in complexity. They can be of the "self-test quiz" variety - where students practice quick responses to specific facts; or they can be of the "project" variety - where to solve a challenge entails a deep understanding of both the search process and the regulations themselves. Associated with many challenge questions is informational media explaining the rational for the correct answer to the question.

STAR-AMT EVALUATION SUMMARY

Method

The November evaluation of STAR-AMT sought to discern not only whether or not learning occurred but also what kind of learning occurred. The sample was composed of two classes of five students each from an FAA Part 147 school who were currently taking the Federal Aviation Regulations (FARs) and documents research class. All ten students worked with the computer application. Pre- and post tests were taken before and after the treatment and comparisons were made between each student's gain or loss in their overall scores and for scores within each test segment. The study was conducted over a one week period. Each student was provided with a 486 multimedia PC with CD-ROM capability and ear phones.

Both the pretest and the post test were composed of five sections. The first three sections were short answer questions covering material in the Overview, the New Technicians' Scenario (scenario 1) and the Special Inspections' Scenario (scenario 2). Section four was composed of standardized multiple choice questions found in typical tests for AMT certification. The questions were similar in content to the content covered in STAR. The last section was a series of true/false questions covering Privileges and Limitations of AMTs. Privileges and limitations are one of the overriding themes in the STAR-AMT curriculum. The total points for each of the tests were based on a scale of 110.

When making distinctions between the two classes in the results section below, one class will be referred to as the morning class and the other class as the evening class.

Results

Figure 12.4 shows the overall test scores for both groups. The subjects in the morning class are S1 to S5 and the subjects for the evening class are S6 to S10. Most students showed improvement from the pretest to the post test though the evening group shows a more substantial gain than the morning group. When viewing the average test scores between sections both groups showed substantial gains for the sections about the first and second scenarios and a moderate gain in the section on privileges and limitations. The evening group showed dramatic gains in the overview section but the morning class did not. As a group their scores were below their performance in the pretest. The performance for the two groups on the standardized questions remained about the same. The performance of eight of the ten students remained the same and relatively high (getting all five questions correct or missing only one) between pre- and post test. Two students did worse on the post test (missing 2 of the 5 questions).

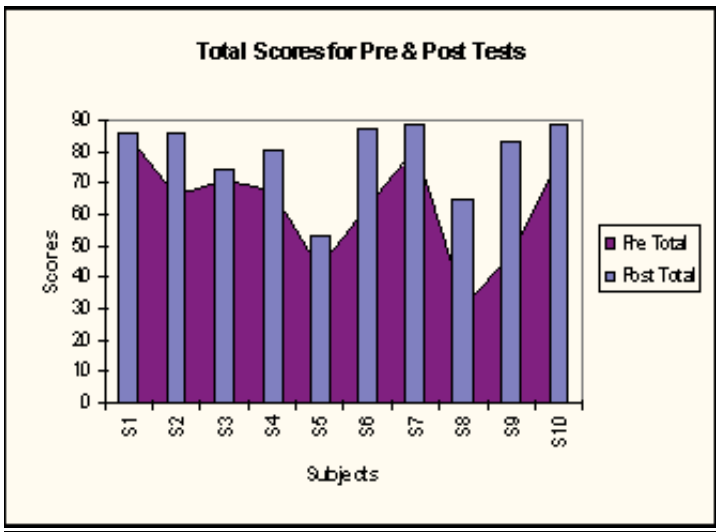

Figure 12.4 Pre- and Post Test Results

When analyzing individual test scores, four of the ten students showed a gain of 20 or more points between pre- and post test (Table 12.1). Three students showed a gain of ten or more points and two students showed gains of less than ten points. Greatest gains were seen among subjects who had scored less than 70 points on the pretest. In a couple of cases more than 30 points were gained from one test to the next. Gains were less dramatic for those scoring over 70 points on the pretest, either showing a gain of about ten points or in two cases showing no gain between tests.

Table 12.1 Individual Gains or Losses Between Pre and Post Test

Discussion

Even though the sample size is small, performance trends are positive. The most dramatic gains were experienced by those who scored poorly during the pretest. STAR seems to be particularly well suited for curriculum review or remedial work, particularly for students who have not as yet grasped the "big picture."

Two of the subjects who benefited the most from the STAR experience were students for whom English was not their primary language. The pervasive use of audio narration complementing the text may have given the added scaffolding foreign students needed to boost their comprehension levels. This may indicate that STAR-AMT could be beneficial for training of the international aviation community in US Federal Aviation Regulations and is an area where further studies would be informative.

Students acquired concepts most readily from material presented in the scenarios and in the case of the evening group, the overview. These improvements did not translate into better performance on the standardized questions. Since, however, most of the students performed well on both pre-test and post test on the standardized questions, a ceiling effect may be in evidence here. The desired outcome would be to show that STAR-AMT contributes to improvements in understanding both the big picture and achieving high scores for standardized test questions. This small sample size for both students and number of questions shows improvement only in the targeted curriculum "understanding the big picture." A much more extensive study addressing differences in curricular and testing styles for STAR-AMT and standard curriculum (as represented by standardized tests) will need to be done before an informed discussion can be presented.

STAR-ASI

From Training Aid to Job Aid

STAR-AMT has been designed to be a training resource to complement instruction rather than to replace it. Any part of the program could be used within the context of a lecture presentation, or as a reference, or for independent study. Even the scenarios were designed to be explored rather than just stepped through. The structure of STAR is flexible to complement different styles of teaching. While there are many strengths to this approach, there are also some weaknesses. Independent exploration encourages self-directed learning, but at a cost of homogeneity of learning across individuals. While students are exposed to the general body of knowledge from several different vantage points, there is less control over the particular information that an individual acquires. As an on-the-job training aid, however, this browser-oriented design approach is advantageous.

For STAR-AMT, resources augment and support training; for STAR-ASI, the emphasis is reversed - training augments and supports resources.9 Even in the context of on-the-job training, the primary activity and concern of each Aviation Safety Inspector (ASI) is having the right information at the right time to do his or her job well. Sometimes that may be learning how to conduct oneself during an inspection; other times it may be reminding the ASI which forms are needed for a particular inspection. In either case, STAR is designed to handle both needs.

STAR for Aviation Safety Inspectors is composed of the same general components as the STAR program for AMTs. Three of the learning environments - scenarios, resources and challenges - are identical functionally, with new content simply replacing old content. A new learning environment, Task Flow Charts for inspections, has been implemented in place of the Overview learning environment. Below is a description of this new learning environment.

Inspection Task Flow Charts

Each inspection is considered to be a task (Figure 12.5). For their on-the-job training, the airworthiness group had developed task flow charts that show the logical steps for each inspection task, including decision points (e.g. Has a FAR been violated?). By simply implementing these flow charts on the computer, the STAR team has been able to create an interactive version of that representation. Now a new recruit not only has a visual representation of each inspection procedure, but also can investigate each step in the procedure. All other learning environments can be launched from a step in a task flow chart. Depending on the instructional objective, one has the option to ask a quiz question, show what a form looks like, attach relevant passages from an Order or a FAR Part, comment on what an inspector's responsibilities are, or create a mini scenario. Task Flow Charts give each inspection procedure a structure; the dynamic nature of the computer provides informational depth to that visual structure.

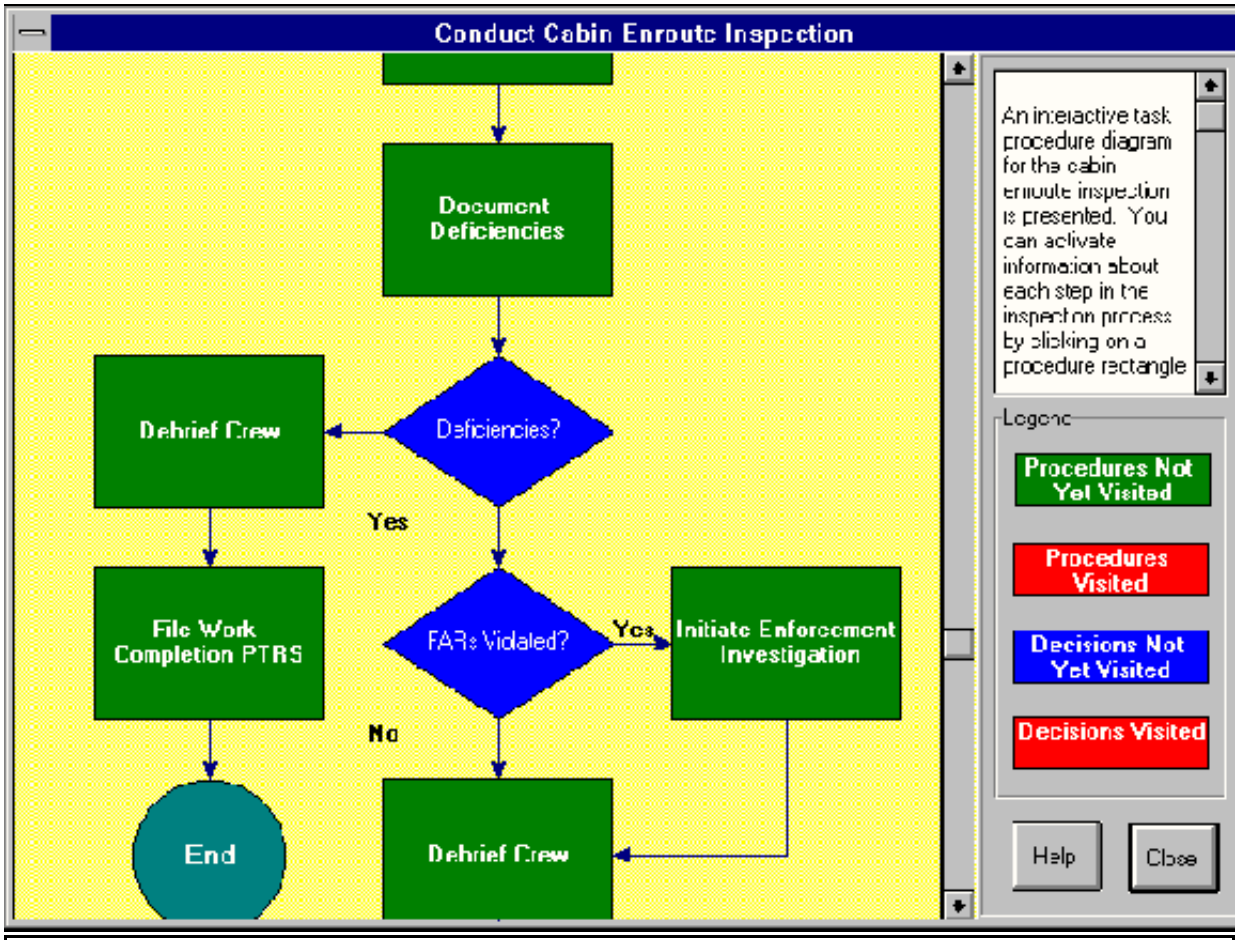

Figure 12.5 Task Flow Charts

This structure can be used in several ways, depending on the experience of the user and his or her present needs. For a new recruit, the flow chart is a training aid that he or she can step through, see the organization of the inspection, quiz him or herself, look up terms, or read relevant documentation; he or she can view sample forms and review how and to what purpose they are used. A veteran can review the steps of an inspection not done in a while before venturing out into the field. Or they might use it purely as a reference to look up which form they are suppose to use or the meaning of that acronym they never really learned. Scenarios which target new recruits more than veterans might never be touched by veterans. However, a mentor might employ the scenarios as a vehicle for discussions with new recruits.

Conclusion

In complex domains, the curricular goal should not be that everyone knows the same thing, but rather that everyone supports the same general conceptual scheme of the domain with some variation in the details of their common understanding. STAR represents a more open exploratory approach to training than the more lock step approach most commonly seen in the training of procedural knowledge. In an open approach, students are provided with a mechanism for acquiring a global understanding of a domain. As an individual builds a conceptual map, that individual will incorporate different details to support that conceptual map. Thus, while each individual will acquire an understanding for "the big picture," the details that support that global understanding will vary. This approach to knowledge acquisition supports and perpetuates communication within the knowledge community. Common domain themes support the tacit assumptions of the "truths of the domain" under which everyone is operating, while variation in details promotes ongoing discussion of and refinement of the community's collective knowledge. As long as the conceptual scheme is sound, and the details incorporated within the scheme are sound, then the variation in the details of knowledge between individuals is actually a strength rather than a weakness within the community. The STAR approach contributes to the reduction of errors resulting from non compliance with the regulations by training personnel to understand the functional purpose of the FARs and the role they play to ensure compliance with these regulations. STAR gives aviation personnel the "big picture" for how the FARs govern the daily operations of aviation maintenance.

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Dr. Chandler has twelve years experience in educational technology. Dr. Chandler was awarded a Ph.D. in curriculum and instruction, an MS in computer science and an MS in computer science education from the University of Oregon. She received a BA from Denison University with a double major in Biology and Philosophy. Her dissertation work was on the facilitation of theory-oriented problem solving through the use of process highlighters in computer simulations. Prior to joining Galaxy Scientific, Dr. Chandler spent three years as a research scientist in the AI lab at Georgia Institute of Technology. There she designed and managed the development of a case-based browser to aid elementary teachers in science instruction.

Since arriving at Galaxy Scientific two years ago, Dr. Chandler's principle project has been the design and development of the System for Training of Aviation Regulations (STAR). STAR is a multimedia application that employs a scenario-based approach to train personnel in complex domains. The original version of STAR has been developed for Aviation Maintenance Technicians in training. STAR has recently been repurposed to function as an on-the-job aid for Aviation Safety Inspectors. Her most recent project with Galaxy is the design and development of a distance Learning Center for the FAA Office of Aviation Medicine through the World Wide Web.
