Scenario-based Multi-Level Learning for Counterterrorism Intelligence Analysis

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ABSTRACT

Threat analysis is a vital component of homeland security. It is comprised of very complex tasks that utilize the fundamentals of data analysis, pattern recognition, and critical thinking. The US Army Intelligence Center and School at Fort Huachuca offers the Intelligence in Combating Terrorism (ICT) course as a solid, two week training program for Intelligence Analysts. An entire week is solely devoted to threat analysis exercises based on real-world scenarios. These intense and comprehensive exercises are what make the ICT course a very successful training program. The knowledge and proficiency accumulated through this practice is, measurably, more rewarding. However, a restricted audience and limited instructor resources created a challenge. A self-paced, distance learning solution that preserved the benefits of a hands-on experience was needed.

This paper discusses the diverse challenges and breakthroughs of delivering a web-based ICT as the first, SCORM 2004 compliant course for the Army, while implementing an innovative Intelligent Tutoring System (ITS) that employs Artificial Intelligence techniques to automatically assess student performance and provide adaptive coaching in the context of realistic threat scenarios. This paper will also discuss how these challenges were addressed in developing the pioneering multi-level web-based training to meet the goals of increasing knowledge and strengthening the skills of Intelligence Analysts.

ABOUT THE AUTHORS

Dr. Ramachandran is research scientist at Stottler Henke Associates, a small business dedicated to providing innovative Artificial Intelligence solutions to real-world problems. Dr. Ramachandran's interests focus on intelligent training and education technology including intelligent tutoring and intelligent synthetic agents for simulations. She is also interested in issues of motivation and metacognition. Experience with military and private industry gives Dr. Ramachandran a unique perspective on the needs and requirements of the ultimate end-users and their constraints. She contributes expertise in AI, instructional systems, probabilistic reasoning, and knowledge management. She has developed ITSs for a range of topics including reading comprehension, high-school Algebra, helicopter piloting, and healthcare domains. She has participated in workshops organized by the Learning Federation, a division of the Federation of American Scientists, to lay out a roadmap for critical future research and funding in the area of ITSs and virtual patient simulations. She has developed a general-purpose authoring framework for rapid development of ITSs, which is currently being used to develop an intelligent tutor for process control and a tutor for first responders.

Emilio Remolina is an Artificial Intelligence research scientist at Stottler Henke Associates, Inc. He received his Ph.D. in Computer Science, specializing in cognitive robotics from the University of Texas at Austin in 2001. His graduate work focused on map building, whereby an autonomous robot combines sensory information and actions it performs in order to build and localize in a map of its environment. Dr. Remolina's research interests include intelligent tutoring systems, planning, simulation and common sense reasoning.

Chad R. Barksdale is an Instructional Designer at Imedia.it, Inc. a design firm which provides performance based training approaches with complex programming architecture. He earned his B.A. in Communications from Texas State University and his M.S. in Instructional Technology from the University of Houston – Clear Lake.

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BACKGROUND

Walk into any military installation and you will see posted notifications informing you of the current threat level to the site. Most people often do not notice this sign as they go about their business. Nonetheless, this information plays a very important role in providing adequate security to a site and its personnel. During times of elevated threat, you can be sure that security personnel are ready and proactively vigilant to prevent possible attacks. Behind the signs are a large team of intelligence and security experts that determine the threat level, and develop plans and procedures for preventing an attack.

A key player in this team is the Intelligence Analyst (IA) who has the job of determining the level of threat to an installation on any given day. Intelligent Analysts use all the information available to them to analyze and assess the possible threats to an installation, assess the likelihood of various attack scenarios, estimate the level of threat, and recommend force protection measures. While the likelihood of elevated threats and the amount of information traffic may depend on the location, the importance of the intelligence analysis does not. Thus, an IA in an installation in Saudi Arabia may be presented a lot more significant information than someone in California; however, they both have equal responsibility for using their best judgment and skills to make the most accurate estimate possible with the available intelligence. IAs must maintain the highest level of alertness and vigilance. Adequate preparedness relies very heavily on good analysis. Too many high-threat alerts lead to wasted resources and reduce public's rust in the alerts thus leading to complacency. The consequences of being too conservative are obvious.

Cognitively, an IA's job is very demanding. IAs have to sift through a high volume of information traffic, separate relevant from irrelevant data and track various people, organizations and associations between them. While being immersed in the details of this analysis, they should also be able to step back to identify and confirm patterns of activities and events and in order to predict hat events may follow. Good training is critical to ensuring the availability of highly-skilled IAs. Complex, cognitive skills such as these are best strengthened by using hands-on exercises that closely resemble the real tasks.

The US Army Intelligence Center and School in Fort Huachuca is one of the premier centers for training Intelligent Analysts. They offer a two-week course that is focused on Intelligence Analysis skills. The first week covers basic instruction and the second week is devoted entirely to a hands-on intelligence analysis exercise. Trainees work on a real-world intelligence analysis problem with guidance from the expert instructor. Each stage of the intelligence analysis, from information analysis to pattern recognition to threat assessment, is covered as a part of this exercise.

While this training course provides a great foundation, its duration and requirement to be onsite at Fort Huachuca limits its accessibility. The Army wanted to translate this concept to a web-based course that can be used by trainees anywhere, anytime. A distance learning course could serve as a preparation for onsite training and as refresher training. The Army wanted a course that includes realistic simulation exercises with automated assessment and coaching in order to facilitate self-paced learning. The simulations would be supported by IMI (Interactive Multimedia Instruction) courseware to provide didactic knowledge instruction.

The Army requirement presented several technical challenges. One was the SCORM compliance requirement. Intelligence analysis is a very information intensive process. Large amounts of data in the form of message traffic and information correlation has to be transferred back and forth between the server and the client. Realizing this within the SCORM framework was a challenge. Additionally, automating performance assessment in the context of a complex, free-play

simulation also presented challenge which was surmounted using rule-based, Artificial Intelligent techniques.

OVERVIEW OF THE COURSE

Adaptive learning is making its mark in Web-based Training (WBT) for the military. Courses that implement adaptive learning help easily frustrated learners work at their own pace until they feel comfortable with the content. Learners who have not mastered the content are allowed more time to gain experience in the practice mode, increasing their confidence level. Learners who have mastered the content have the opportunity to show their skills and advance to learning that is more challenging and beneficial to them. This method increases learning efficiency by allowing students to work on their skill level and not waste time with content that may be too easy or too difficult. Learners differ in many ways. "Whether it is in appearance, learning style, multiple intelligence, prior experience, personal preference, or social/emotional development, students differ" (Gregory & Kuzmich, 2004, p. 2). Adaptive learning addresses the differences of each learner. Adaptive learning, as applied to the ICT training, starts with a pre-assessment of the learner and resultant placement in a skill-level group. Everyone has his or her own strong and weak areas of ability. "Students need to be placed in groups that maximize their instructional time based on their performance levels" (Gregory & Chapman, 2002, p. 70). These different skill-level groups address the same content but at different learning levels. This differentiation allows for "modification in content, process, and product based on the needs of the student" (Auld et al., 2000, p. 3).

The specific path taken by an individual student within the ICT Tutor depends on her performance on the simulation exercises. A comparatively short pre-test scenario is used to determine the student's expertise level. Students can be classified either as Level 1 or Level 2, with the latter being more advanced, based on their score in the pre-test. Figure 1 shows the course map.

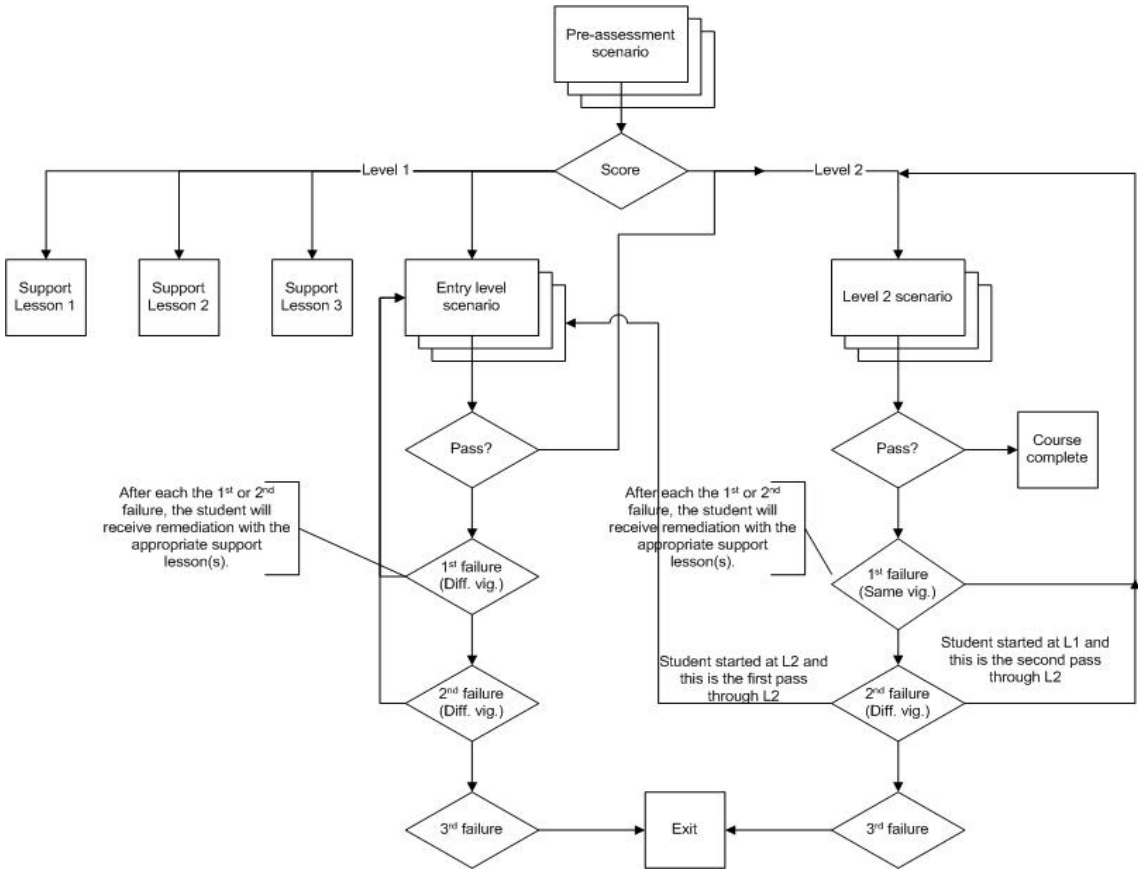


Figure 1: ICT Tutor flowchart

The pre-assessment in this training is equal in difficulty to the final assessment that the learner has to take in order to pass and receive credit for the course. This training is divided into three parts. All students will begin with the Pre-assessment Scenario. The Pre-assessment Scenario is designed to evaluate the student to determine their knowledge level. Depending on the student's pre-assessment score, they will then be placed into either a Level 1 or Level 2 scenario. Students, who perform below 80% on the pre-assessment, must complete three Knowledge Lessons, prior to beginning the Level 1 Scenario. Here, the students who begin on Level 1 will have three attempts to successfully complete the Level 1 Scenario before moving on to the Level 2 Scenario. Students who score 80% or higher on the pre-assessment, will be allowed to begin the Level 2 Scenario. Students, who begin with the Level 2 Scenario, will have three attempts to meet the performance standard. If the student fail to meet the performance standard by the second attempt, the student must successfully complete the three Support Lessons and a Level 1 Scenario before the student attempts at the final Level 2.To successfully complete the training, the student must pass the Level 2 Scenario with an 80% overall score. After three failures in either Scenario, the student will be exited from the course.

Simulation

Each scenario places the student in the role of an Intelligence Analyst in charge of assessing threat to an installation and makes recommendations for security. Along with background information on the installation and the organizations of interest, the student is given a set of messages that form the data for his analysis. The simulation consists of three analysis tools the student has to use to organize the data and extract patterns from it. Figure 1 shows the main screen of the simulator. Each tab allows students create and edit one analysis tool.

1. Association Matrix: An association matrix provides a way of noting entities such as people and organizations that are relevant and of potential interest to the analysis. It also captures known or suspected associations between these entities. While it is important to note all entities that may be relevant to a scenario, it is also important to not clutter the matrix with too much information which can hinder pattern recognition. The student has to learn the distinction between potentially relevant and irrelevant information to note in the matrix. The student also has to learn to differentiate between confirmed and unconfirmed associations. Finally, the student has to learn to utilize the symbology correctly.

The following figure shows a screen capture of the tutor showing a partially constructed association matrix.

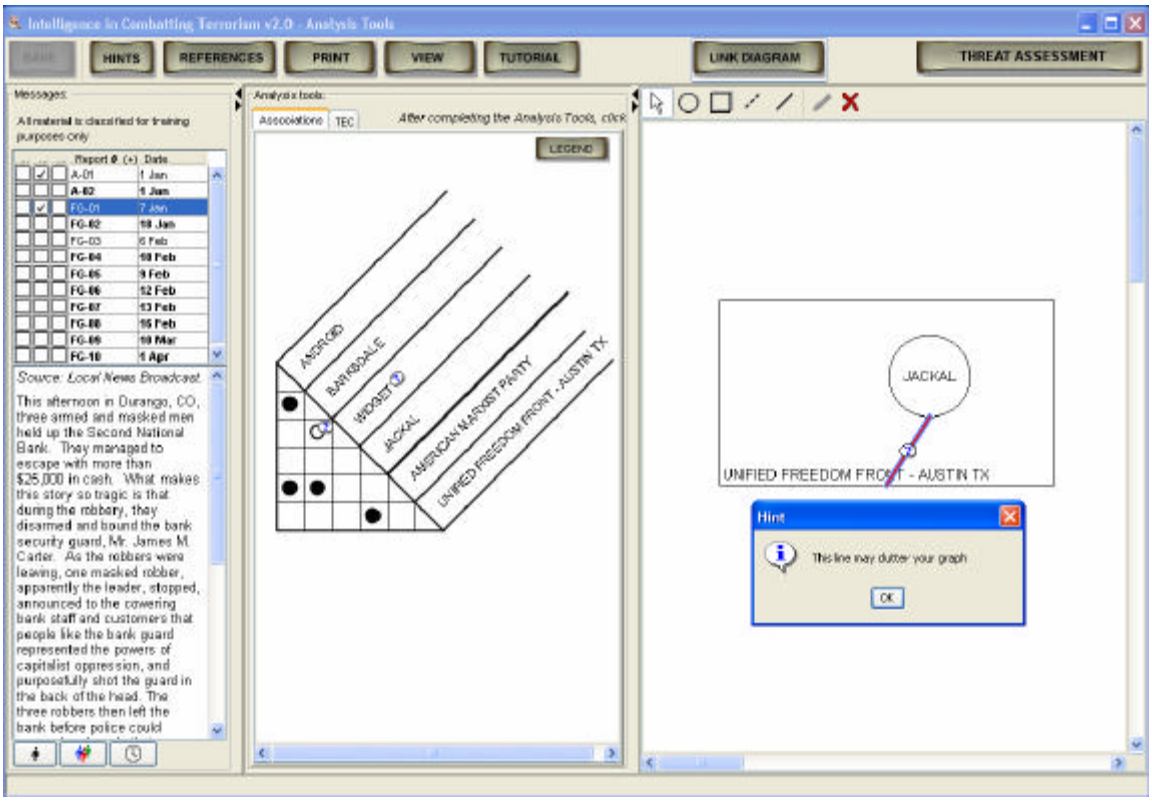


Figure 2: Screenshot showing the message display panel, an Association Matrix and a Link Diagram

2. Time Event Charts: The TECs allow the student to note important events in a timeline. Placing events in the right chronological order makes it easier to detect patterns of activity.

3. Link Diagram: Link diagrams are a graphic representation of the information in the association matrix. Although they capture the same information as the other tools, the graphic representation makes it easier to detect patterns of associations and events. The vital part of creating link diagrams is to include all the important information without cluttering the diagram with irrelevant data.

Once students are satisfied with the entire association matrix, the TEC and the Link Diagram they have constructed, the final task is to do a threat analysis based on this data. Threat analysis is presented as a series of multiple-choice questions that the student must answer.

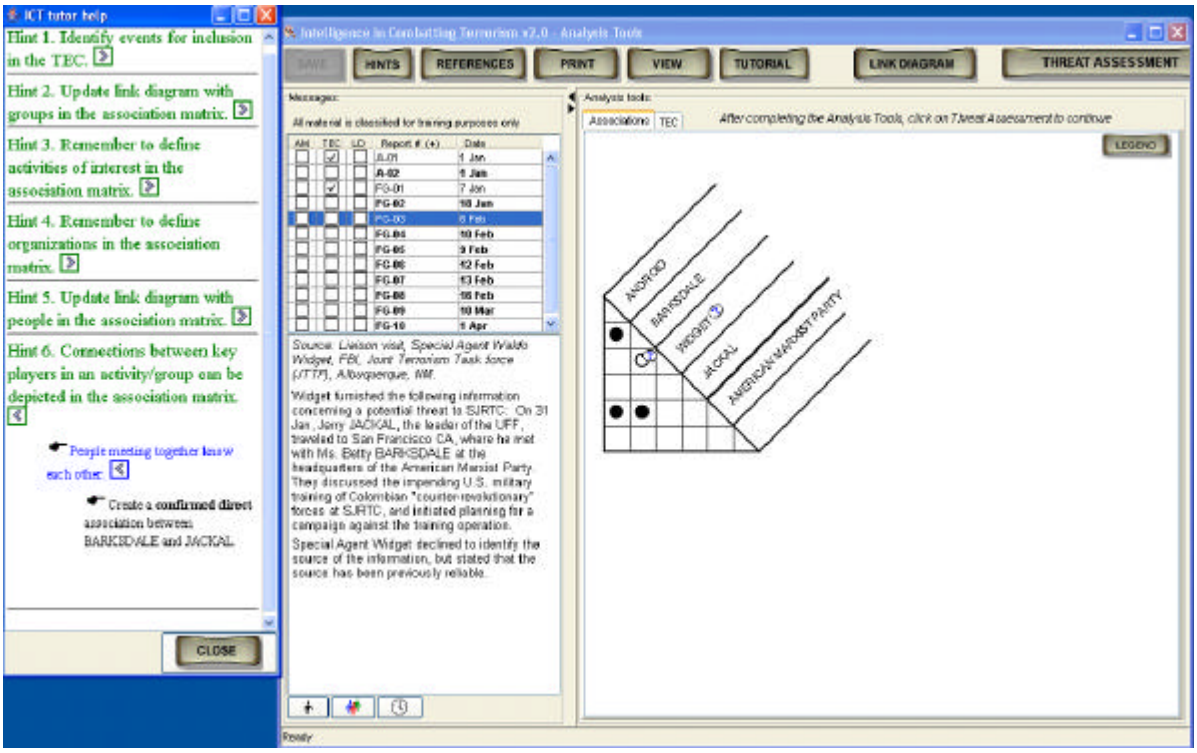


Figure 3: This screen shows the Hint window which provides guidance on associations and events that have not yet been identified by the student.

Feedback

One method used in constructivism is coaching. Coaching depends on the "types of students and their needs" (Gregory & Kuzmich, 2004, p. 18) and is achieved by adding feedback to the course. Appropriate feedback "helps students maintain a sense of control, reduces uncertainty, and encourages a higher level of thinking" (Gregory & Kuzmich, 2004, p. 17). As such, useful feedback must be descriptive, so as to offer the learner detailed, constructive information. Feedback is meant to "support learners at points where their own aptitudes or attitudes might infringe on learning" (Smith & Ragan, 1999, p. 25). It is the "process of providing just-in-time, just-enough assistance" to the learner (Dabbagh, 2003, p. 39). Feedback is especially important when "supporting novice learners by limiting the complexities of the learning context" (Dabbagh, 2003, p. 39). Feedback that is "planned and tuned to specific student behaviors and needs is effective" (Gregory & Kuzmich, 2004, p. 20). Feedback should be given to a learner throughout the course and at the end of the training to recap the performance and review the learner's progress.

The ICT Tutor includes the following forms of feedback:

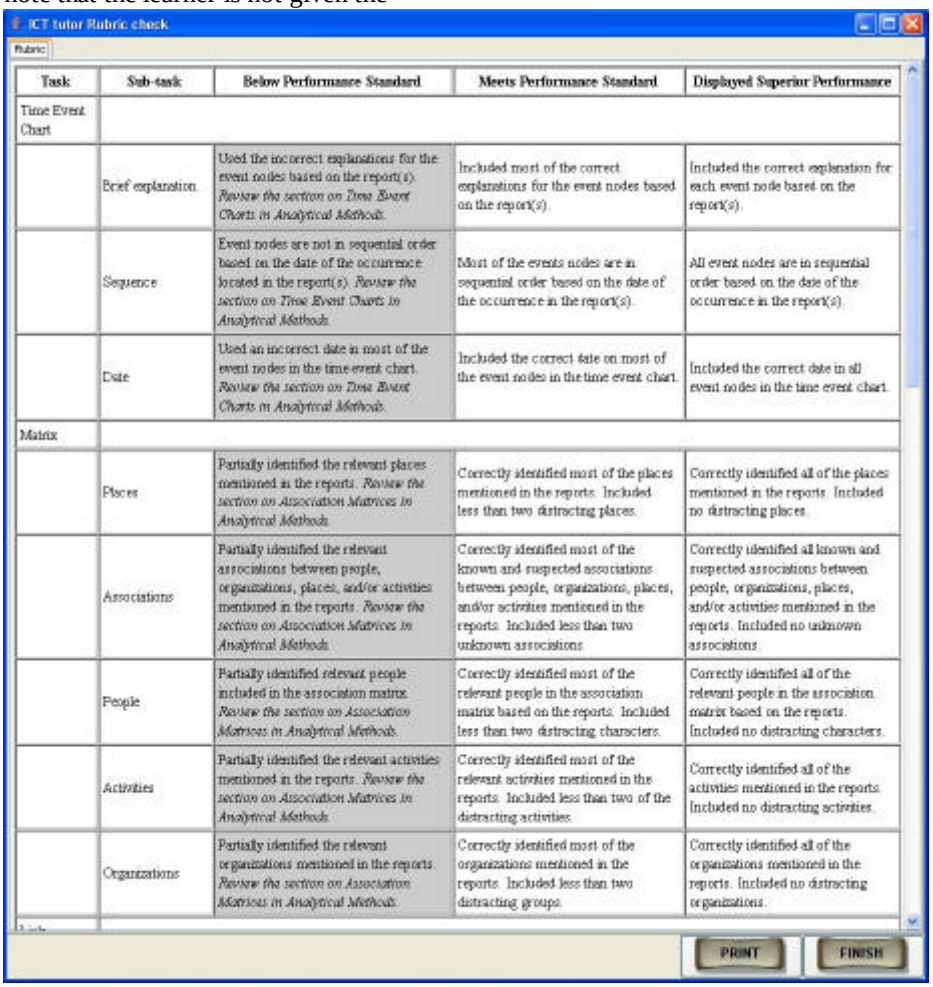
1. **Correct identification all the important and relevant data contained in a message:** Some messages in the message traffic can be densely packed with relevant information that must be recorded for analysis. It is easy to miss potentially key information, so a checkmark, as shown in Figure 1, is used to indicate when the student has completely and correctly identified all the information from a message.

2. **Incorrect entries on the analysis tools**: The tutor shows a question mark over student entries that are assessed to be incorrect. Clicking on the question mark leads to hint, as shown in Figure 2.

3. **Multi-level hints**: In addition, the ICT tutor provides hints to help students identify and record important information. There are three levels of increasingly specific hints. The first level hint is a

high-level principle intend to nudge the learner into associated message. The second level hint gives more specific information; the final level of hint explicitly tells the student what to do. Frustration can quickly sap a learner's motivation. These hints were designed to give novice students a way to move forward without being stuck for too long. Figure 3 shows an example of such hints.

3. **After-action Review in the form of a report card on performance**: Upon completion of the threat assessment analysis questions, the student receives a report on their performance as shown in Figure 3. It is important to note that the learner is not given the thinking about how that principle applies to the answers to the questions in the AAR. This is a requirement that the Army outlined in the statement of work for this project. While the answers to the questions are critical, it is more important that the student learn what types of questions are important to ask in order to receive the most crucial information. Not giving the learner the answer is part of assessment security that Imedia.it has implemented and will be further discussed in the next section. Figure 4 shows a sample report presented by ICT Tutor.



Task	Sub-task	Below Performance Standard	Meets Performance Standard	Displayed Superior Performance
Time Event Chart				
	Brief explanation	Used the incorrect explanations for the event nodes based on the report(s). *Review the section on Time Event Charts in Analytical Methods.*	Included most of the correct explanations for the event nodes based on the report(s).	Included the correct explanation for each event node based on the report(s).
	Sequence	Event nodes are not in sequential order based on the date of the occurrence located in the report(s). *Review the section on Time Event Charts in Analytical Methods.*	Most of the events nodes are in sequential order based on the date of the occurrence in the report(s).	All event nodes are in sequential order based on the date of the occurrence in the report(s).
	Date	Used an incorrect date in most of the event nodes in the time event chart. *Review the section on Time Event Charts in Analytical Methods.*	Included the correct date on most of the event nodes in the time event chart.	Included the correct date in all event nodes in the time event chart.
Matrix				
	Places	Partially identified the relevant places mentioned in the reports. *Review the section on Association Matrices in Analytical Methods.*	Correctly identified most of the places mentioned in the reports. Included less than two distracting places.	Correctly identified all of the places mentioned in the reports. Included no distracting places.
	Associations	Partially identified the relevant associations between people, organizations, places, and/or activities mentioned in the reports. *Review the section on Association Matrices in Analytical Methods.*	Correctly identified most of the known and suspected associations between people, organizations, places, and/or activities mentioned in the reports. Included less than two unknown associations.	Correctly identified all known and suspected associations between people, organizations, places, and/or activities mentioned in the reports. Included no unknown associations.
	People	Partially identified relevant people included in the association matrix. *Review the section on Association Matrices in Analytical Methods.*	Correctly identified most of the relevant people in the association matrix based on the reports. Included less than two distracting characters.	Correctly identified all of the relevant people in the association matrix based on the reports. Included no distracting characters.
	Activities	Partially identified the relevant activities mentioned in the reports. *Review the section on Association Matrices in Analytical Methods.*	Correctly identified most of the relevant activities mentioned in the reports. Included less than two of the distracting activities.	Correctly identified all of the activities mentioned in the reports. Included no distracting activities.
	Organizations	Partially identified the relevant organizations mentioned in the reports. *Review the section on Association Matrices in Analytical Methods.*	Correctly identified most of the organizations mentioned in the reports. Included less than two distracting groups.	Correctly identified all of the organizations mentioned in the reports. Included no distracting organizations.

Figure 4: Sample after-action review

CHALLENGES

Designing for SCORM Compliance

The ICT Tutor is a highly-interactive, data-intensive application with advanced automated assessment and coaching, and complex sequencing of content. As such, it broke new grounds for SCORM-based courses. Accommodating such a complex design with the SCORM framework (http://www.adlnet.gov/scorm/index.cfm) presented many challenges. Prior to the web-based ICT Tutor, SCORM v1.2 allowed the use of large, single SCOs.

Course designers found that these "super SCOs" limited the ability to split up learning objectives and implement complex remediation. Programmers found that SCORM v1.2 restricted sequencing and navigation features in the LMS. With this in mind, the courseware designers went to the client with the idea of using the newly released SCORM 2004. With the new version of SCORM, programmers would be able to build the course skeleton using dummy content while the content was being created. This method maximized team efficiency. Once the course content was complete, it could then be dropped in when it was time to test.
Designers could utilize better and faster remediation techniques which help dissect learning objectives. New scoring rubrics would utilize more measurable points which allowed students to track their learning path and progress. This division of objectives gave way to increased reusability of content, bringing the ICT IMI to the forefront of e-learning. ICT Tutor was soon to become the first ATSC SCORM 2004 compliant course.

A second challenge in the development of ICT Tutor was the restriction placed on the data exchange between the LMS server and a SCO by the SCORM standards. Each ICT Tutor scenario typically takes about 3-4 hours to complete. An outlet was needed for students to exit the simulation at any time, ensuring that they can start back where they left off the next time. All the information in the association matrix, the TEC, and the link diagram had to be sent back to the server for persistent storage. This was a challenge within SCORM framework which imposes a restriction that the size of the data passed from a SCO to the LMS be under 4KB. Meeting this restriction was a critical challenge because failure would mean the failure of the scenario-based training approach. It was through careful encoding of the all the messages, the student only knows the information contained in the messages he has read so far. It would not be very useful to give students hints about information in the last message when he is still processing the first. To handle this, ICT Tutor also maintains a model of the current state of knowledge of the student based on his entries and the messages he has read. The rule-base also has rules for determining what the student should be able to infer from what he has read. One example of such a rule is: "If a message supports that two people know each other, then the student will know such fact when he knows about the people involved and has read the message." Another example is: "the student can derive a fact whenever he knows a justification for the fact." Based on this rule, when ICT Tutor determines that the student should know some fact, it information that we were able to comply with this size. However, this constraint imposed by SCORM severely limits the amount of interactivity that can be designed into a distance learning course and should be reconsidered.

Making the web-based ICT Tutor SCORM 2004 compliant was a challenge in many ways. Forging new territory, the designers and programmers, while working closely with the Advanced Distributed Learning Network (ADL), were met with a high learning curve, finding and conquering limitations. Ultimately, using SCORM 2004 provided a better assessment of students. It gave way to utilizing real-world scenarios instead of traditional tests. SCORM 2004 helped make the web-based ICT Tutor a starting point for many other projects on the quest to meeting the goal of creating true, adaptive training.

Automated Performance Assessment

Another significant challenge was developing automated performance assessment for these simulations. We represented the facts and associations contained in the messages in a rule-base. For example, "United Freedom Front is an organization" would be assertion in this rule-base. Similarly, "there is a confirmed association between Barksdale and the American Marxist Party" would be another. Rules like "if A works with B, A belongs to GA and B belongs to GB then groups GA and GB may be working together" infer associations that are not explicitly stated in the messages. This rule-base represents the ground truth. A student's entries into the analysis tools are compared to the ground truth assertions to determine their correctness. This straightforward representation needs to be augmented to accommodate the fact that, whereas the ground truth represents the knowledge captured by will generate a hint to help him identify the fact if he has not already.

Truth maintenance was an additional issue we had to consider. It is possible for later messages to retract or modify information presented in earlier messages. A common example is when a message indicates a possible association between two entities which is confirmed in a later message. Although the ground truth represents the association as confirmed, the ICT Tutor needs to represent the fact that it was first unconfirmed and then later confirmed. We implemented an AI technique called Automated Truth Maintenance (Ref) to ensure this. This algorithm updates the rule-base when facts are modified or retracted to ensure consistency.

VALIDATION

An Operational Validation was administered to participants at Fort Huachuca. All participants have a military intelligence background, either 96B or 97B. Of the six participants, four completed the course during validation. All participants attained 80% or better on each of the 23 measurable activity groups, with the exception of two participants that withdrew early. There was dramatic improvement in participant scores with repeated attempts. The chart below shows the average errors per attempt for all participants for each scenario level. The Level II Scenarios provide little help or mentoring to the student. Despite this, the errors per attempt fell at a faster rate than for Level I. We think this presents a strong case for the multilevel training model that was used. The skills that were developed in Level I with substantial tutoring were carried forward in Level II where there was very little tutoring.

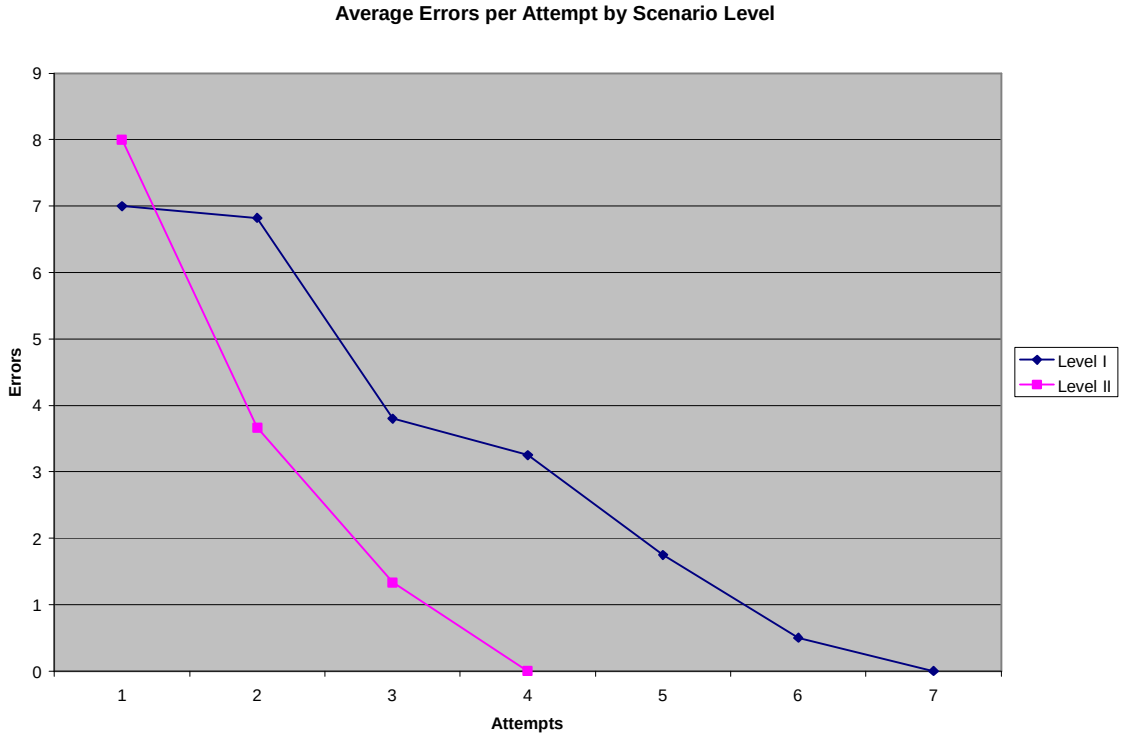


Figure 5: Graph showing number of errors mapped against number of scenarios performed

CONCLUSION

This paper describes how a complex, highly interactive distance learning course implemented to SCORM-compliance. ICT Tutor is the first ATSC SCORM 2004 compliant course. Designing to SCORM compliance presented a few challenges that were surmounted by using SCORM 2004 and through careful encoding of the data being passed back and forth between the SCOs and the LMS. Automated assessment and coaching was addressed by using rule-based representation and inference techniques. A limited validation study indicates that ICT Tutor is effective as an instructional tool.

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