THE VIRTUAL SCHOOLHOUSE

John Leddo, Ph.D.
Research Development Corporation
Herndon, VA 20171-3205

James Kolodziej
Research Development Corporation
Herndon, VA 20171-3205

Training is undergoing significant changes within the military. There are considerable pressures to cut costs and move training from the schoolhouse to the field so that it can be delivered "just in time" and be more responsive to individual unit training needs. Technology is seen as a central piece in this trend. Simulation has played a major role in military training. Distributed Interactive Simulation (DIS) allows multiple trainees to interact in real time on a common training problem. While DIS is a powerful training tool, a trainer is typically required to review trainee performance and make the appropriate teaching and remedial points. As training scales to larger and larger exercises, the trainer will naturally focus on general team performance at the expense of individual training needs. Intelligent tutoring systems (ITSs) have focused on providing instruction on a one-to-one basis. Integrating DIS and ITS technologies offer the opportunity to capitalize on the strengths of both: the ability to conduct large scale team exercises while providing each trainee with personalized instruction. The present paper reports a Phase I Small Business Technology Transfer (STTR) project in which a Distributed Interactive Intelligent Tutoring Simulation (DIITS) was developed to train Army Infantry squad and fire team leaders the skills they need to cooperatively perform military operations in urban terrain (MOUT). The intelligent tutoring system technology allowed trainees to still receive feedback and remediation regardless of whether or not a human instructor was present. This gives the technology the flexibility to be used "on demand" by trainees, not just when scheduled by instructors. The DIITS included intelligent agent technology to play the role of scenario agents when a human was not available to fill in. This gave the technology added power as it could be used for training regardless of the number of trainees available at the time. A scenario editor was also created to allow training scenarios to be developed by users. The intention of this was to increase the customizability of the technology to individual user needs. Finally, the technology was constructed to be generic and modular to support extension and reuse as training requirements evolve. These characteristics were demonstrated in several ways including the transfer of technologies across projects, the substitutability of modules across systems and the ability of the technology to respond to user-defined scenarios without further modification.

ABOUT THE AUTHORS

Dr. John Leddo is President of Research Development Corporation. He earned his Ph.D. in Psychology from Yale University in 1988. Dr. Leddo specializes in developing training technologies along with the cognitive learning models upon which the technology is based.

Mr. James Kolodziej is Chief Technical Officer of Research Development Corporation. He holds an MS in Computer Science from George Mason University. Mr. Kolodziej leads RDC's technical team in developing intelligent tutoring system and intelligent agent technologies.

THE VIRTUAL SCHOOLHOUSE

John Leddo, Ph.D.
Research Development Corporation
Herndon, VA 20171-3205

James Kolodziej
Research Development Corporation
Herndon, VA 20171-3205

INTRODUCTION

Training is undergoing a substantial change in the military. In particular, there is a strong push to move training from the traditional "schoolhouse" model into the field. The motivations behind this are several. First, there is a tremendous cost both in real dollars and opportunity to bring soldiers to the schoolhouse to receive training. In addition to travel and per diem costs ("real dollars"), soldiers spend time away from their units and hence temporarily suspend performance of their regular duties ("opportunity costs"). Given the downsizing of the military both in budget and size of the active force, both of these costs represent a strain on the goal of providing a ready, well-trained fighting force.

Second, there is tremendous concern that the effects of schoolhouse training may degrade before the skills that are trained are actually put to use on the job. This is particularly true of National Guard and Reserve personnel that see duty only a fraction of the year and have little opportunity to practice and maintain military (or MOS) skills while they are performing their "full-time" jobs. In fact, Leddo et al. (1990) found that most experts they studied felt that the bulk of their expertise was acquired through on the job training rather than at the schoolhouse. This type of finding has led to the notion of "just in time" training, where training is delivered to the job site when it is needed so that the skills being trained will be at their sharpest when they are actually used. The need for "just in time" training is at its peak and will only grow. Weapon systems are growing increasingly high tech and sophisticated, the number of missions/theaters a soldier must prepare for has increased, and the level of responsibility thrust upon soldiers, particularly those in leadership positions has also increased. Unfortunately, Army recruits tend to leave high school ill prepared for the kinds of critical thinking and problem solving skills required rise to this challenge (National Assessment of Educational Progress, 1992), thus forcing even more training responsibility onto the Army.

Third, with a reduction in the fighting force of the Army, the pool of expertise is shrinking. Military experts are simply retiring and their expertise retires with them. As a result, the pool of outstanding instructors has also shrunk. This creates a need to leverage existing expertise.

The motivation to reduce training costs, to make training more timely and robust, and to maximize the use of diminishing expertise is driving current Army thinking of how to push training from the schoolhouse to the field. One methodology being employed is the use of distance learning technology. The spirit of distance learning is to have training resources (typically instructors) at a central location and the content is broadcast to remote training sites.

While the spirit of distance learning is the more general concept of receiving training without the requirement that the instructor and instructional materials be collocated with the trainee, most distance learning efforts have focused on networking training sites and leveraging instructors by broadcasting their instruction to multiple locations. This does meet several of the objectives listed above: fewer instructors are needed to reach many students and training can be delivered without the cost of bringing students to a schoolhouse.

There are some drawbacks with the way many distance learning paradigms are currently implemented and which the current proposal intends to address. First, the "just in time" goal is often sacrificed as the administrative requirements of assembling the large numbers of students to receive training at remote sites often precludes delivering instruction to individual students when they most need it. Second, distance learning paradigms often sacrifice some of the most beneficial features of the schoolhouse model, namely the opportunity to direct mentoring from the instruction and the opportunity to work in collaborative problem solving environments. This is often an unfortunate artifact of distance learning paradigms that simply send teaching by telling over a channel.

One medium over which distance learning is enjoying increased popularity is the Internet. The Internet is designed as a collaborative medium. Therefore, it lends itself to more of the mentoring types of activities typically found in a schoolhouse. The Internet is enjoying increased use in distance learning. One class of technologies that have been used in Internet-based distance learning is Multi-user Dungeons (MUDS) and MUDS Object-oriented (MOOs). MUDS are exploratory environments (typically text-based) that allow users to enter and explore "rooms" in cyberspace. Users can communicate with others in the MUD. A MOO is similar to a MUD but here users are allowed to construct their own rooms and objects. MUDS have become so popular as an Internet-based learning environment that there is even a university (Diversity University) that exists entirely in a MUD (i.e., all courses are taught in the MUD). Many other universities routinely offer Internet-based courses to supplement classroom ones.

We see two critical weaknesses that need to be addressed by Internet-based distance learning technologies such as MUDS and more general distance learning paradigms that center around broadcasting lectures to remote sites.

The first weakness is the limitation of the types of activities that students are exposed to. For example, MUDS foster text-based interaction. Learning activities center mostly on discussion. While current research activities are looking to add multimedia capabilities to MUDS, these efforts are still in the beginning developmental stage. Similarly, while conventional distance learning technologies broadcast more rich media such as video to students, the opportunity for students to interact and engage in learning activities (as opposed to passive viewing) is limited. We believe that distance learning technologies need to provide students with the opportunity to engage in realistic collaborative exercises as they would in a schoolhouse or field exercise. The marriage of Internet-based distance learning with simulation-based instruction would represent a tremendous value added leap in training technology.

receive

The second weakness is the limitation of teacher mentoring. While technologies such as MUDS support teacher participation, one of the unique benefits of MUDS (or the Internet in general) is its continual availability regardless of physical location, time zone, etc. Students routinely use MUDS and the Internet without teacher supervision. To maintain the strength of this availability (which is key to the notion of achieving "just in time" training--i.e., training on demand), it is necessary for the training environment to be effective even when a teacher is not present. Traditional distance learning paradigms suffer from this even more in that they are exclusively dependent on a teacher to broadcast training content.

We believe the key to addressing this issue is to make the learning environments "intelligent". By intelligent, we mean that the environments should embody the same sorts of skills a live teacher would have, were there one always available to work on an individual basis with the students. What teachers bring to the process is a knowledge of what needs to be taught, an ability to assess students to determine their learning needs and styles, a knowledge of how to teach (including what exercises are necessary) and an ability to get the training resources necessary to deliver those exercises. In order to make the learning environment intelligent, we integrated intelligent tutoring system (cf., Brna, Ohlsson and Pain, 1993; Greer, 1995) and intelligent agent technology into the learning environment. This is manifest both in terms of implicit intelligence in the activities that the trainees perform and in the form of intelligent agents that can serve as mentors and co-problem solvers when needed to reduce the requirement that instructors and other trainees always be available in the virtual schoolhouse. Ultimately, intelligent agents may serve other roles such as "reference librarians" to help locate material or as sources of subject matter expertise that a trainee could query for information. These latter capabilities are beyond the scope of the current effort but are part of RDC's overall strategic plan for the Virtual Schoolhouse.

The goal of our overall effort is to create a distance learning environment that combines Internet-based access to resources, virtual and constructive simulations, and intelligent tutoring system and agent technologies. The resulting technology will be a "virtual schoolhouse" that reflects the benefits of a schoolhouse and extends them by making the learning environment more personalized to the individual needs of each trainee (through intelligent tutoring and intelligent agent technologies), yet does not have the physical limitation that instructors, trainees and resources be collocated both spatially and temporally. We envision the implementation of this in the form of training resources that are accessed through a central world wide web site, downloaded and run locally. Editing tools would be provided so that the technology could be customized to individual unit needs.

THE VIRTUAL SCHOOLHOUSE TECHNOLOGY

Based on our review and analysis of the needs of the training community, which was greatly supported through interactions with the following members of the Ft. Benning Infantry community: the Directorate of Training (DOT), U.S. Army Infantry School (USAIS); the Battle Lab and the U.S. Army Research Institute field unit, we established the following goals for our technology:

1. training problems should be realistic
2. instructional mechanisms should be embedded in the training environment
3. the technology should support individual or team training regardless of whether sufficient participants are available
4. the training environment should support customization of training scenarios to unit objectives.

Based on this, our goal was to develop a simulation-based intelligent tutoring system (SITS) to provided realistic problems with embedded instruction and integrate intelligent agents into the simulation to provide realistic human behavior for computer-generated forces. We also developed a scenario editor which served two functions: it allowed scenario customization and it demonstrated the power of our technology by showing that it would work effectively on scenarios generated by end users, not just those generated by the project team.

The Phase I technology was based on transfer and enhancement of technologies developed under two related projects: a project sponsored by the U.S. Army Simulation, Training and Instrumentation Command (STRICOM) to develop a squad and fire team leader MOUT trainer using a virtual simulation-based intelligent tutoring system and a project sponsored by the Defense Advanced Research Projects Agency (DARPA) to develop intelligent agents for MOUT.

A Modular Simulation-based Intelligent Tutoring System (SITS) Architecture.

One of the lessons we learned early on in our work in simulation and intelligent tutoring systems is that each development effort tends to be costly with little reuse of software across projects. Further, once a system is developed, it tends to be relatively inflexible in terms of supporting customization to user needs or updating when new domain knowledge is acquired. Because of this, when we first started our STRICOM project, we sought an alternative method of development.

Our solution was to create a modular system. There were three major components: a virtual simulation in which users could run through training scenarios; an expert knowledge model of the domain that served as the assessment and tutoring component of the system; and a communications protocol that relayed simulation state and user action information from the simulator to the expert knowledge model and instructional requirements back from the knowledge model to the simulator. We discuss each of these components in turn.

An expert knowledge model of MOUT. In the cognitive science and psychology literatures, several frameworks have been proposed as models of expert (and non-expert) knowledge. These schemes tend to address different types of knowledge. For example, scripts (Schank, 1982; Schank and Abelson, 1977) are used to represent goal and planning knowledge that is used in fairly routinized environments. Scripts are generalized sequences of steps used to achieve a goal. Script-like schemas can also be used to integrate bodies of knowledge into a larger framework.

Knowledge about data patterns and how objects are organized together (e.g., the configuration of a laboratory) can be represented by object frames (c.f., Anderson, 1980; Minsky, 1975). Frames are very much like scripts in that they are expectancy-driven organizers of knowledge. We conceptualize scripts as focusing more on goal and plan-related knowledge while frames organize collections of objects. Frames can also be distinguished from semantic nets (cf., Quillian, 1966) which tend to organize information about individual concepts and relationships between them rather than collections of objects. For example, a fire team may best be represented by a frame since it is a collection of people and equipment while a rifle may best be represented by a semantic net that describes its features.

Knowledge about situation-specific procedures can be represented by production rules (cf. Newell and Simon, 1972). Production rules are expressed in the form "IF [antecedent], THEN [consequent]", where antecedents are situational conditions that determine when procedures are to be executed and consequents are the procedures executed under those conditions. Production rules are useful in both carrying out procedures (e.g., "If this step has been completed, then do this next step.") and also generating inferences (e.g., "If the following problem features are observed, then infer that this is an [X] type of problem."). Production rules can be distinguished from scripts in that scripts organize entire goal-driven plans, while production rules organize specific actions. Scripts can be viewed as collections of production rules much the way that frames can be viewed as collections of semantic nets.

Finally, causal and analogical reasoning can be captured by mental models (cf., de Kleer and Brown, 1981; Johnson-Laird, 1983; Leddo, Cardie and Abelson, 1987). In our framework, (Leddo, Cardie and Abelson, 1987), mental models are viewed as encoding the causal rationale for why a specific problem solving procedure is used. One of the factors that distinguishes the way experts solve problems from the way non-experts do is the former's heavy reliance on mental models and the ability to use them to select an appropriate problem solving strategy to meet a set of objectives.

We have discussed five different representation frameworks (scripts, object frames, semantic nets, production rules and mental models) for representing expert knowledge. Experts possess diverse knowledge that is richer that can be handled by any single framework (Leddo et al., 1990). Leddo, Cardie and Abelson (1987) developed an Integrated Knowledge Structure (INKS) framework that combines these individual schemes. In the INKS framework, scripts serve as the general organizer of knowledge, linking plans and goals together. Production rules give situation-specific procedures to be executed given conditions that arise during the execution of a plan. Frames organize collections of objects that are utilized in the execution of plans while semantic nets organize features of the individual objects within a frame. Mental models provide the rationale for why procedures are executed and how they are instrumental in achieving objectives.

The INKS framework can be used to model MOUT knowledge. For example, a script could represent the process of clearing a building such as breaching the building, moving through hallways, stacking, breaching doorways, clearing rooms, etc. Production rules could model specific steps in the overall script such as how a four man fire team should enter a room with a center door. Semantic knowledge could model knowledge about specific equipment or building features (e.g., closed, unmarked door with 2 hinges and 1 lock). Frame knowledge could model knowledge about the building and its layout. Mental models could model the rationale behind certain actions such as why it is important to provide security before sending a fire team down a hallway.

The INKS framework served as the basis for modeling a the domain, the trainees' actions in the simulation environment and determining how to update the simulation. The expert model also served as the basis for driving the behaviors of the intelligent agents.

This architecture allowed us to construct a simulation-independent knowledge model that was a MOUT expert, but knew nothing of the individual training scenarios. As a result, it was not tied to the simulator. In this respect, the expert model was like a human expert that could be brought into a training exercise without prior knowledge of the scenario being used, but could still assess and instruct students as long as it got information about the scenario along the way and what actions the trainees were taking.

Similarly, the modular architecture allows changing the simulator without affecting the underlying expert model. The result of such an architecture makes the system more modifiable without major rebuilding of the fundamental components.

This STRICOM architecture demonstrated its power in the present technology. It was clear that if we were to implement the intelligent agents from a separate project and create scenario editing, it would be desirable to have a constructive simulation rather than a virtual one as the rendering requirements of the simulator are much easier and more suitable for Phase I level resources. Because we used a modular architecture, we simply had to create a constructive simulation. The underlying expert knowledge model and communications protocol remained largely unchanged. Therefore, the constructive version was created in about 1 month (compared to the year it took to create the analogous virtual version).

At the time we created the constructive simulation, the underlying knowledge base focused on fire team leader only and was a one-person trainer. Along the way, for the STRICOM project, we added the knowledge base for the squad leader and created a two-person virtual trainer. Again, because the expert knowledge model was independent of the simulator, we were able to add the new squad leader knowledge without substantially changing the simulator (other than having it render the new members and record the squad leader actions to send to the expert knowledge model).

The resulting system is a two person trainer that currently runs over a peer to peer network. Actions taken by each trainee processed on their individual simulators and passed to their partner's simulator for analogous processing. Future plans call for extending this technology to a client and server architecture.

Our basic premise for the virtual schoolhouse is that training should be made available "on demand" regardless of whether an instructor or other trainees are present. In order to achieve flexibility with regard to instructor availability, we established a toggle for whether or not the system provides feedback to the trainees. When a human instructor is present and can provide this feedback, the feedback that the intelligent tutor provides can be toggled off. When the human instructor is not present, the intelligent tutor feedback can be toggled back on.

The Intelligent Agents.

With the basic modular SITS architecture developed, it was relatively easy to transfer the DARPA intelligent agent technology into the simulator. Essentially, the intelligent agents were represented as expert knowledge about how different agents in the simulation would behave. Essentially, these were updates to the expert knowledge model—no changes were needed to the simulation itself.

We noted, however, that the true intent of "on-demand" training requires that a trainee should be able to receive the same high quality training regardless of whether other participants are available for the scenario. Therefore, we wanted to create a mechanism whereby real time control of a scenario agent could be transferred from human to computer (i.e., intelligent agent).

The underlying expert knowledge model enabled this to happen. When the system is being used by a human trainee, it monitors the trainee's actions and compares them to its own expert solution of how to solve the problem. If the trainee transfers control to the computer, the system simply carries out that expert solution given the state information it continues to receive from the simulator. When the trainee retakes control, the system returns to a monitoring mode but still computes its own expert solution to the problem. By having constant information of the simulation's "state of the world" and its own expert solution computed, the system is always prepared to transfer from active control of an agent or trainee monitoring and back again.

Editing Tools.

It was clear from our discussions with members of the Infantry community that multiple training scenarios were needed. Both to meet this objective and to test the power of our expert knowledge model, we constructed scenario editing tools that allowed real time changing of simulation parameters.

This feature was supported entirely by our modular architecture. If the expert knowledge model was scenario dependent, then any change in the scenario would throw the model off. However, because our architecture was constructed such that the expert knowledge model learned of the scenario as the trainee progress through it, it did not distinguish between what was a preset scenario feature or one that was created on the fly.

The scenario editing tools were created based on parameters the underlying expert knowledge model would understand. This encompassed a wide range of parameters. Among these were:

- number, location, training level, combativeness of the enemy

- number and location of civilian non-combatants
- speed and accuracy of friendlies and enemies to fire their weapons
- weapon lethality
- whether doors were open/closed, marked/unmarked, and how many locks and hinges they had

As we discussed earlier, our system uses a modular architecture. As a result, the expert model that runs the intelligent tutoring system and the intelligent agents receives information from the simulation in real time. It has no prior knowledge about what the scenario features are. Therefore, scenario features can be changed in real time without disrupting the flow of the simulation.

EVALUATION RESULTS

We evaluated our technology in two ways. First, we evaluated the realism of our intelligent agent technology with military experts. Second, we had military experts review our technology to provide us with feedback for future directions.

Evaluation of realism of intelligent agent technology.

There were two forms of this evaluation. First, in several demonstrations of the technology, one at Research Development Corporation and several at Ft. Benning, we had military experts create their own scenarios, both at the start of a simulation run or in real-time during the execution of a simulation-run. In all cases, RDC personnel had no prior knowledge of what parameters the experts would wish to change. In no case, did the system fail to operate (often referred as "crashing"--a common demonstration phenomenon when a system is given input outside its working parameters) or exhibit an unexpected behavior, suggesting it was incapable of coping with the scenario.

The second form of the realism evaluation was to prerecord both a human and the system controlling the fire team leader in separate runs of identical scenarios. Both prerecordings were played side by side for groups of observers. There were three groups of military experts (numbering approximately 6-8 per group), who would be familiar with the expected behavior of humans working in the scenario and three groups of engineers (numbering approximately 2-10 per group), who would be familiar with behaviors generated by expert systems. Again, one group was conducted at RDC, the others at Ft. Benning. The experts were asked to distinguish which recording was made of the human operator and which of the system. In general, the experts and engineers were unable to make the distinction (many even guessed wrong). Those that did guess correctly cited a shorter latency between computer-issued commands than human-issued ones, presumably because the human needed to enter commands through a keyboard, which took time.

This evaluation raised an interesting additional benefit for our technology. Experts occasionally found themselves disagreeing with each other as to what the "correct" action should be in a situation. While this did raise the important point of validating the underlying expert knowledge used by the system, it also showed how experts often do disagree with each other, and having an expert model articulate tactical decisions is a means for prompting experts to discuss and reason about their problem solving methods.

Evaluation For Feedback For Future Directions.

In the present project, we worked very closely with members of the Infantry community at Ft. Benning. Upon completion of the project, we asked two distinct communities within Ft. Benning to evaluate our work and provide us feedback. These were the Directorate of Training and the Battle Lab. Below, we present common points that were general across the communities as well as the areas in which their needs differed.

Common Points. In general, our work was positively evaluated by all who saw it. All agreed that the work was valuable to the Army and should be continued. In presenting their views in how the work should be continued, the following consistent points were made:

1. The technology may be centrally located, but should be locally used and controlled.

Most distance learning technology holds the technology in a central location and then "broadcasts" (e.g., via satellite, Internet) the content to remote locations. This tends to serve two purposes:

- The technology can be updated at one location and disseminated from there, thereby reducing administrative costs of mass distribution.
- The distributed nature of the technology allows soldiers from different locations to train together.

The members of the Infantry community indicated that for the types of training that we were focusing on, that units train together as an integral unit using tactics, techniques and procedures that get adapted to the specific unit. Therefore, while the first benefit of distance learning was applicable, the second actually operated at cross purposes to the way units currently train.

In other words, the Infantry evaluators were of the opinion that there would be very little training with soldiers in different locations. Further, having a single training system that was designed for every unit was at cross purposes with the goal of allowing each unit to customize training to their tactics.

The solution that was proposed was to have a central location for the technology that could be accessed by the different units. However, the desired goal is to allow each unit to download the technology and run it locally, while furnishing them the tools to customize the technology to their specific missions and tactics.

This represents a significant departure to standard distance learning paradigms that may have users access a web site and receive individualized on-line training. This is flawed for several reasons. First, it omits the team training that is central to Army operations. For tasks such as MOUT, the bulk of what needs to be trained is team operations. The standard web-based instruction does not handle this. Second, many distance learning environments are not suitable for team training and will fail when scaled from individual to team training. The Internet is a prime example of this. Team training requires that real-time scenario and event information be made available to all participants in a timely manner. Distributed Interactive Simulation (DIS) networks have as a requirement that transmission can be made in such a manner. The Internet is far too slow and variable in its transmission rates to support real-time team training. The trouble that this runs into is that different trainees can have tactical scenarios that are out of synchronization with each other, thereby influencing what events they think are happening (e.g., one person may think there is an enemy soldier in the same hallway, whereas another might think that the enemy has already left).

The solution we came up with, store the main technology on a central, web-based location, but allow it to be downloaded and run locally, meets these needs. First, the central location allows easy access to the latest updates to the technology, which is consistent with the distance learning intent. Second, having the technology be downloaded and run locally, still moves training from the schoolhouse to the field (thereby realizing the cost savings that distance learning is desired to achieve), but meets the goals of giving the units the opportunity to run the technology on a local network (thus meeting the real-time transmission requirements of team training) and giving units local control of the software so that they can adapt it to their needs. Of course, the latter goal requires that supporting tools be made available so that the software can be so modified.

2. The training be scaled up to focus on platoon leader as well as squad leader and fire team leader training.

The present system allows a squad leader and fire team leader to be trained. Members of the Infantry community expressed a desired to see the MOUT training be scaled to the platoon level. This was so for two reasons. First, it is typically the mission of a platoon to clear an entire building. Therefore, it is the right level of echelon for such training. (It was also noted that the platoon leader was probably less experienced than the squad or fire team leaders and may be in greater need of the training.) Second, the platoon leader's decision making is less procedural than that of the fire team leader or the squad leader. It was felt that for the types of procedures that fire teams and squads carry out, that these procedures can be trained just as well and cheaply using live simulations (e.g., moving in hallways, entering rooms). Platoon leader decision making is far more complex and typically involves decisions that do not lend themselves well to live simulations such as dealing with breaches in buildings, calling in air support and dealing with buildings of different construction. It was generally felt that our virtual schoolhouse technology would be most useful in lower level procedures that characterize fire team leader decision making.

3. There need to be editing tools that allow the users to vary scenario parameters.

The comments from 1. and 2. made it clear that an important direction that we need to take in the future is giving the user community the ability to create their own scenarios. Currently, our technology allows some customization in terms of which doors are open or closed, marked or unmarked, number and location of enemy and civilian forces, whether the enemy are armed or unarmed, well or poorly trained, etc. The two main types of editing tools requested by the Infantry were:

- tools to vary the floor plan and building construction so that different tactics and theaters may be represented (e.g., the flimsy construction of Somalian buildings compared to the more sturdy construction of European buildings) and
- tools to allow the user to construct different enemy doctrines and tactics so that they could depict different threats that soldiers might face. Consistent with this was the desire to allow the enemy forces being played by humans as well as agents.

Differences between the Directorate of Training and the Battle Lab. In the present project, we focused primarily on developing constructive simulations. However, as discussed earlier in this paper, much of the technology being transferred in this effort comes from a separate initiative in which virtual simulations are being developed for MOUT training. We found a general preference in the DOT community for virtual simulations and in the Battle Lab community for constructive simulations. This appeared to be directly linked to their respective interests.

DOT was concerned with leadership training. Therefore, members of this community liked the virtual simulation because it was more immersive and more closely represented what a soldier would see in an actual simulation. Additionally, it was observed that the added graphics might make the training experience more fun and "gamelike" thereby inducing soldiers to seek training on their own time.

training these sorts of decisions as opposed to the The Battle Lab was more concerned with modeling and analysis. In particular, they had a strong interest in mission analysis and mission rehearsal. Therefore, they were more interested in seeing how the events of the battle unfolded and liked the constructive simulation where they could see everything. The virtual simulation provided a "trainee's eye view", although there was a toggle that provided a "sky view" as well.

Also the Battle Lab was particularly interested in conducting the "what if" analyses for the different scenarios. Therefore, they were especially interested in having scenario editing tools that allowed them to change different assumptions of the battle and the simulation model.

REFERENCES

Brna, Ohlsson, S., & Pain, H. (1993) (Eds.) Proceeding of Artificial Intelligent in Education '93. Charlottesville, VA: Association for the Advancement of Computing in Education.

Greer, J. (1995) (Ed.) Proceeding of Artificial Intelligent in Education '95. Charlottesville, VA: Association for the Advancement of Computing in Education.

Leddo, J., Cohen, M.S., O'Connor, M.F., Bresnick, T.A., and Marvin, F.F. (1990). Integrated knowledge elicitation and representation framework (Technical Report 90-3). Reston, VA: Decision Science Consortium, Inc.

NAEP 1992 Trends in Academic Progress (1992). Washington, DC: National Center for Education Statistics.