PEDAGOGICALLY STRUCTURED GAME-BASED TRAINING: DEVELOPMENT OF THE ELECT BILAT SIMULATION

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ABSTRACT

ELECT BiLAT is a prototype game-based simulation for Soldiers to practice conducting bilateral engagements in a cultural context. The prototype provides students with the experience of preparing for a meeting including familiarization with the cultural context, gathering intelligence, conducting a meeting and negotiating when possible, and following up on meeting agreements as appropriate. The ELECT BiLAT architecture is based on a commercial game engine that is integrated with research technologies to enable the use of virtual human characters, scenario customization, as well as coaching, feedback and tutoring.

Because the prototype application is intended to be a learning environment, pedagogy has been central throughout development. The project followed a five-phase process: (1) analyze the training domain; (2) develop a story board prototype; (3) implement a computer version of the training prototype; (4) refine training objectives and link their conditions and standards to game activities; and (5) develop training support content for students, instructors, and training developers. The goal is an authorable game-based environment that uses the pedagogy of guided discovery for training Soldiers in the conduct of bilateral engagements within a specific cultural context.

1. INTRODUCTION

This paper describes the underlying processes used during, and some of the initial lessons learned from, the development of the ELECT BiLAT training prototype, one of the first products of the Learning with Adaptive Simulation and Training (LAST) Army Technology Objective (ATO) program. The purpose of the LAST ATO is to develop tools and methods to prepare leaders and Soldiers for conducting operations against an asymmetric enemy in the Global War on Terrorism.

The ELECT BiLAT prototype is a game-based simulation that provides Soldiers a practice environment for conducting bilateral meetings and negotiations in a cultural context. While it is too early to report on the effectiveness of the prototype as a training tool, there are a number of aspects of this project that are worth reporting to the technology and training development communities. In particular, ELECT BiLAT: (1) addresses a non-kinetic training domain that is relevant to the Contemporary Operating Environment (COE), (2) employs customized game-play mechanics to provide a more immersive and interactive experience, (3) makes extensive use of story-based scenarios, (4) leverages virtual human and game technologies to support social interaction, (5) incorporates intelligent tutoring to enhance the learning experience, (6) was designed to enable rapid scenario development and modification (i.e., the scenarios are authorable by the end-users), and (7) used a pedagogically-oriented, five-phase approach throughout the development of the training prototype.

While the five-phase approach described below reflects many of the best practices of the training development community, what was special in this case was that it was applied across the processes of a multi-disciplinary enterprise comprising technologists, game

designers and industrial game developers, creative writers, psychologists and Soldiers. The LAST ATO partners include the Army's Research, Development and Engineering Command's Simulation and Training Technology Center (RDECOM STTC), the University of Southern California's Institute for Creative Technologies (USC-ICT), the Army Research Laboratory Human Research & Engineering Directorate (ARL HRED), and the Army Research Institute for the Behavioral and Social Sciences (ARI). This team worked collaboratively to develop a game-based training prototype that leverages findings from the science of learning and provides a sustainable pedagogical structure by using training objectives as a focal point.

Whereas there are many examples of commercial games that have been adapted to support military training objectives, ELECT BiLAT is a game-based training application built from the ground up with specific end-state training objectives in mind. The pedagogical design section describes an explicit framework for developing training objectives and refining them as the training application is built. The goal of this paper is to describe the framework so that other developers can incorporate it into their future efforts to produce pedagogically sound, interactive, virtual training systems. In addition, this paper reports on some of the lessons learned in the course of developing this tool.

2. BILATERAL ENGAGEMENT

The purpose of the ELECT BiLAT training prototype is to provide Soldiers with an interactive, game-like simulation for practicing their skills in conducting meetings and negotiations with local leaders in a specific cultural context. For ELECT BiLAT, the training domain of bilateral meetings was chosen for its importance in current and future stability, security, transition, and reconstruction operations (Department of Defense, 2005; Chiarelli & Michaelis, 2005).

The term 'bilateral engagement' is used to describe the intentional activities of discussion, conference and negotiation that take place between two parties to bring about agreement (Wunderle, 2005b). In a military context, bilateral engagements occur at all levels of command, from squad leader to the general officer level; it is an activity that must be integrated with other operations in order to yield a successful campaign in a region. Another reason for the importance of mastering this skill set is that a successful bilateral engagement can save lives by defusing situations within a town or region where there exists the potential for agreement rather than violence. Lack of proficiency in this domain has the potential to cause second- and third-order effects with long-lasting negative consequences.

Wunderle's (2005b) approach to bilateral engagement in military operations was one of the most influential sources in the design of the ELECT BiLAT prototype. Wunderle draws heavily from Ury and Fisher's (1991) work on principled negotiation, and he mapped these principles onto the military decision-making process. Wunderle emphasizes the preparation phases of a bilateral engagement[1] and not only identifying one's own intended outcomes but also identifying and anticipating the objectives of the meeting partner. This analytical process maps to two of Ury and Fisher's negotiation principles: (1) separate the people from the problem and (2) focus on interests, not positions. Successfully applying these principles requires extensive research to identify the problem and the interests of the partners.

Following the initial analysis of the objectives and interests of both parties, the next phase of Wunderle's methodology is what he calls, "develop intended outcome strategy," which maps to a third negotiation principle from Ury and Fisher (1991)—invent options for mutual gain. It is during this phase that the planner needs to identify a bottom line that serves as an acceptable alternative outcome to the intended outcome. While this process does not guarantee that the planner will identify an option that maximizes mutual gain, higher headquarters can suggest win-win solutions during this phase through coaching and feedback.

After planning is complete, the meeting is conducted, with particular attention being paid to time management and sequencing. While the planning process is a necessary condition for success, the ability to interact at a personal level is also crucial. Again, good preparation can help, especially if it includes gaining an understanding of the cultural background of the meeting partner. Wunderle (2005a) suggests that understanding the culture[2] such as communication styles, perception (both ways) and how respect is shown (or not) profoundly influences the outcome of a bilateral engagement. Ury and Fisher identify these same factors as crucial in principled negotiation. These thoughts were also echoed by the Officers who shared their personal experiences during interviews for this project.

Finally, following the meeting, it is critical that the leader follow through on promises made, identify outstanding issues, and plan next steps. In many cases, the knowledge gained from one bilateral engagement may have a direct bearing on who the next meeting partner

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[1] Wunderle equates this process to intelligence preparation of the battlefield (IPB, Department of Army, 1994).

[2] Wunderle defines culture as a shared set of traditions, belief systems, and behaviors.

should be and what issues are raised in subsequent meetings.

3. GAME-ORIENTED DESIGN

USC-ICT engaged faculty and students from the Game Innovation Laboratory[3] of the Cinema-Television School at USC to design a game-like simulation that would implement the principles and processes just described. As described later, ARL-HRED and ARI , in collaboration with researchers from USC-ICT, performed a task analysis on key materials that detailed the steps and considerations in the process of conducting bilateral negotiations. The result was a set of training objectives that the ELECT-BiLAT prototype needed to address. The game design team proceeded to create a story board prototype that allowed them to iteratively test game play mechanics before committing to the expensive step of writing computer code and creating artwork. The prototype was play-tested internally and with subject matter experts. In each phase of testing the feedback was factored into the design of another version of the system.

In the end, the game was designed to focus the student on performing tasks directly related to the training objectives identified during the task analysis. The design supported the concept of a multi-phase process for bilateral engagement: meeting preparation, rehearsal, conducting the meeting, and after action review. The game play experience depended on the attention to details in the process (e.g., the modeling of constraints like time, resources, and trust). For example, during the preparation phase, each information resource accessed by the student is associated with a time cost associated. However, the game does not have to model actions in real-time. Rather, time is deducted from an in-game clock to represent how long it might have taken in the real world to track down the information and process it. During the meeting phase, the attitude of the meeting partner is affected in part by the level of trust that has been generated by earlier actions and things said. The trust variable is one of a number of variables that affect the game play, but it is the only one exposed to the student. It is a simplistic representation of a complex behavior but serves as a way of reminding the student of the importance of building trust with the meeting partner.

One of the criticisms of game-based training has been that that there is too much emphasis on graphics and the "wow!" factor at the expense of training effectiveness (Hays, 2005). This need not be the case, because there is some empirical evidence on how to develop effective immersive training systems (Ricci, Salas, and Cannon-

Bowers, 1996). Garris, Ahlers, and Driskell (2002) highlight game features leading to better training performance. Campbell, Quinkert, and Burnside (2000) suggest that structuring training based on training objectives leads to improved training outcomes. Belanich, Sibley, & Orvis (2004) found that trainees are more likely to recall game content if the "storyline" is relevant to the training objectives. Based on these results, the design philosophy behind the ELECT-BiLAT training game was to take a training-objective-centric approach to game design in concert with game designers.

4. STORY-BASED SCENARIOS

A crucial component of the ELECT BiLAT prototype is the use of story-based scenarios. A training experience in ELECT BiLAT does not end with a single bilateral meeting, rather, it is a series of meetings that accomplish a broader set of mission objectives. This aspect of the game design reinforces the notion that Army leaders are dealing with complex social networks that interconnect and affect one another in sometimes surprising ways.

The scenarios were loosely based on open-source stories about problems encountered in different locales around the world. The writers developed fictional characters with varying backgrounds and attitudes that require the player to understand each individual, their interests and issues, and their cultural background as it relates to the others in the social networks of the scenario.

There is a qualitative difference between a story-based scenario and the event-based scenarios that are typically used to drive military simulations. Stories have rich characters with the power to engage the user during interactions. Good stories have interesting plots, with dilemmas, suspense, and unexpected twists. A well designed story contains many links among characters and events, so it is not just a physics-based cause-and-effect experience, rather, "social physics" are at play, which are much more unpredictable. A well-crafted story-based scenario allows the student to have a social experience that is not achievable in an event-driven simulator.

5. TECHNOLOGIES

The ELECT BiLAT prototype is structured around the major phases of a bilateral engagement: preparation, rehearsal, meeting and after-action review. While each phase requires specific functionality, they all share the need for visualization and a user interface. ICT's Integrating Architecture (IA) (van Lent, et al., 2004)—a communications and software platform supporting research component integration—provides the graphical environment via an embedded Unreal 3D game engine

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[3] Including Prof. Scott Fisher, Prof. Chris Swain, Prof. Peggy Weil, Jesse Virgil and Jessica Rosenblatt.

commercially available through Epic Games. To support the needs of the game play and scenario content, as well as the goal of authorability, the system architecture underneath the platform was designed as a service-oriented, heterogeneous and network-based architecture consisting of discrete agents providing the following functions: graphical user interface, dialogue management, social simulation, experience management, character animation, online coaching and reflective tutoring.

The Experience Manager (EM) supports the preparation phase whereby the trainee conducts research and rehearsals prior to engaging with the selected meeting partner. The EM manages character availability, the research available on each, and the set of game objectives requiring completion to progress in the scenario. It is also responsible for initializing the game environment prior to the meeting starting. The preparation phase is very information-intensive, and required several usability studies in order to finalize an accessible interface. Preparation was also authoring-intensive requiring scenario details that could be discovered and then linked to executable actions in the meeting to follow.

Meetings in ELECT BiLAT are enabled through a simulation that requires the support of several components. The Dialogue Manager (DM) handles turn-by-turn conversation for the virtual character and passes utterances to Smartbody for non-verbal behavior generation. Smartbody sends these animation and speech timing signals to IA in order to render the character's onscreen performance. Throughout the meeting, the user is assisted by the coach based on relevant meeting traffic. The coach relies on the tutor system's knowledge database that is populated with pedagogical meta-information for the entire meeting. Finally, the Psychsim social simulation determines negotiation decisions during the sub-phase of the meeting where business terms are being offered and requested.

Authoring scenario details for the meeting consisted of building high-level meeting actions (e.g., flatter host) and specifying the possible effects on the meeting partner. Dialogue utterances were written and then mapped in the system to an effect on the meeting partner. They could also be mapped to spontaneous conversational interjections triggered by defined pre-conditions (e.g., the meeting partner offering tea when pleased with how the meeting is progressing).

All meeting actions were linked to training objectives that are tracked by the coach and tutor system. Dialogue utterances are then processed through a non-verbal generation and speech workflow to cache the Smartbody animation data needed. Finally, the more strategic negotiation actions are defined and parameterized with

respect to meeting partner goals for consideration by the PsychSim system.

To complete the game cycle, an after-action review follows all meeting engagements and is hosted by the reflective tutor. During a simulated meeting, the tutor dynamically builds an agenda to review with the trainee. The post-meeting walkthrough consists of a Socratic discussion of both positive and negative meeting events. Visualization was supported by the Dialogue Manager's utterance history and a "VCR" playback via Smartbody in a virtual video display. At the conclusion of the analysis session and the meeting cycle, the trainee returns to the objectives status screen in order to consider what to do next based upon what s/he has learned.

The software infrastructure supports the overall training objectives of the game as well as the scenario content needed to provide an immersive student experience. Some of those components were the result of the transition of research technologies, many of which were never previously available for game environments.

The SmartBody project (Lee & Marsella, 2006; Kallmann & Marsella, 2005) is part of the ICT's virtual human project (Swartout et al, 2006). SmartBody was designed to employ a range of different animation techniques. Most significantly, it supports an approach to procedurally generated animation that generates behavior dynamically and automatically, given an utterance. The integration of this technology makes it possible to more rapidly generate and modify scenarios beyond what is currently contained within the system.

PsychSim (Marsella & Pynadath, 2004; Pynadath & Marsella, 2005) is an AI framework for implementing social simulation and provides a great deal of power to model the impact that group membership has on the attitudes of a meeting partner, and vice versa. To facilitate the authoring of PsychSim models, a tool was developed that takes an author-provided high-level specification of the negotiation participants and automatically translates that specification into PsychSim models. PsychSim also provides explanation facilities for its behavior that will eventually be coordinated with the explanation and dialogue capabilities of our Explainable AI (XAI) system.

6. COACHING AND REFLECTIVE TUTORING

For learning to be effective it should be *guided* (Kirschner, et. al., 2006). To provide guidance in ELECT BiLAT, an intelligent tutoring system (ITS) is included as a key component of the system. Building off previous work (Lane, et. al., 2006), two kinds of ITS technology were implemented: a *coach* and a *reflective tutor*. The coach is used during meetings to provide feedback and

hints, while the reflective tutor works with the coach to guide after-action reviews (AARs).

The coach runs in the background watching every action taken by the player during meetings. Each action is assessed as correct, incorrect, or mixed. To make this determination, it consults an *expert model* (also part of the ITS architecture) that looks up the learning objective(s) associated with the action and whether or not that action moved the negotiation partner closer to an ideal state (e.g., when trying to build trust, did the action actually improve trust?). The coach also decides whether or not to give explicit feedback after each action by consulting pre-configured settings. For example, an instructor can adjust the coach to give only negative feedback after errors. Or, the coach can be set to give positive feedback on a schedule (e.g., every second correct action), or in some combination with negative feedback. Finally, the coach maintains a rudimentary model of the learner based on learning objectives, and can give targeted feedback when certain learning objectives are active.

Since there is little time for extended periods of discussion during a meeting, effort was taken to keep coaching utterances short and to the point. Using the coach's assessment, the reflective tutor generates an *agenda* of topics to discuss during the AAR. The tutor then uses a cognitive model that includes a variety of tutoring tactics to address these topics. With such tactics as direct feedback, conceptual questioning, "what else" questions (asking about alternative courses of action), and XAI investigations (allowing students to ask virtual humans in the game to explain their actions), the reflective tutor is able to go beyond simple mission statistics and discuss the conceptual issues of the domain.

7. PEDAGOGICALLY ORIENTED DEVELOPMENT PROCESS

The development of ELECT BiLAT started with a critical assumption: the game environment is not a vehicle by which learning is delivered, but rather it provides a practice environment to augment and internalize lessons learned. Prior to interacting with the ELECT BiLAT training prototype the student should receive instruction on how to conduct a meeting engagement, how to negotiate, and how the particular culture being studied will influence the conduct of meetings and negotiations.

One lesson learned thus far is there are at least five phases in the process of developing an immersive training system that is pedagogically-structured and designed so that new scenarios can be authored. The phases of the development process identified here are: (1) analyze the training domain, (2) develop a story board prototype, (3) implement a computer prototype, (4) further specify and refine training objectives, conditions and standards and, (5) develop training support material. While this process was used specifically for the ELECT-BiLAT training game, it could also be used by other training system developers who are interested in producing pedagogically structured, immersive training environments.

1. Analyzing the Training Domain. The first stage in the rapid development of this training application began with examining the Contemporary Operating Environment (COE) to determine the focus of training for the application. The next step was to organize the knowledge and skill domain of what would be trained. However, there was no prior official delineation of this training domain, which clearly represents a "wicked problem," with better or worse rather than right or wrong solutions (Rittel & Weber, 1973). Therefore, this required the development of training objectives based on a task analysis of the domain.

Project team members interviewed subject matter experts (SMEs) and reviewed available literature in the training domain as part of the cognitive task analysis process (DuBois & Shalin, 2000; Hackos & Redish, 1998). This process of identifying and organizing training domain content started with discussions and interviews in conjunction with the initial Army customer, but also included other interviews at various military facilities with related domain experience. SMEs were asked about appropriate and inappropriate actions, the conditional variables that influence specific courses of actions, and how they currently instruct trainees. SME interview data was combined with available documentation specifying the necessary phases, tasks and key personnel. The documentation used as primary references for this information included field manuals (Air Land Sea Application Center, 2004; Department of Army 1993, 1994), articles written by deployed military personnel and leaders (Heidecker & Sowards, n.d., 2004; Karabaich, 2005), and research reports (Meliza, 1996; Morrison & Meliza, 1999).

These data were then coalesced into training objectives that indicate appropriate and inappropriate tasks, based on specific conditions, and the standard to which these tasks should be demonstrated; a format familiar to Army instructors (Department of the Army, 2003). Each training objective consisted of three sections: the general description of the training objective, the conditions where the training objective was relevant, and the standards indicating the actions that would demonstrate adherence to the training objective.

One training objective identified was the use of a win/win strategy during negotiation (described in section 2). During the training domain analysis process, LTC Wunderle and three other Army SMEs emphasized the

importance of win/win. To illustrate the role pedagogy played throughout the development process, the impact of this training objective on the development of the training tool will be described in the subsequent steps.

2. Develop Story Board Prototype. As described in section 3, the game designers developed a paper and pencil prototype, or story board. This prototype game design was linked to the results of the analysis phase. An instructional planning document based on the task analysis and the training objectives was developed to delineate the training domain information and outline the requirements of the game. Pedagogical controls were also drafted (e.g., how feedback could be structured), and implemented in the paper board-game.

The prototype was demonstrated for instructors that would ultimately use the training system and additional Army personnel. The feedback gained from these demonstrations was used to guide modifications to the training game before subsequent demonstrations in an iterative development process. The use of a paper prototype allowed for rapid modifications to the prototype without incurring expensive and time consuming computer programming resources. It was also during this phase that in-game content started to be created based on SME vignettes. The content was tied to the training objectives and validated by SMEs. The training objectives were used as an information source for game content (characters, stories, etc.) and the training objectives served as an overarching framework.

For example, the win/win strategy for negotiation was integrated into two key game design elements identified in this prototype. First, the preparation phase of the game required the player to identify the negotiation partner's desired outcomes promoting a win/win framework by promoting a student's understanding of a negotiation partners needs or wants (e.g., a police captain needs helmets and flashlights for his officers).

The second aspect of the game reinforcing this training objective was identified in the actual negotiation phase of the game. If the student learned about the need for helmets and flashlights, s/he was expected to try to acquire those resources, then offer them during the negotiation. Without these to offer, the student would not achieve a win/win outcome and the chances of successfully negotiating would be reduced.

3. Implement Computer Prototype. Using the paper prototype as a development plan, the transition to a computer prototype was initiated. This included design of the user interface, implementation of the game mechanics, implementation of the authoring environment, and encoding of the initial scenario content. As this occurred,

further SME feedback was incorporated to validate game mechanics and content.

When working versions of the system were available, playability testing was conducted with training instructors and other Army personnel. Playability testing provided an important iterative role in the development process. By putting pre-alpha game versions in front of end-users, feedback could be collected about game mechanics, in-game content, and realism of Army tactics, techniques, and procedures (TTPs) modeled in the computer environment.

An authoring tool was developed along with the initial prototype. It promotes a pedagogical approach to content development by situating training objectives as the fundamental component of a new scenario, requiring that they be created first. As game content is developed, the learning objectives are linked with relevant training objectives so that the coach can perform assessments and the reflective tutor can conduct AARs. The win/win training objective is connected to game actions such as telling your partner that the "U.S. wants to cooperate and work with the Iraqi police" (an example of the subtask of developing relationships).

4. Refine Training Objectives, Conditions and Standards. As described above, the training objectives and their related sub-tasks were refined, and linked to game actions as a means of "scoring" and continuous assessment. The ITS in the game monitors play on a turn-by-turn basis and keeps a record of the learner's successes and failures. A second benefit of explicitly linking training objectives to game content is that it provides an indirect confirmation of the game content. That is, if it is found that certain game actions do not seem to support any training objective, or that some training objectives are "orphaned", then it is clear that revision is needed.

This organization of training domain content allowed for the identification of commonalities among tasks that were considered appropriate, tasks that were considered inappropriate, and the conditions that influenced the appropriateness of these tasks. This structuring included both what should be done and what should be avoided, which allowed the ITS to identify both correct and incorrect responses and the conditions that influence the appropriateness of actions.

For example, if the student selects the action to tell his/her partner the U.S. will cooperate with local police at the appropriate time – during a business phase – the coach will recognize this as a positive action, and if the positive feedback is "turned on," deliver the message "This action builds trust and rapport," which reinforces the training objective of creating win-win situations. If the student needs a hint, the message would be "How can you

collaboratively resolve this conflict?" If the action is taken during a "social" period, it will be considered an error. A different training objective in the game is to follow the social lead of the host – if the player attempts to talk about business before being cued to do so, there are similar (negative) feedback messages for that case. The reflective tutor can devote more time to discussion since it runs after the meeting when it won't break the flow, so its utterances include deeper explanations for why actions are good or bad and may discuss possible alternative courses of action.

5. Develop Training Support Material. Lastly, a set of learning material and instructions for training developers, instructors and students was produced to allow for turn-key employment of the learning application, either as part of an existing Program of Instruction (POI) or as a stand alone learning module.

This training support material includes introductory information on the training domain so that trainees can learn the information that they will practice while using the ELECT-BiLAT training system. Also included in the support material are directions for instructors on how to use the game interface, work through the phases of the game and ideas on how to use the game to promote discussion and learning in a class. Much like the reflective tutor, these training materials help tie the training objectives to the game content. In the case of the win/win example, the materials provide background and examples to show how an instructor might discuss successful negotiation tactics in the context of the game.

8. CONCLUSION

In the past, some of the difficulties with game-based training included a lack of appropriate instructional techniques, unrealistic or inappropriate training scenarios, and poor communication between instructors/SMEs and game developers (Belanich, Mullin, & Dressel, 2004; Hays, 2005). In the ELECT-BiLAT project these concerns were addressed by developing a system based on sound pedagogical principles, creating training scenarios drawing on and validated by the instructors and SMEs, and applying an iterative development process with frequent interaction between instructor/SMEs and the training system developers.

As part of the goal to create a rapid development framework, work is being done to make in-game content and functions authorable. These tools are being targeted at a number of different users. One user is an instructor who could use desktop and web-based tools to manipulate and generate content without the support of a programmer. Another user is the training developer who will build and maintain the applications. And, finally, some of the tools

and methods being developed such as the SmartBody animation engine aim to reduce the authoring needs of the content developers.

The development framework used for ELECT BiLAT has already yielded much in the way of defining a deliberate approach for the development of game-based learning applications. The use of training objectives, based on a task analysis of the training domain, as the foundation for developing pedagogically sound training provides implicit validation of game content, promotes relevant tutorial feedback, and acts as the basis for automated assessment. This structure allows game-based training to be developed with clear learning goals and a means to reach those goals. Such training systems will provide our Future Force with the skills needed to be successful.

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