URBANSIM: A GAME-BASED INSTRUCTIONAL PACKAGE FOR CONDUCTING COUNTERINSURGENCY OPERATIONS

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ABSTRACT

Operation Iraqi Freedom and Operation Enduring Freedom have identified the need for instructional and training solutions that develop the skills of Battalion and Brigade Commanders in formulating situational understanding in order to successfully lead operations in a counterinsurgency environment. In this paper we describe the UrbanSim Learning Package, a game-based instructional software suite for Commanders and their staffs for directing and coordinating full-spectrum operations where the stability component is predominant. We describe a formal instructional design approach to the development of this instructional software, which consists of a component that introduces key concepts in counterinsurgency operations and a component that allows students to develop their skills in a simulated counterinsurgency environment. We describe how intelligent automated tutoring is used to provide formative feedback to students in the practice environment, and discuss our approach to student performance assessment.

1. INTRODUCTION

In the book *Fiasco,* Thomas Ricks points out that many of the tactics initially employed by U.S. commanders in 2003 "led away from the strategic goal of winning the political support of the Iraqi people" (Ricks, 2006). Conventional tactics achieved overwhelming successes in the initial stages of operations in Iraq. However, it quickly became apparent that the technological advantages of the U.S. forces were countered by the unconventional tactics of an insurgency. The U.S. forces were going to need to "relearn the principles of counterinsurgency (COIN) while conducting operations against adaptive insurgent enemies." (FM-3-24, 2006). This need led to the development of the Counterinsurgency Field Manual, FM 3-24/MCWP 3-33.5 to better understand insurgent operations and tactics to counter these operations through a combination of offensive, defensive, and stability means. Additionally, significant updates were made to the Operations Field Manual (FM 3-0), which now dedicates an entire portion to a discussion of the tactics, techniques, and procedures for planning, preparing, and conducting full-spectrum operations (FM 3-0, 2008).

Today's Army leaders face extremely stressful and demanding missions that are, in many cases, not covered by standard tactics and doctrine. These operations, which combine both lethal and non-lethal aspects of warfare, are referred to by Dr. David Kilcullen as "armed social work," in which U.S. and Host Nation forces attempt to "redress basic social and political problems while being shot at" (Kilcullen, 2006). The training challenge is to develop adaptable leaders who function effectively in complex environments and succeed in novel situations unlike any they may have experienced in the past (ATDLP, 2003; Wong, 2004).

In this paper, we describe the UrbanSim Learning Package, a game-based instructional software suite for battalion and brigade commanders and their staffs for directing and coordinating full-spectrum operations with a "stability-focused" component. UrbanSim's focus is predominantly, but not exclusively, on non-lethal operations in support of the local citizenry and government that take place after primary offensive and defensive efforts have concluded. We discuss the instructional approach, the design and development of the student experience, mechanisms for measuring performance, the role of intelligent tutoring and assessment, and our lessons learned throughout the instructional design lifecycle. Although the instructional and system designs employed for UrbanSim target the battalion and brigade command level, there are generalities within the approach that make it suitable for a variety of stability-focused domains, including interagency and joint operations, higher echelon

command (Corps and Division), and even non-military operations (non-government organizations, State Department).

2. INSTRUCTIONAL DESIGN

The UrbanSim Learning Package has adopted a formal instructional design approach to guide the development of the underlying experience. This design approach has proven successful in the development of the ELECT BiLAT training system (Hill et al., 2006), a precursor to UrbanSim that focuses bilateral negotiations with cultural awareness. Building on the lessons learned from ELECT BiLAT and applying the principles of Guided Experiential Learning (Clark, 2004), a set of processes were employed that would determine how the UrbanSim instructional software would be developed, tested, deployed, and used in a classroom setting. This section describes the seven steps of this process, including lessons learned, as they relate to UrbanSim.

2.1 Step 1: Identify the training context

The first step in the design approach is to identify and understand the context in which the instructional software will be used. For UrbanSim, the target training audience is students in the Tactical Commander Development Program at the School for Command Preparation, Ft. Leavenworth. Instructors highlighted the need to give future battalion and brigade commanders attending this course the opportunity to practice directing COIN operations. While sufficient curricula materials already existed for traditional symmetric, force-on-force style operations (i.e., offense, defense), there was a gap in less traditional stability-focused operations. As a result, it was determined that UrbanSim would target this area and include the capacity to provide practice in directing operations in these kinds of missions. The goal identified for the UrbanSim instructional package was to provide future battalion and brigade Commanders with an interactive experience, allowing them to practice full-spectrum operations where stability is predominant.

After identifying the training domain, the integration of UrbanSim into the current program of instruction was considered. This involved determining how much time could be devoted to the topic (both in class, and as assigned work out of class) and how to realign the current program of instruction so as to open up this time.

Next, an initial set of learning objectives was identified for the educational package. A learning objective is a "statement of what students will be able to do when they have completed the instruction" and is articulated as quantifiable, measurable verbs that signify a demonstrable learning outcome (Arreola, 1998). Formulation of the initial learning objectives required several discussion sessions with instructors and subject matter experts. These learning objectives focused on how to develop situational understanding, develop and describe the Commander's visualization, think during decision-making and directing actions, and self-assess progress in stability-focused environments.

2.2 Step 2: Conduct a Cognitive Task Analysis

Upon formulation of the initial set of learning objectives, a Cognitive Task Analysis (CTA) was conducted. A CTA is a process that employs specific interview and observation strategies to extract both the explicit and implicit knowledge that experts use to perform a certain task (Schraagen et al., 2000). The task associated with commanding a battalion is defined as complex because it requires the use and coordination of both controlled (conscious) and automated (procedural) knowledge that extends over a long period of time (Van Merrienboer et al., 2002). The results from a CTA describe the detailed skills required to *successfully* complete the complex task. The intent is to organize and give meaning to observable behavior through the "unpacking' of knowledge. For UrbanSim, CTA interviews were conducted with experts that included battalion Commanders who recently returned from the Iraqi theatre. Through these interviews, the goals of UrbanSim were further refined to include gaining and maintaining the support of the local population within an area of operations to achieve a safe environment secured and governed by the Host Nation. The CTA also multiple measures are used to gauge success, including Measures Of Effectiveness (MOE) and Measures Of Performance (MOP). The sequence of procedures used to accomplish this task were to 1) conduct mission analysis, 2) conduct deliberate reconnaissance, 3) review and approve targeting-synchronization matrix, and 4) assess progress toward achieving overarching outcomes.

These high-level procedures laid the framework for the package's final set of terminal learning objectives and provided the pedagogical foundation for the detailed instructional design in Step 4 below. The final set of terminal learning objectives were as follows:

1. *The Population is the Center of Gravity*: the student should understand how to create a safe, secure, and prosperous population that is the cornerstone to self-sustainment and a functioning Host Nation government.
2. *Conducting mission analysis*: the student should employ higher headquarters products and running staff estimates to formulate and continuously update a complete situational understanding and visualization of the battlefield.
3. *Conduct mission planning:* the student should develop the set of products that allows them to

articulate a desired end state and courses of action for a COIN operation.

4. *Directing action*: student's use staff, subordinate, and higher headquarters updates to direct action in a COIN environment to a) continuously update and refine the student's situational understanding, b) advance towards achieving their desired end state, and c) anticipate 2nd and 3rd order effects.

5. *Assessing performance:* the student should employ lines of effort (LoEs), MOEs, and MOPs to self-assess mission progress in a COIN operation.

2.3 Step 3: Formulate the initial instructional design

In this design approach, the task objective, procedures, and specific tasks identified by the CTA (along with the terminal learning objectives) are used to develop an instructional design that operates within the limitations of the training context (see step 1). For UrbanSim, these considerations led us to an instructional design that consisted of two separate, but intertwined, components: a *Primer* and *Practice Environment*. Though the CTA identified specific tasks that a Commander could take to be successful in a COIN operation, it was found in steps 1 and 2 that students entering the Tactical Commander Development Program at the School for Command Preparation required additional practice to regain the working and conceptual knowledge necessary to execute these tasks successfully. Therefore, a Primer was introduced to provide a student with the core conceptual and associated task knowledge that would allow them to be successful in the game-based Practice Environment, described further in section 3.

2.4 Step 4: Performance measurement

For an instructional application such as this, the primary reason to measure performance is to gather data that can be used to give the student feedback and to steer their future thinking in the right direction. There are two kinds of performance measures that can be used in this manner: *outcome* measures and *process* measures. Outcome measures are derived directly from the state of the world. One type of outcome measure is factual information about the environment. For example, how many IEDs were detected this week compared to last week? The other type includes attitude measures from the local simulated populace. The intelligent agents in UrbanSim Practice Environment have beliefs and goals; therefore we can "poll" the simulated population to assess their attitudes (e.g., Do you support attacks on the host nation military?). Because the ultimate goal of COIN operations is to gain the population's support for the host nation government, and this is one of the main points we want our students to appreciate, it is important to be able to track the course of such measures, and use them to provide feedback to students.

Process measures are concerned less with the state of the world, and more with the way in which students make decisions. The training goal is to shape student thinking to follow the themes (or terminal learning objectives) falling out of the CTA (section 2.2). In a computer-based learning environment, however, we are limited to the interactions between the student and the user interface. It is therefore important to design the user interface so that observable user interactions support inferences about underlying cognitive processes. For example, if a student never takes an action to advance a particular LoE, it can be inferred that advancement of this LoE does not figure prominently in their decision-making. To infer attention to the different LoEs, then, the interface (and game mechanics) should support which LoEs the student is primarily trying to advance with each action taken. There are several challenges involved in designing these types of measures into the training system. First and foremost is determining inference rules by which cognitive processes (or lack of them) can be inferred from patterns of system interactions. Another challenge is designing those measurement opportunities into the system without them becoming so intrusive as to undermine the flow of the simulated mission. The most important outcome measure used in UrbanSim is how much time the student spends in each of the various user interface displays. This value is tracked during the course of a scenario to determine whether emphasis is placed to heavily on a particular type of view (such as the map), while disregarding the other views critical to the mission (network display, LoEs, MOEs, running staff estimates, etc).

2.5 Step 5: Identify technologies and develop a prototype

Once the instructional design has been created and performance criteria identified, a brief but thorough review of appropriate technologies should be conducted to identify candidates that best meet the pedagogical needs of the classroom. Performing this step before an instructional design has been created poses significant risks because the design ends up being constrained by the limitations (or features) of the technology. Immediately after identification of candidate technologies, a prototype should be rapidly developed and delivered to the instructors to highlight the features of the instructional design. Rapid prototypes can also assist with managing expectations by providing the customer with a preview of the courseware and its functionality. With assistance from the University of Southern California's Game Innovation Lab, a Microsoft Excel-based application was created that allowed a player to direct action with subordinate units in a COIN operation and see effects on the world state. From here, a primitive virtual representation of this Excel-based program was created with an off-the-shelf 2D game engine. Although this early prototype differed significantly from the final version of the game-based

Practice Environment, it did provide instructors with a concrete idea of the intended learning experience. It also supplied the instructional design team with input from the classroom regarding modifications to the mechanics and interactions with the software.

2.6 Step 6: Production

After the prototype has been demonstrated and input received from the classroom, the instructional design formulated in Step 4 is adjusted and finalized. Production then commences with development of the underlying courseware, always keeping the classroom abreast of progress and adjustments to the instructional design. This communication proves invaluable as the classroom is able to inform the design team of potential changes in the curriculum, which may or may not require shifts in the design. Upon development completion, various forms of testing takes place, ideally within the classroom when the courseware is in a stable state. Finally, initial deployment to the classroom occurs after testing and quality assurance is complete. The first versions of the two UrbanSim instructional components (Primer and Practice Environment) were produced at the USC Institute for Creative Technologies along with industry partners, and are described in section 3.

2.7 Step 7: Courseware assessment

After initial deployment, user testing and assessment is conducted that will provide suggestions for the refinement of the user's experience which may, or may not, include refinement of the instructional design. This is a critical step in the courseware lifecycle process as it ensures the courseware does not become stale over time, or as the course makes changes to its curriculum. Though this refinement cannot occur in perpetuity, it is important to keep the channels of communication with the classroom open long after the courseware is delivered. Strategies for assessment of the UrbanSim Primer and Practice Environment are discussed in section 5.

3. URBANSIM SYSTEM DESIGN

As discussed, UrbanSim consists of two separate, but intertwined, components. The Primer introduces the student to the core principles and associated tasks for conducting stability-focused operations using interactive video clips, stories, part-task practice sessions, and reading materials. The Practice Environment allows the student to conduct such an entire operation, from planning through assessment. Employing the principles from Guided Experiential Learning, these two components provide the student with the core concepts and task knowledge necessary to command units within the contemporary operating environment.

3.1 The UrbanSim Primer

The UrbanSim Primer introduces the core concept and task knowledge required for a future battalion commander to successfully command in a COIN environment. It takes the form of an interactive tutorial that guides a student through the required conceptual knowledge and associated tasks for conducting a COIN operation. Taking approximately one to two hours to complete out of the classroom, the Primer prepares the student for when they enter the complex Practice Environment. It is broken into eight lessons, each of which contain a narrative, interview segments from former Commanders, and an actual interaction with the Practice Environment software as a means of demonstrating the task to the student. The eight lessons in the UrbanSim Primer are:

1. *Population is the center of gravity*: how a Commander can provide for the population's protection, welfare, and support
2. *Higher headquarters' products*: products provided from above that guide the planning of the operation, i.e. Operations Order, Commander's Critical Information Requirements (CCIRs), and LoEs
3. *Intelligence gathering and analysis*: running staff estimates that allow a student to conduct Intelligence Preparation of the Battlefield, including Political, Military, Economic, Social, Information, Infrastructure (PMESII) and Sewer, Water, Electricity, Academics, Trash, Transportation, Medical, Fuel (SWEAT-MF) analyses
4. *Navigating human terrain*: additional staff estimates that includes human intelligence and social networks
5. *Student products*: student-created products. In the case of battalion commanders: Commander's Intent, LoEs, CCIRs, MOEs, and a running sync matrix
6. *Anticipating 2nd and 3rd order effects*: how to use the products above to learn how to anticipate intended and unintended effects in a COIN fight
7. *Execution*: how to employ the appropriate strategy to in a COIN fight (clear-hold-build, active versus reactive, combined action, limited support)
8. *Assessment*: how to measure success in an ill-defined domain such as COIN. Using quantitative and qualitative metrics to interpret LoE advancement

One of the unique features of the UrbanSim Primer is its arrangement around the Guided Experiential Learning model of lesson structure (Clark, 2004). For each lesson in the UrbanSim Primer, the student is walked through a series of lesson parts that are derived from the pedagogical lesson format of this model:

First, the student is presented with the lesson's learning objective, describing what the student will be able to accomplish in a COIN operation after completing the lesson that they were unable to accomplish before the

lesson. For example, the student will learn how to develop battalion commander products, such as the Commander's Intent, CCIRs, LoEs, and MOEs for a stability-focused mission. Second, the student is presented with the reason why achieving the learning objective will enable the Commander's success in a COIN operation. For example, correctly employing LoEs will assist the Commander in formulating a complete situational understanding of the battlefield.

Third, the student is presented with an overview, using visual models and a brief description, of the lesson's placement in the overall Primer, as well as lesson parts that comprise it.

Fourth, the student is presented with the concepts, processes, and principles that are the prerequisite knowledge for learning the specific procedure outlined in the lesson. For example, a CCIR would be described along with how it is used in a COIN setting.

Fifth, the specific task or capability that a Commander must possess is demonstrated or articulated through interviews, visual cues, and interactions with the Practice Environment software. As an example from the UrbanSim Primer, a student is presented with a snippet from an interview with a former battalion commander of how MOEs allowed him to gauge success in his area of operation. The actual procedure for authoring an MOE in the Practice Environment is then demonstrated.

Sixth, the student is then directed to the Practice Environment software where they practice the procedure themselves. The environment in which the practice takes place begins with easier scenarios, and increasingly becomes difficult as the student completes various lessons. The increase in complexity is cumulative, with the more difficult exercises building upon knowledge/results from the simpler exercises. Additionally, guidance from the Primer weans as the student progresses through each part of the lesson. For example, after the player has authored a Commander's Intent in one lesson part, they will then use that Commander's Intent to identify their CCIRs in a subsequent lesson part. Areas of and interactions with the Practice Environment are unlocked as they progress through the Primer lessons as not to overwhelm the student with the complexity of the software.

Seventh, the student's performance in these increasingly difficult exercises is evaluated to determine if a) what they did was correct, and b) how they must adjust their approach so the learning goals are accomplished. In the UrbanSim Primer, an automated tutor provides feedback on the actions undertaken by the player, and shows how a different set of actions may have led to a more desirable outcome.

3.2 The UrbanSim Practice Environment

The UrbanSim Practice Environment is a game-based social simulation that allows a student to plan, prepare, and execute a COIN operation. Similar to a turn-based strategy game (such as Civilization or Age of Empires), the student directs subordinate units to take action in a virtual environment, and attempts to successfully complete a COIN operation using the products/strategies learned in the Primer.

The layout of the Practice Environment is derived from an amalgamation of several sources including CTA results, discussions with subject matter experts, U.S. Army doctrine, and experiences directly from theatre, of which the latter proved to be particularly useful. Though the CTA identifies specific tasks that the student must execute (conduct mission analysis, deliberate reconnaissance, etc), it does not always achieve the precision necessary for implementation in the practice environment. Experiences from theatre provided many of underspecified pieces, such as the use of PMESII and SWEAT diagrams as a means of analyzing the area of operation. The specific learning objectives targeted for the Practice Environment include how to successfully plan for, prepare for, and execute a COIN operation, as well as self-assessing performance in this complex domain. To meet these learning objectives, the Practice Environment is divided into a series of different stages that the student navigates through.

Read Ahead: Before entering the actual Practice Environment application, the student is provided with a set of read-ahead material that is used to familiarize them with the area of operations. This material takes the form of hard copy documentation, and is intended to mimic the "left seat, right seat" exercise that Commanders participate in when first deployed to theatre where the departing Commander provides the incoming Commander with a full overview and assessment of the area of operations. Area maps, historical information, dossiers, target folders, and preliminary staff estimates are some of the products provided to the student up to a week before playing through an UrbanSim scenario as a means of immersing themselves in the physical and cultural landscape that the virtual environment will simulate. The premise behind providing this material ahead of time is to prevent wasting valuable classroom time having a student become familiar with a complex area of operation.

Mission Overview: After preparing with the read-ahead material up to a week in advance, the student enters the classroom and launches the Practice Environment application. The scenario is loaded and the student is provided with the products produced by higher headquarters that outline the overall mission strategies and goals. This includes the higher headquarters

Operations Order, Commander's Intent, CCIRs, and LoEs. Each of these products provides a foundation for the student to develop their situational understanding of the battlefield, which is then supplemented with the products in Mission Analysis.

Mission Analysis: After familiarizing themselves with the higher headerquarters products, students then review the information provided by their immediate staff. Identified as running staff estimates, these products are often produced by Intelligence (S-2) and Operations (S-3) Officers to help the Commander formulate his visualization of the area of operation. For UrbanSim, these products are provided to assist the student develop their visualization of the entire spectrum of the mission (offense, defense, stability), with an emphasis on the stability component. These products include PMESII and SWEAT analyses, target folders for key individuals and groups in the area of operation, and assorted network overlays. The network overlays were initially designed as a single social network that illustrated the relationships that exist between various simulation entities and coalition forces, but it was determined after discussions with subject matter experts that several other network types were useful to Commanders in theatre. As a result, additional networks were added (military, political, and economic) that represent relationships not just between individuals, but also between groups/organizations, and even structures. All of the information that comprises these products are dynamic, and subject to updates as the student plays through an UrbanSim scenario (e.g., PMESII-PT and SWEAT analysis values that are updated as conditions in the area of operation change over time).

Mission Plan: After formulating their understanding and visualization of the scenario area, the student then describes their understanding through the development of assorted Commander products, which will be used to inform the course of action they plan to take. This includes the traditional Commander's Intent and CCIRs, but also includes LoEs and MOEs, which are increasingly being employed by Commander's to rapidly update their situational understanding as the operation is executed.. One of the central mechanisms for student assessment is through LoE monitoring, therefore it was required that we develop an approach that allowed LoE values to be computationally determined. To accomplish this, every action taken by both the player and all Non-Player Characters (NPCs) in a scenario has a set of world state effects that in turn affect a set of LoEs (Civil Security, Governance, Economic Development, Information Operations, Infrastructure, and Essential Services). Conflicting effects as a result of student/agent actions are resolved through a simple additive model. In this Mission Plan phase, the student identifies relevant LoEs for the particular mission, and during runtime these LoE values are dynamically updated to assist the student understand their progress towards achieving the desired end state. In sum, LoEs both provide an overall summary of the student's progress in a mission (through the LoE values) and play a key role in supporting decision-making (the intelligent tutor's use of LoE's is discussed in the next section).

Directing Action: After developing their Commander's products, the student then enters the direct phase, which is analogous to a turn-based strategy game. The student directs subordinate units to take action on key individuals, groups, and structures in the scenario in an attempt to reach their desired end state as articulated in the Commander's Intent. Each turn cycle represents one-day in simulation time, though actions can take multiple turns (i.e., days), and can be interrupted if conditions in the world do not allow the action to complete (e.g., money runs out to construct a school). The scenario ends when one of three conditions becomes true: 1) the specified mission duration ends (i.e., run out of turns), 2) the student (or instructor) terminates the session prematurely, or 3) the performance of the student diminishes significantly over a period of time as a result of increased violence and decreased population support for the host nation.

The underlying agent system controlling the actions of NPCs is PsychSim, which directs action based on decision-theoretic reasoning and allows for the transparent inspection of declarative models of NPCs goals and beliefs (Pynadath & Maresella, 2005). Additionally, the agent models can be inverted to generate explanations and causal chains to reason about why agents performed the actions they did. This feature is critical to providing intelligent guidance for the student, which is described in Section 4. Furthermore, the agents are capable of reasoning about the responses that other agents will have to their actions, which significantly increases the complexity of the state space but also affords a level of reasoning not seen with many simulation systems today.

Mission Debrief: The final phase of the Practice Environment is the Mission Debrief, which summarizes and analyzes the student's progress in the scenario. This includes bar charts and graphs illustrating the student's progress as it relates to LoEs and MOEs over time, as well as the amount of time they spent in each of the various displays (spatial, network, planning, performance). This last assessment metric is intended to inform the student that they should not be focusing their attention on just one or two displays, but rather dividing their time equally across all as a means of developing a complete situational understanding of the area of operation. The primary metric used to inform the student's success in a scenario is the value of the population's support for the Host Nation government.

This is represented as a Population Support Meter, and is available to the student throughout the scenario, but is also used as an important assessment tool at the completion of a scenario. This value is updated similar to the way the LoE values are updated: every agent in the scenario has a "support for Host Nation" state feature, which increases or decreases depending upon the actions taken to affect it.

4. INTELLIGENT TUTORING

The UrbanSim practice environment presents a huge problem space, with many solution paths of varying degrees of quality. This complexity is a strength in that it attempts to provide a realistic practice environment through modeling of human behavior, but also presents challenges in terms of learning. Specifically, large open learning environments that rely on discovery learning can be problematic for early-stage learners (Kirschner et al., 2006). The need for guidance is a reoccurring and established principle of instructional design (Merrill, 2002) and is delivered in two key forms: through the Primer (discussed in section 3) and by an intelligent tutoring system (ITS) that provides feedback in the practice environment.

Expert human tutors and the best ITSs deliver *formative* feedback – that is, "information communicated to the learner that is intended to modify his or her thinking or behavior to improve learning" (Shute, 2008). Explicit feedback can be used for a variety of reasons, such as to verify the correctness of an action, explain correct answers, remediate misconceptions, reveal goal structure, and more. Feedback can be delivered immediately after an action, or after some delay. The best choices for feedback content and timing depend on many things, including task domain, nature of the skill being learned, the aptitude of the learner, whether the learner has a performance orientation, and more (Shute, 2008). The UrbanSim ITS is designed to support both immediate and delayed feedback.

As discussed, one of the goals of UrbanSim is to teach about the broader and unintended effects of actions taken in stability-focused operations (fourth learning objective: directing action to anticipate 2nd and 3rd order effects). Understanding the role of NPCs in the PsychSim models is part of this. Each NPC agent acts to achieve its goals and makes decisions based on the state of the world. Although the student cannot directly order non-U.S. NPCs to take (or not take) certain actions, she or he can certainly affect the world state. A key goal for the ITS is to help the learner understand this idea, and to take actions that 1) limit the ability of NPCs to take harmful actions, and 2) enable NPCs to take helpful actions. In other words, *the learner should be thinking about how their actions influence the actions of others* – the ITS frames its feedback in this light and attempts to reveal the reasoning behind NPC's actions: why they made the decisions they made, what consequences (seen or unseen) were most relevant, and under what circumstances different decisions would have been made.

To support learning of unintended consequences, we have implemented an *anticipate-wait-relate* tutoring strategy. That is, after the learner has proposed an action and the ITS has decided to apply the strategy, three steps are taken: (1) Elicit the anticipated effects of that action. That is, ask the learner to assess that choice by indicating, via drop down menus, how she or he expects that action to affect the world state or relevant LoEs. (2) After this input, allow the game to proceed for some number of turns (which is only 1 at the time of this writing, but longer delays are possible). (3) Finally, the ITS presents the learner with the *actual* results for comparison.

The system is able to provide feedback before or after the initial action proposal, or later (step 3), along with the comparison between anticipated and actual outcomes. Our focus thus far has been on this delayed form of feedback. Application of this strategy requires answers to at least two questions. First, what is used to trigger the strategy? In other words, when should the learner be prompted to anticipate the effects of an action? Second, how should the ITS support reflection on the results of the comparison? Of course, the learner could easily be asked to anticipate outcomes to every action, but this would quickly become a distraction. Also, learning could potentially occur by simply allowing the learner to inspect the predicted versus actual outcomes and learn from them. This also is unappealing, especially given the rich PsychSim models that drive NPC behavior. In fact, our approach leverages these models and the reasoning capabilities of PsychSim.

Our initial approach to answering the question of when to ask the learner to anticipate is to use look-ahead. If an LoE is about to decrease from a user action, the ITS will ask the learner to anticipate either the effect on the LoE or world state features that contribute to the LoE calculation. We currently focus on potentially damaging actions the learner can take. Regarding feedback, we have implemented an approach based on *causal chains* of the reasoning behind the NPCs. These causal chains reveal the state changes that occur based on learner actions, allowing the learner to see the connections between their actions, the world state, and the ensuing NPC actions. Additionally, the ITS also queries PsychSim to reveal what conditions would have led to different NPC actions. For example, an NPC's ability to have taken one very bad action may have been impossible had the learner taken a different action at that turn. The ITS's aim here is to support the learner's reflection in imagining what other actions could have produced such world states.

5. ASSESSMENT

Assessing student performance in this instructional package occurs through several forms. First, students judge their own progress during missions by studying MOEs and MOPs and relating them to identified LoEs. Second, population modeling provides the lower-level information necessary for automatically measuring the student's performance within a scenario. Third, intelligent assessment of learning is supported by tracking student recognition of important events, including the anticipation of 2nd and 3rd order effects that the ITS supports.

In future work, we intend to determine empirically the relation between patterns of decision-making and outcome measures (were the LOEs advanced or not?). If particular patterns lead consistently to positive outcomes, whereas others lead to negative outcomes, and we are able to automatically monitor each student's pattern,that would provide a basis on which to provide each student customized feedback intended to shift their pattern closer to one leading to positive outcomes. In his book Logic of Failure, Dörner (1996) summarized research on policy making in the context of complex socio-economic simulations. He categorized his participants' "think-out-load" protocols as reflecting different types of cognitive processing. He found that the relative proportion of time spent using the different processes followed a different pattern in "good" participants as opposed to "bad" participants, where good and bad related to the participants' ability to make the simulated society prosper as opposed to collapse. Analogously, we intend to collect think-out-load protocols from Soldiers interacting with Urbansim, identify from these the different cognitive processes engaged (e.g., information seeking or decision making), and examine how the relative time spent in each process changes over the course of working the scenario. If there is a link between certain patterns and positive vs. negative outcomes, we would then need to determine how to refine the user-interface so as to capture these patterns. Additional think-out-loud protocols would then be required to verify the relation between the actual thought pattern and the pattern inferred from user-interaction data.

Analysis of think-out-load protocols has an additional benefit by providing a means of validating the training system itself. Players who demonstrate patterns of thinking proscribed by the learning objectives ought to be successful in moving the world state toward a desired end state. If not, then the instructional and system designs must be refined as discussed in section 2.8.

ACKNOWLEDGMENTS

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