Simulation & Gaming

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# Exploring interactive stories in an HIV/AIDS learning game: HEALTHSIMNET

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*Simulation Gaming* 2008; 39; 39 originally published online Dec 17, 2007;
DOI: 10.1177/1046878107308093

# Exploring interactive stories in an HIV/AIDS learning game: HEALTHSIMNET

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*This article is based on work to develop an interactive documentary learning game called HEALTHSIMNET, which is intended for improving practice in a health care network. The authors look briefly at past work done to develop interactive narratives using structural artificial knowledge representation techniques. They illustrate a method for collection and analysis of documentary data acquired during semi-structured interviews with participants of a network of health practitioners in the HIV field. The article reviews the expansive theory of learning and explains how the technique can yield interactive narrative. They discuss the design implications of this work for their interprofessional learning game. They end with a description of the game and a discussion of the extent to which games developed using this method can be said to sustain the kind of learning described by activity theory.*

KEYWORDS: *activity theory; actor interaction; artificial intelligence; cultural historical activity theory (CHAT); edutainment; endogenous video games; experiential learning; game structure; health care; implicit learning; interactive narrative; learning by expansion; learning environment; narratives; simulation games; HIV/AIDS; interprofessional health practice; video games*

The interactions of actors in any multiparticipant activity or situation can undoubtedly be viewed and studied as if they were the interactions of actors within a game. The *game* is a powerful concept as well a dominant product category. When a game creator successfully aligns the many factors that define a game, the result for the player can be profoundly engaging and satisfying. Some researchers, and perhaps more commercially interested commentators, have suggested that the entertaining aspects of gaming could be transported to professional development media to create *edutainment* that could capture the inherent interest and fun of game play, and

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AUTHORS' NOTE: Thanks are given for helpful critique from Dr. Marc Cavazza of University of Teeside, to two anonymous reviewers, to Irene Goldstone and Julio Montaner at the BC Center of Excellence in HIV and to staff of the Oak Tree Clinic in Vancouver. Michael W. Dobson was principle investigator with a Social Sciences and Humanities Research Council network called SAGE (simulation and gaming environments) for learning, a Canadian network directed by Professor Louise Sauvé, Télé-université, Quebec, and Professor David Kaufman, Simon Fraser University, BC, Canada.

SIMULATION & GAMING, Vol. 39 No. 1, March 2008 39-63
DOI: 10.1177/1046878107308093

by stealth this could lead to painless learning for the user (Prensky, 2001). This suggestion is, of course, rife with underdetermination and has the potential to be highly misleading when taken at face value. However, in our studies we have confirmed that implicit learning (Rieber, 1996) can be designed into simulation games when variables in context of action are manipulated to achieve an exaggerated effect of the setting for the learner (Ciavarro, Dobson, & Goodman, in review). This finding illuminates a little of the relation between games and learning; however, it really only illustrates one possibility from several.

There is a good deal of valuable evidence for the benefit of games in learning. From clues about what motivates players, to the recognition of the cultural functions that anthropologists tell us constitute the role of games in cognitive and social development, the evidence of the importance of games (as typically conceived at least) as vehicles for learning is highly compelling (Rieber, 1996). Aspects of challenge, curiosity, fantasy, and control are widely recognized as engaging characteristics of motivating experiences. Socially, game play offers the cultural function of risk-free imitation and accommodation of practice, an experience that reaches far beyond kindergarten learning in the sandbox. Furthermore, the games we play are also culturally expressive of our values (Roberts, Arth, & Bush, 1959) indicating the complexity of the society and its relation even to the supernatural.

Although our goal is to create games that lead to learning, our approach is to focus on the endogenous aspects (Malone & Letter, 1987) of game play and their relation to learning. It has been said that endogenous video games connect game design and domain content by integrating relevant practices of the learning environment into the structure of the game so that mastering the learning environment is itself the learning outcome (Holland, Jenkins, & Squire, 2002). In this model learning to navigate the game architecture provides an introduction to how knowledge is organized in the modeled domain. However, games used in this way tend to be supplemented with an additional plan that models the structure of the game onto an outline of the curriculum. In this limited endogenous view it is thought that strategy games do not necessarily establish viable analogies with real-world phenomena; however, they can complement high-quality classroom learning experiences. In this view there is a perceived need for learners to research the historical connections implicit in the game model, to collaboratively reflect on their play, and to relate their experience to conventional standards-based content (Squires, 2005).

Our goal is for a stronger relationship between game structure and learning. Our approach is to create game structures that model fairly closely (almost simulate) the object, events, and phenomena within a setting. In this mimetic way (Young, 1999) the game can serve less as a curriculum outline and more as an environment for experiential learning. To achieve this stronger view of endogenous design for learning games we have focused on the generative substructure of the game play. This approach is far more limited in its claims than the global *edutaining* of the school curriculum or even the more specific weakly endogenous approach. However, our work thus far provides a reasonable possibility that realistic benefit can emerge from this attempt to create engaging and plausible learning games (Myers, 1999).

The HEALTHSIMNET game (see illustrations in Figure 8) models the interactions of participants in a network of health care professionals and lay players involved in care and treatment of those with the human immunodeficiency virus (HIV). Our goals in the project are,

1. to design a new media game for health professionals
2. to develop a design method for documentary games using cultural historical activity theory
3. to explore the modeling of a practice situation using narrative.

Each of these goals is substantial in its self but is addressed to some extent by what follows.

The game we designed was intended to allow participants to see aspects of a health practitioner network that were invisible during the normal practice of their work lives. We wanted players to be able to explore realistic narratives and to interact with them to strategize and attempt to improve their performance. Also we wanted professionals to gain experience crossing the boundaries between their practice fields to better understand each other's roles and needs. To achieve this we have developed a method that builds narratives based on stories told to us by health practitioners.

HEALTHSIMNET is formally a game, although its content, pace of interaction, and the seriousness of the outcomes make it more serious and more realistic than video games typically found in stores. It may even violate some of the essential principles that games researchers have determined as defining characteristics of the game experience. Nevertheless we believe that our game may capture a key combination of learning theory and interaction design that can lead to a reproducible practice for the creation of learning games.

This learning design process draws on analyzing data regarding current practice and is based on a theory of learning that emphasizes a shift in practice as the goal of learning. The learning theory that best addresses the need is called *learning by expansion* and derives from cultural historical activity theory (CHAT) first developed in Soviet Russia (Vygotsky, 1978) and now attracting considerable interest and application in workplace learning (Engestrom, 2004), human-computer interaction (Nardi, Whittaker, & Schwarz, 2002), and schoolteaching practices (Barab, Hay, & Yamagata-Lynch, 2001). Although CHAT is sometimes seen as a research method, in our work we have taken the view that it is complemented by other qualitative approaches that specialize in the reliable construction of theory from real-world data. Grounded theory (e.g., Corbin & Strauss, 1990) is one such method, and it comes with its own systemic processes for analysis of qualitative data.

It is worth pointing out that although stories have been successfully used in scenario-based design to develop requirements analysis and task analyses (Rosson & Carroll, 1995) our purpose was not to understand how to support users' typical task or activity structures to build a usable interface for their activity. Our data stories are used at a level beneath the interface, to generate game play. With this comprehensive set of stories from several professionals we set about reviewing the alternatives for implementing interactive narrative for game play. This article highlights some of that analysis because it helps to set the role of artificial intelligence (AI) in games in respect to this symposium as well as revealing our design decision making.

## Collecting stories of HIV care

The genesis of our learning game began with a series of meetings with professionals involved in HIV/AIDS care in the southern British Columbia, Canada, including the Centre of Excellence in HIV/AIDS in Vancouver, the Fraser Valley Regional Heath Centre for Communicable Disease, and members of the organization British Columbia Persons Living with AIDS. Our pilot interviews with network members revealed intricate and moving accounts of people's life struggles whether from the point of view of a person living with the disease or from the perspectives of those with health care roles.

The pilot interview data has been open and axially coded using appropriate software tools developed for text analysis (Muhr, 1991) to reveal many interesting phenomena. The first stage of analysis used grounded theory (Glaser, 2002) that is essentially inductive development of explanation from corpus data. Typically in grounded theory research, cases are examined for similar outcomes and reviewed for common conditions to find causal factors. Data is open coded in categories, concepts, and properties and axial coding then relates these categories and properties into causal relationships: the phenomena, the conditions, the context, the intervening conditions, the action strategies, and the consequences (Corbin & Strauss, 1990). As we see later, these structures can form the basic components of interactive story and are used to generate our narrative game experience.

Figure 1 shows a tiny fragment of an interview coded with key categories. We should note here that the analysis of data followed a pattern somewhat different from typical grounded theory research. Normally, the key categories in the data should emerge as the researcher reviews the text. In this work, we looked first for examples that fit within the activity theory framework that is described below. Although this may be a controversial move within some ethnographic circles, it presents for us a way to systematize the process of analyzing data to increase the reliability of findings within this sociocultural framework.

The stories we collected were all tremendously moving and were also diverse in their perspectives. The emphasis on these stories was to find errors or breakdowns in health care practice and to look predominantly for stories involving several disciplinary interactions. One, for example, detailed a struggle with legal interpretation of *confidentiality* intended to protect minors but which, in effect, temporarily stalled a public health nurse from taking measures for a young female who had been sexually involved with a man tested positive for the virus. Another recounted an elderly HIV+ person whose social and economic status was so unlike the characterizations of those at risk that she remained sick and went untreated in care for many years and was finally diagnosed postmortem. We heard that numbers of general physicians have little knowledge about the disease, and in rare cases patients had been given

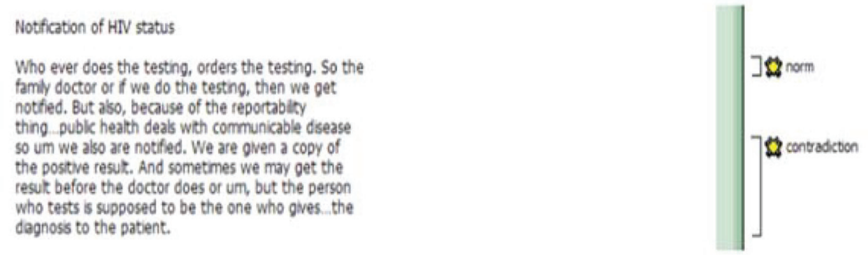



**FIGURE 1: Data Excerpt From Analysis Program, Illustrating a Part of the Coding Scheme (far left)**

medications in error. Advances in pharmacology, changes in health care provider agreements, and individual patient conditions together can complicate the selection of the best medication for a single person.

Most prevalent was a failure to recognize or diagnose the disease. We heard that many cultural groups, for example, low-risk women, are not so well cared for in their emotional and psychological needs as those groups identified earliest as being at risk. Notably, we heard on several occasions of the power and affect of spiritual experiences on patients' well-being. And in other situations, in apparent contradiction, churches were also criticized for taking judgmental attitudes toward people with addiction problems, many of whom live with the disease. The range and depth of stories collected helped us realize we could never provide a comprehensive analysis of the network; however, at the same time, the depth and complexity of experienced events encouraged us to continue to uncover more.

## Learning activity structures

To transform the stories into interactive narrative we draw on an approach that offers a way to link causal fragments together. *Expansive learning* is found in cultural historical activity theory (Engestrom, 2001, 2004; Leont'ev, 1978) and can be used to structure the representation of events found in any multiple participant activity particularly to illustrate the tensions that exist in such systems (Dobson, Le Blanc, & Burgoyne, 2004; Engestrom, 2004; Engestrom, Puonti, & Seppanen, 2003). This framework is sometimes used to help design collaborative learning in interactive media and is often linked by Vygotsky's (1978) claims about the cumulative advantages of communication among individuals with different core skills and consequential increases in a group zone of proximal development during collaborative activity.

Activity theory provides a way to understand how changes can take place in systems through the reciprocal and unified processes of *internalization* and *externalization*.

Not unlike the model of tacit and explicit knowledge construction described by Nonaka and Teece (2001), Engestrom and Middleton (1998) how internal thinking processes can be manifested externally to create new artifacts and social practices (shifts in practice). The idea is that what drives change in systems are the contradictions and tensions between individuals and other sociocultural influences and other activity systems. New systems are created by resolving those tensions creating a spiral process called *learning by expanding* (Engestrom & Middleton, 1998).

> The essence of learning activity is production of objectively, societally new activity structures (including new objects, instruments, etc.) out of actions manifesting the inner contradictions of the preceding form of the activity in question. Learning activity is *mastery of expansion from actions to a new activity*. While traditional school going is essentially a subject producing activity and traditional science is essentially an instrument producing activity, learning activity is an *activity-producing activity*. (Engestrom, 1987, p. 116)

This conception of social engagement in activity has stimulated a series of investigative attempts to integrate CHAT into various interactive learning design projects. One recent attempt (Mwanza, 2002) created an eight-step process for analyzing activity in workplaces based on the component parts of Engestrom's model, that is, subject, object, objective, tools, community of practice, roles, and rules followed by a review of contradictions and thematic tensions. In the formal learning area we find a prescription for designing cooperative learning environments based on activity theory (Jonassen & Rohrer-Murphy, 1999). These authors added to activity theory the idea that procedures, routines, operations and actions are subcategories of activity. Expansive learning theory may actually be more difficult to fit within traditional instructional design principles, and attempts to do so often minimize its uniqueness (that learning involves enlarging the perspective of the learner) as we have done elsewhere (Dobson et al., 2004).

In our design of HEALTHSIMNET we are motivated by a goal shared with Barab who uses CHAT and actor-network theory (Barab, Barnett, Yamagata-Lynch, Squire, & Keating, 2002; Barab et al., 2001; Latour, 1993) to build networks of events through activities in classroom learning experiences to show how learning spreads through networks. Whereas we have focused on the activity system as a unit of analysis, these authors use the term *action-relevant episodes* (ARE), which are of a similar grain size and make a very reasonable unit of narrative. In our solution, we see that narrative is constructed from complex conditions that are mediated by a rule of some kind that often includes the division of labor and interaction with instruments of action and then with some probability leads to an outcome. To use an example we have already discussed: the family physician that rejects a patient from his practice because he has no knowledge of HIV can only do this after a diagnosis has been made.

We see below that the construction of interactive narrative from narrative structure is a challenge that appears superficially simple but has occupied AI researchers in recent decades and draws on a long intellectual history.

## Narrative structures

The idea of games based on interactive narrative and story schema has roots in the classical work of Aristotle's *Poetics* (Young, 1999). There are several ways that computational approaches have been used to create interactive narrative (Crawford, 2004; Ryan, 1991; Young, 1999), although this is a rapidly developing and currently very active field. By *computational* we mean those that rely on high-level knowledge representations and make use of transformations on those representations to achieve behaviors. Responses to this goal range from problem-solving representations for interactive progress through a story state-space, through programs that use schemes and scripts to model a story genre and create multiple versions, work that models logic within scripts to determine outcomes that depend on variable values, all the way to work which illustrates, even within linear narratives, structures that are neither simple nor monotonic.

Perhaps the simplest structural definition of a story is that of a series of states created by allowable transformations on the initial and following states. Possible stories, by this definition, would consist of all the allowable paths through a network of states. In the following example, shown in Figure 2, there are three characters: a fox, a chicken, a farmer and one object: a bag of grain. The rules of story progress are that if the fox and the chicken, or the grain and the chicken, are placed unsupervised in the same location, then there is a predictable and undesired outcome. The object of the story is for the farmer to get all his livestock and feed across the river in a boat that only carries just two items plus the farmer. Beginning at the top of the diagram and tracking through the states in square brackets, the model shows two paths through the space of states that achieve the happy ending. Other paths are possible but lead to disadvantageous outcomes.

This model might be called a problem-solving model of story generation where sequences of states are achieved by generating possible states in series, and by considering the following states, establishing whether they reach the end goal state. It is based on a look-ahead search algorithm used in the simplest and earliest of problem-solving processes (Rich & Knight, 1991). Clearly, however, game players require more. Good stories are shaped by the plausibility of characters and their behaviors, the rise and fall of action, and the logic of cause and effect. The narrative, whether is it interactive or not, for it to be successful must be a rendering of all this and the explicit and implicit telling of the character's plans with suspenseful and dramatic timing. A problem-solving approach is far too limited to achieve this.

Another, slightly more sophisticated way to generate narrative from structure is to create an abstract grammar for the story form and to populate slots with data objects to create a series of events. This approach is used in the early period of AI and storytelling research (Rumelhart, 1975; Shank & Carbonell, 1979; Simmons & Correira, 1979). The work by Vladimir Propp (1928/1968) is the best and most celebrated source of this work. His original model explains that the typical Russian folktale is built around seven types of persons (or spheres of action corresponding to

```
            [[fa,f,c,g], []]
                   |
             [[f,g], [fa,c]]
                   |
             [[fa,f,g], [c]]
                /      \
               /        \
 [[g], [fa,f,c]]        [[f], [fa,c,g]]
       |                       |
       |                       |
 [[fa,c,g], [f]]        [[fa,f,c], [g]]
        \                     /
         \                   /
             [[c], [fa,f,g]]
                   |
             [[fa,c], [f,g]]
                   |
            [[], [fa,f,c,g]]
```

1. The farmer, the fox the chicken and the grain all on the left bank.
2. The farmer takes the chicken across in the boat.
3. The Farmer returns with an empty boat leaving the chicken on right bank.
4a. Farmer takes fox and chicken across and returns with chicken and grain (leaving fox).
4b. Farmer takes chicken and grain across and returns with the fox and chicken (leaving the grain).
5a. Farmer takes grain from left to right bank (leaving chicken)
5b. Farmer takes fox from left to right (leaving the chicken
6. Farmer returns to the left bank with empty boat to collect chicken and take it to right bank.

**FIGURE 2: Two Successful Story Paths for the Story of the Farmer and His Goods**

performers): the villain, the donor, the helper, the princess (and father), the dispatcher, the hero, and the false helper.

The following story plots present three from the very large but all-the-same limited series of stories that are possible using this scheme. In his seminal work he proposed six starting situations that summarize the legacy of Russian folklore including kidnapping, the tormenting of a character during the nighttime, the lack of a bride or some other desired outcome, the pushing of a character into a chasm, and the expulsion of the hero from a community. Stories may then proceed in predictable fashion through a space of alternatives.

Although his state transition analysis provides several starting points they nearly all lead to a state of counteraction with the villain that is responded to immediately by a journey and soon after with a fight in an open field with the villain. In midstory the variety is greater including the development of magical agency, the impersonation of the hero, the test or completion of a difficult task and, just like all low-budget movies, several protracted chases. Story end games include the achievement of initial desires by force or cunning, or the exposure of falsity. Virtually all stories culminate with the return of the hero to his wedding and ascension to the throne. This model is at its best in classifying fixed-form narratives and their variants, and it is clear that it could not do justice to our patients or health worker's experience (M. Cavazza, personal communication, 17 October 2006).

The extended model of this approach is to build primitive and complex plot units beginning with positive and negative events. Aggregated primitives can be pictured with a diagram grammatical language to show, for example, mixed blessing, change of mind, loss, success, and so on that are, in turn, further aggregated to bigger units

**Kidnapping** ⇒call for help ⇒Release of hero ⇒start of counteraction vs. villain ⇒departure of hero ⇒test of hero ⇒hero fails test ⇒punishment or retaliation ⇒return of hero ⇒punishment of villain ⇒wedding.

**Tormenting at night** ⇒announcement of misfortune ⇒start of counteraction vs. villain ⇒departure of hero ⇒hero's fight ⇒arrival of hero unrecognized ⇒claim of false hero ⇒recognition of false hero ⇒punishment of villain ⇒wedding and accession to the throne.

**Lack of bride** ⇒dispatch of hero ⇒start of counteraction vs. villain ⇒fight in an open field ⇒ride of hero ⇒attempt to destroy hero ⇒attempt averted ⇒hero seizes magical agent ⇒return of hero ⇒punishment of villain ⇒wedding and accession to throne.

**FIGURE 3: Shows Three Transitions Through Propp's Model of Story Progress**

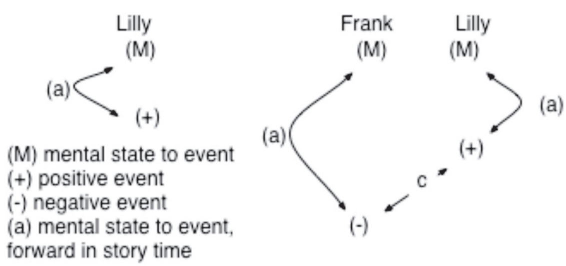



**FIGURE 4: A Plot-Unit for the Motivation and Competition Themes, the Graph Nodes Are Story Events and Character Mental States. Links are Relations Determined by the Types of the Linked Nodes (Lehnert, Dyer, Johnson, Yang, & Harley, 1983).**

such as fleeting success, sacrifice, inadvertent aggravation, and even bigger themes with several characters that include the malicious act, the double cross, the request honored with a conditional promise, and so on. These are modeled on the idea of the context-sensitive grammar using augmented transition networks and are contrasted with context-free grammars that provide less flexibility to produce interest in the stories generated. Figure 4 shows two plot unit forms. Motivation is illustrated as the link between the positive effect of the event (a) on the mental state (M), and when two similar structures are presented for separate characters we can see the impact of competitive motivations on each character as pictured in right side of Figure 4.

From the perspective of story generation this approach is although considerably more interesting than the state transition models, still profoundly limited because of the narrative qualities that remain absent. In this regard, we still cannot represent plot dynamics and overt or virtual plans associated with characters inside the story. These qualities are required to produce story *tellability* (Ryan, 1991). This notion (tellability) is a function of creative narrative that dwells on the concept of the characters' projected

FAIRY TALE (X) ⇒
FAIRY STORY (X) ⇒
SETTING (X, Y, Z) ∩ EPISODE (X)

SETTING (X, Y, Z) ⇒
LIVE (x, y, z),
PLACE (y) ∩ TIME (z) ∩ CHAR (x),
KNIGHT (x) ∪ PRINCE (x),
BRAVE (x) ∪ HANDSOME (x)

EPISODE (X) ⇒
MOTIVE (X) ∩ ACTION (X)

MOTIVE (X) ⇒
DESIRE (x, y),
CHAR (x) ∩ PRINCESS (y) ∩
HOLYOBJECT (y)

ACTION (X) ⇒
ASK-MARRY (x, y) ∪ RESCUE
(x, y, z) ∪ QUEST (x, y)
∪ PRAY (x, y, z)

PRAY (X, Y, Z) ⇒
CHAR (x) ∩ GOD (z) ∩
HOLYOBJECT (y),
KNEEL (x) ∩ SAYPRAYER (x, z)
∩ ANSWER-P (x)
POSSESS (x, y)

QUEST (X, Y) ⇒
[CHAR (x) ∩ WANTS (x, y) ∩
HOLYOBJECT (y) ∩ LOST (y)] ∩
[GOTOORACLE (x) ∩
REVEALORACLETO (x) ∩
PLACE (y) ∩ FIND (x, y)] ⇒
POSSESS (x, y)

**Figure 5: Adapted from TELLTALE**
SOURCE: Adapted from Correira (1980).

plans, their passive projections, and the actual sequence of events. These ideas are crucial to the creation and understanding of narratives and plots that capture the interest of the reader. Certainly within the fictional genre they are a requirement.

Another approach seen in Figure 5 is the top-down schema driven approach of TELLTALE (Correira, 1980) that instantiates slots with elements and creates a tree-shaped representation of the story structure. A rule is applied if its preconditions are satisfied, and rejected otherwise. Satisfaction occurs when a precondition corresponds to an established fact, or when it can be asserted without creating contradictions with already generated elements. When a precondition names another rule it delays its decision until it has found whether or not this rule is itself applicable. Although more powerful than the strictly Proppian models, it does not generate the semantic polyvalence that is required for story tellability. It cannot create the kind of model in the Cinderella story below.

Another approach of the early 1980s was the *simulative algorithm* in which the semantic representation is divided in two. The static component lists the members of the narrative universe and describes their properties, while the active component contains the historical events that alter these properties. After a universe is created, the system enters a loop of generating events, computing their consequences, and creating new states to reflect these effects. The result is a trace of the changes that affect the narrative universe over time. A strictly chronological generation of events is essential to the simulative approach. The automatic novel writer (Klein, 1979) followed this approach. The real breakthrough resides in its ability to represent the modal structure of the narrative universe. The simulative algorithm decomposes this universe into a plurality of worlds and assigns each narrative proposition to a specific domain. The characters of a story are defined by not only their physical, objective

**A**

| *Actual Events* | *Virtual Events* |
|---|---|
| 1. Cinderella and her stepsisters invited to the ball<br>2. Cinderella makes herself a dress<br>3. Stepmother forces Cinderella to stay home<br>4. Stepmother takes stepsisters to the ball<br>5. Fairy Godmother appears to Cinderella<br>6. Fairy Godmother performs magic to get Cinderella outfitted for the ball<br>7. Cinderella goes to the ball in a magic carriage<br>8. Cinderella meets the Prince at the ball and he falls in love with her<br>9. Cinderella leaves the ball at midnight, losing her shoe | 19. Cinderella goes to the ball with stepmother and stepsisters<br>20. Prince asks for Cinderella's hand at the end of the ball<br>21. Stepsisters dance with the Prince at the ball<br><br>***Virtual Embedded Narratives***<br><br>Cinderella's intent at point 1: 2, 19, 8, 20 …<br>*Stepmother's passive projection at point 1: 2, 19, 8, 20 …* |

**B**

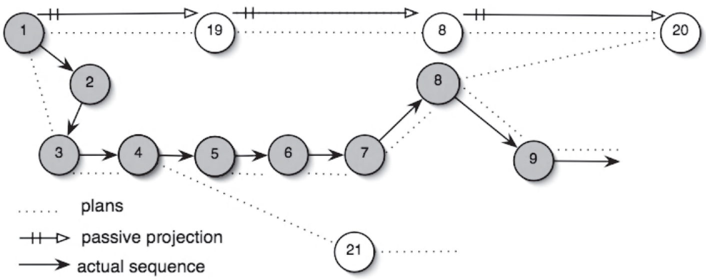



**FIGURE 6: Excerpt of Polyvalency Analysis of Plot and Event Projection in Cinderella**
SOURCE: Adapted from Ryan (1991).

properties but also their correct and incorrect beliefs, their system of affective values, their goals, plans, fears, and rules of behavior. Also in this genre, Michael Lebowitz (1985) developed the UNIVERSE system that connected current situations to new plot options with the goal to create a story that could continue indefinitely (based on day-time television soaps).

For fictional stories, it is said that *semantic polyvalence* in a story (the multiple points of view and intentions) create the possibilities for reader engagement. This analysis of the story of Cinderella below shows the complexity of multiple intentions within the plot. Numbers within the diagram are referred to in the Figure 6.

The presentation gives an idea of the complexity built into this simple folktale. Notice that when Cinderella and her stepsisters are invited to the ball her passive projection and plan are to be there (19), to meet the Prince and for him to fall in love with her (8), and for the Prince to ask for Cinderella's hand at the end of the ball. However, the stepmother also has a plan from the beginning (1) to keep Cinderella away from the ball (3). Notice that all these plans and projections preexist any actual story events, and nothing really happens in the history of events until (2) when she begins to make her own dress. Ryan's analysis (1991) extends to around 50 nodes; however, this excerpt illustrates the main kinds of events and embedding.

This complexity seems to challenge some simple assumptions about cutting up linear stories and creating nonlinear experiences from them. Certainly any approach that focused solely on the historical events in a story without regard to the plans and passive projections of its characters would likely fail to reproduce the engagement of the crafted story. Recently we have seen computational models of narrative ordering and suspense development envisioned (Young, 1999) using planning mechanisms and implemented with considerably more structured tools than their ancestors (Riedl & Young, 2004). Although their goal is to generate finished coherent plots using a planning system, a major shift from previous methods in their approach is to model the intentions of characters and to measure the effect of actions on achieving internal character goals.

In the late 1990s in interactive narrative and artificial intelligence, there began a major shift that we believe provides the basis for this area to yield considerable results in coming years. Some researchers have continued in the more plot-focused field of interactive narrative but take advantage in many cases of newly available game development engines (Fairclough & Cunningham, 2003). In their project OPIATE the authors created an open-ended procedural view of stories that is based on the structuralist style and inspired by contemporaries (Crawford, 2002; Sgouros, 1999). OPIATE is a 3D adventure game with characters, objects, and locations. There is a social simulation and a representation of attitudes and goal-directed behaviors. Characters interact with objects to create events in the story. An independent story director agent initiates events by being aware of the story world and giving relevant goals to the nonplaying characters, an approach that is being developed recently by others (Peinado, 2006). Knowledge of game events is distributed between the players by a gossip mechanism. The system has a case library of plans. Case-based planning encodes knowledge as a library of cases and deals with new problems through the mechanisms of recalling previous similar cases, adapting them for reuse, and assessing and storing the resulting new solution. A suitability metric is used to determine the case to implement.

At the same time, however, others (Cavazza, Charles, & Mead, 2002; Marsella, Johnson, & LaBore, 2003; Mateas & Stern, 2002) have begun to focus on modeling characters in interactive narrative and providing an environment for interactive narrative to emerge. Cavazza's interactive storytelling system (Cavazza et al., 2002) for example, is implemented in Unreal Tournament and based on character interactive storytelling where character plans are described using a hierarchical task network that is a formalism based on AND/OR graphs. Narrative is represented as a search process carried out by a planner that takes the AND/OR graph and generates from it an equivalent state-space graph in a process. A real-time variation of the AO* algorithm is used to find optimal solution subgraphs that correspond to character roles in the instantiated story. The story is generated from the interaction of the actor's plans. The authors say that narrative generation can be seen as comprising top-down and a bottom-up component processes, where the top-down parts correspond to the character's role, and the bottom-up ones consist in the situations created by the interaction between characters; these not being determined in advance but based on their initial roles. Although interaction presented from this method is plausibly realistic, they say it turns out to provide too much latitude in the development of stories, so that irreparable plot sequences would occur too often. As a consequence, the system includes a situated reasoning and repair system: returning postconditions when resuming original plans.

On the basis of this last system design combined with a modified interaction approach that does not rely on natural language interaction, we built our own game for professional development in HIV care.

## An interactive game for HIV workers

To understand the implications of all this for our health simulation, we need to filter the work on story understanding and generation through the lens of our users' need to engage with interactive stories in a way that is associated with realistic settings and can lead to players changing their practices. The differences between realistic stories in health care and fictional stories created for entertainment are challenging. Realism is further challenged because documentary stories tend not be so comfortably shaped as those produced in folk narratives—there is no reason they would be so simple or symmetrical.

In our game, we address the challenge to take real stories with multiple participants and to create an interactive narrative from them that remains compelling. The rules that generate new behaviors have to be realistic so that new stories (that have not been reported) are just as plausible as those reported. We are left with options to modify the generative possibilities of the story construction. Several types of systems could be built that by generation will create new stories in systemic (interactive) fashion. The design space is dominated by three major choices: (a) to modify the process of story unfolding, (b) to modify the characters, and (c) to modify the objects of interaction. Each area has an implication for the important goal of plausibility in the documentary story.

First, aspects of the story progression include the events of disease trajectory, typical social behaviors, and the causal relatedness of episodes. We have seen that realistic stories are composed of multiple realistic plans and expectations that are embedded and complex but are far from random or completely nonlinear.

Second, characters in the interactive story can be presented with visual realism, the presence of certain characters and not others; their behavior, speech, plans, and choices can all be the subject of variability and therefore generate new narratives. Earlier work has demonstrated that realism at the level of speech interaction is a difficult route to plausible and engaging interaction (Mateas & Stern, 2002) and that character modeling holds great hope in subduing the endless interactions possible within immersive environments (Cavazza et al., 2002).

Third, the range and kinds of actions available to the players for acting on virtual objects clearly affects the kind of stories generated. Typically the free flow of interactivity within any virtual world tends to result in story lines that are shallow and involve a lot of movement and little substantive plot development (climbing stairs, trying to escape a space to enter another space, or hiding behind obstacles). New virtual spaces can signal levels of complexity and provide contextual cues for what action is expected. Changing the aspects of the context by providing isomorphic views and options to add and modify characters can also be introduced as legitimate game play. The relationship of these design choices to plausible stories is direct. Objects in the virtual world have to be consistent with the worlds being represented, and the addition of new elements has to be consistent with what is possible within those worlds.

So the design of HEALTHSIMNET takes the activity system phenomena from interviews then models the transitions from one system to its expanded replacement. The activity system (which could be thought of as a network or community of practice) is modeled with each participant's goals implemented hierarchically. The system model is built from several players each with their own goal hierarchies. These are added or subtracted from the network by the player, and simple instruments are available to mediate practice. Dialog is attached to leaf nodes in the hierarchy and presented by the nonplayer characters or selected by interaction with a list of options by the player character. This results in an interface similar to other work in agent interaction for health learning (Johnson & Lester, 2000). We draw on the data coded earlier using the activity theory format. Recall that in activity theory the basic unit of analysis is the eight-place array mentioned earlier. This is a more economical way to illustrate the activity triangles that are commonly found in work by Engestrom (e.g., 2001, 2004).

Activity system {subject; object; instrument; objective; rules; roles; community; tensions}

A transition (or expansive learning event) is presented as the resolution of internal inconsistencies or tensions to produce a new different activity system. In the following example, discussed earlier with regard to interviews, a tension arises when a nurse is prevented from achieving her object (to inform a person at risk and reduce epidemiological consequences) because the person is protected by confidentiality regulation. A new system is invoked that involves two new system players: a social worker who is the legal guardian of the minor, and the lawyer who is able to interpret the detail of the confidentially laws. The tensions of the old system are resolved with a modified ruling on confidentiality that forms a part of the new more expanded and more learned replacement system.

System$^1$: {Nurse; Inform infected patient partner; telephone, local knowledge; reduce public health risk, make treatment available; protect confidentiality; *nurse:* finds/informs those at risk; medical system, patients & families; rule of confidentiality vs. object}

Elements that differ from $S_1$ to $S_2$ are shown in bold in $S_2$. First we see the added concern to protect the minor in the rule base. Two new characters are added to the system, a social worker whose role is to guard the minor and a medical health officer who supports the nurse. Finally, a lawyer interprets the law on confidentiality

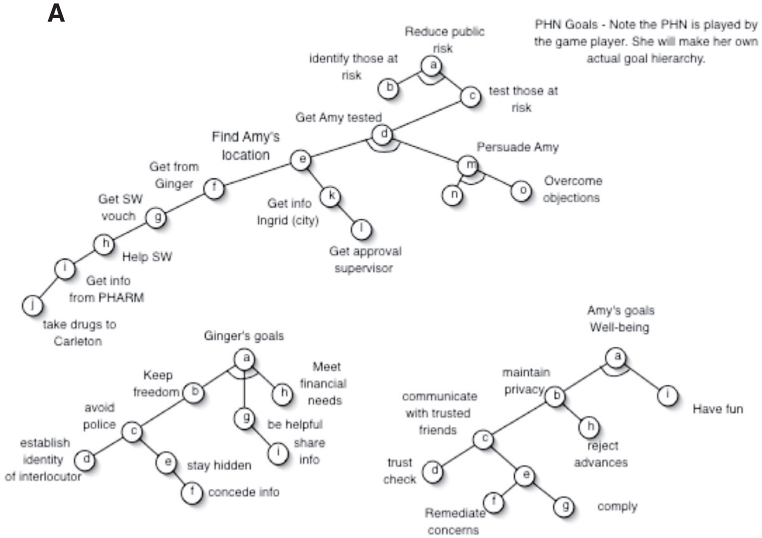
System[2]: {Nurse; Inform infected patient partner; telephone, local knowledge; reduce public health risk, make treatment available; protect confidentiality, **protect minors**; *nurse:* finds/informs those at risk; ***social worker*****: guards minor,** ***medical health officer:*** **support nurses,** ***lawyer:*** **interpret laws**; medical system, patients & families; no tension}

Systems in the game are controlled and changed by players taking on the persona of a character in the game and engaging with the other characters. The object of the game is to learn about other practitioner goals and to change the player's own practice. Changing an activity system cannot be done without dealing first with the goals of others in the system. Characters' goals are formed from earlier data. Recall, for example, the story of the struggle with legal interpretation on confidentiality. Qualitative data was coded as the phenomena (confidentiality and its complications) the conditions (all recipients of health care may expect their information be kept confidential; however, HIV is a reportable disease, and public health workers may use information to warn those who are known to be at risk), the context (dealing with sex partners of people with HIV), the intervening conditions (when risk has been established), the action strategies (the public health nurse will seek out known sex partners and inform them of risk. Situations where information on a person's whereabouts is limited can involve much detective work), and the consequences (if the person is located he or she can be tested and treated if necessary, if not, his or her health may decline, and he or she may unknowingly pass on the disease to others). In one episode in the game that refers to this goal, the player finds out about the lawyer's role and changes her own practice as a consequence.

The activity representations lead to several explicit interactions at the level of game play that correspond to the mechanics of expansive learning. The game enables the player to increase the scope of the activity system and to resolve difficulties in performance. A person is added to the network by visiting him or her or calling him or her from a list. In this way, the community of practice is shifted and the activity system changed. For a player to successfully transition from the first activity system, he or she must make sufficient changes in his or her environment. The goals of player characters are not made explicit until they are executed. Player plans and models exist prior to execution, however, and can be captured during play by studying their play. The nonplayer character goals are currently represented explicitly and cannot be easily changed during play. Our plan for future versions will be for players to adopt the persona of the nonplayer characters and to change their goals and then return to a former character. In this way, the player will be able to manipulate the multiple goal hierarchies in the activity system. In a similar way, the tools used in the game also carry with them certain traits and features that have an impact on the benefit of their use.

The key design strategy for HEALTHSIMNET is the implementation of the hierarchical goal networks for each of the characters, player characters and nonplayer characters. The dialog excerpt below is created from this method and is further reflected on using the analysis tools in the following section. The reader will see

A




B

**1(e) Resident (Ginger):** What do you want? Can't you see I'm busy?
**2(e) Public health nurse:** (Mary): Sorry to bother you. I'm looking for a girl named Ginger.
**3(d) Resident (Ginger):** Yeah? Who sent you?
**4(e) Public health nurse:** (Mary): Maybe you could help me. I'm looking for a girl named Amy Sandoval.
**5(d) Resident (Ginger):** I know Amy. Are you a cop? You sound like one. Go talk to my social worker, she'll know if you're a cop or not.

**FIGURE 7: Interacting Goal Hierarchies From HEALTHSIMNET**

there is little attempt to make the dialog turns based on understanding natural language as others have done (e.g., Mateas & Stern, 2002). Our game design is more concerned with the selections available at each story stage. We believe this approach creates significant variety that substantially addresses the need for interdisciplinary practitioners to experiment with alternative narratives within the game.

In Figure 7 we see the events at which dialog is generated from the interaction of the goal hierarchies. This is a very small extract from a full story, and a longer piece from the same game setting is given below.

The nurse is in midst of executing her main goal which is to reduce public risk and has information about Amy who is a youth who has very likely been exposed to the virus. She is therefore trying to execute a subgoal to get Amy tested which requires finding Amy and persuading her to get tested. Amy's location is available from two sources, and she chooses to follow the first option to get her address from a known friend called Ginger. When the nurse approaches Ginger, she responds at

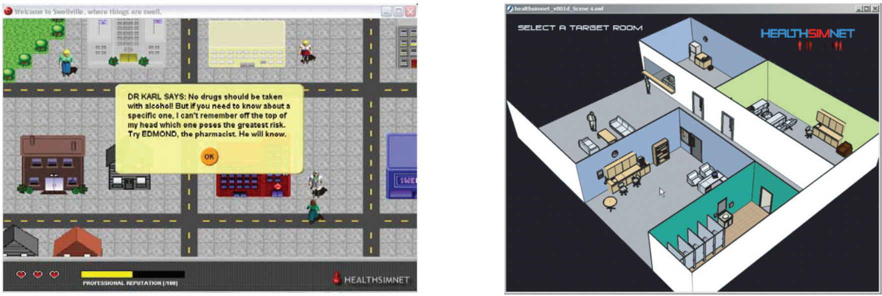



**FIGURE 8: Screen Shots From HEALTHSIMNET Dialog and Context Selection**

node (e) with a stock response that would be given to anyone she didn't know (Her goal to maintain freedom is satisfied by maintaining anonymity). The nurse, continuing to follow her goal, addresses her question to Ginger (e) this is an option from a list of speech acts available to the player. Ginger responds to the second question by trying to meet her goal to find out if the questioner is a plain-clothes police officer. The nurse responds with a second alternative to her same goal (e). Ginger is now left with few alternatives and to stay hidden concedes that she does know Amy, and at the same time directly accuses the speaker of being a police officer and directs her to speak to a social worker that she trusts. This is a compound of two stock dialog acts from (d). The game and the dialog continue, of course, beyond the excerpt and a longer series of interactions is reviewed using our analysis tools below. Although there is no illusion of natural language understanding we believe the dialog is quite successful in realism. The following excerpt was generated from interaction during a recent study with interdisciplinary health students. The bold text shows the options selected cooperatively by a group of students in our recent study. Notes in square brackets show the character is moving around the board.

CONSTABLE JIM SAYS: Well hello! How's your day been? Things are peaceful around here. Just as it should be.

YOU SAY:
1.Can you do me a favor and locate this girl named AMY Sandoval for me?
**2.I'm looking for a girl named AMY Sandoval, you know who she is?**
3.I'm looking for someone named GINGER

CONSTABLE JIM SAYS: I know AMY, but I don't know where she lives. She comes by here once in a while to visit GINGER. I think they're friends. You can find GINGER around the HOTEL LUCKY, she'll be able to help you."

[YOU WALK TO THE HOTEL LUCKY AND START A CONVERSATION WITH A PROSTITUTE WORKING NEAR THE HOTEL]

GIRL SAYS: What do you want? Can't you see I'm busy here?

YOU SAY:
**1.Sorry to bug you. I'm looking for a girl named GINGER.**
2.Maybe you can help me, I'm looking for a girl named AMY Sandoval.
3.You need to get off the street, get a real job. Call me some time, I can help.

*(continued)*

```
BARB SAYS (Street Nurse): AMY Sandoval? Sorry, never heard of her. I don't think she
lives around here. I know all the girls on this side of town.

[WHILE STILL DOWNTOWN, YOU MEET ANOTHER PROSTITUTE, AND SHE SAYS SOMETHING TO YOU]

GIRL SAYS (Prostitute): Things are a bit slow today. I'm glad for it!

[YOU WALK AWAY FROM THE PROSTITUTE AND LOOK FOR THE SOCIAL SERVICES OFFICE; YOU
EVENTUALLY MEET A SOCIAL WORKER OUTSIDE THE OFFICE]

KATHY SAYS (Social worker): Hi. I'm juggling 10 different cases. I'm working off the
side of my desk. They never told us social work would be like this.

YOU SAY:
1.What do you do?
2.I met GINGER, I think you know her? I need her help, but she won't talk to me unless
you tell her I'm really a nurse and not a cop. Can you please help?

KATHY SAYS (Social worker): I'd love to help you, but I need to assist a client with a
treatment issue. I wish I could free up some time to help you. I'm busy looking for
the name of this anti-retroviral drug. It's something not supposed to be taken with
alcohol. One of my clients, I think she's on the bottle again, but she's also on HAART
meds. I want to know if there are any drug interaction issues with her meds? There's a
specific drug a pharmacist told me about that shouldn't be taken with alcohol. I'm
embarrassed to admit I forgot the name. All I can remember is that it begins with the
letter begins with the letter A

YOU SAY:
1. I know what it is!
2. I don't know, but I can find out for you.
3. Sorry, that's not my specialty. Good luck with that.

[YOU WALK AWAY FROM KATHY THE SOCIAL WORKER AND GO TOWARDS THE LOCAL PHARMACY. OUTSIDE
THE PHARMACY, YOU MEET A PHARMACIST NAMED EDMOND]

EDMOND SAYS: Hey, how's your day been?
```

We have now built a number of interfaces through which to present the dialog including the two shown in Figure 8 below. The image on the left is our most recent interface, and this game can be downloaded and played from our Internet site. Options for interaction with the game are presented as orange buttons, and the player may navigate around the game board to locate and communicate with different nonplayer characters.

In summary, the game presents an interesting middle ground within work on interactive narrative by focusing on character representation, specifically character goal hierarchies. Combining this approach with an immersive environment constructively limits the breadth of interaction possible. This much has been done before; however, in this work, instead of dwelling on the problematic area of natural language understanding, our game focuses on dealing with the consequences of choices made by players. In this way we have been able to incorporate rules and features found in our qualitative data collection with practitioners and present a game that is reasonably true to these factors.

## Reflecting on play

It is often said that learning in experiential environments requires debriefing and reflection on users' or players' action (Petranek, Corey, & Black, 1992). Our tool called TEAMVIEW has been designed to create graphical traces of team interactions

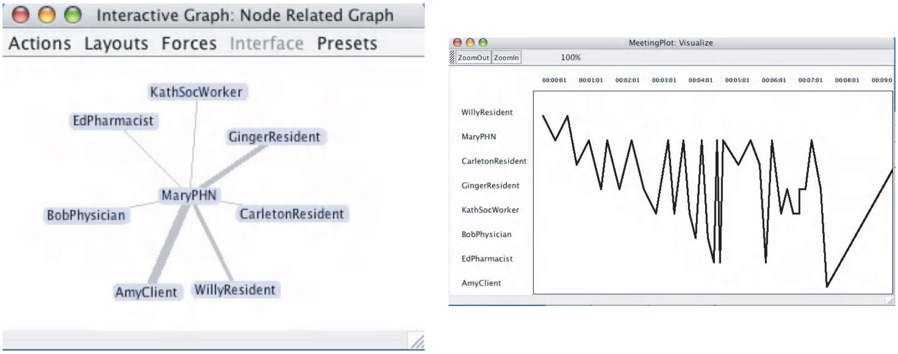



**FIGURE 9: Showing Representations of Dialog Interactions With a Force-Graph and a Talking Stick Plot in the TEAMVIEW Analysis Tool**

in simulations and games. The representations of narrative data present several different views of the interactions in a story. They allow us to illustrate as well as create and manipulate several of the core patterns of interaction. The tools shown were initially created to represent the outcome of interactions between player and non-player agents using simulations of emergency situations in underground railway systems and in nuclear accidents (Dobson et al., 2001). However, they are now being used also to model stories during design process. Figure 9 below shows two representations using pieces of a script constructed within the HEALTHSIMNET game.

The *meeting plot* draws a line in time between each player in the story and shows the passing of conversational control among the participants. We sometimes call this *the talking stick* representation. We can see small sequential interactions in the group between pairs as well as see the return of control to the public health nurse who is the busiest character in our story. The *interactive force graph* aggregates all messages within a story file and draws links between communicating participants. Line thicknesses show the relative magnitude of messages between each dyad. The reader sees a simple visual appreciation of the centrality of each player and an impression of connectedness between each character.

In studies ongoing with our group of practitioners we record interactions using this tool and continue to explore the benefits of using it to support their reflection on their use of the simulation.

Our work with HEALTHSIMNET is being evaluated with empirical methods. Although there is little room here for detail we recently conducted a study that concentrated on two kinds of data. A comparison of the plausibility of story lines created from a game that uses hierarchical goal networks combined with simple language pattern matching with our own interface that combines the goal hierarchies with character dialog options for the player to choose from. Our hypothesis is that our dialog would be more realistic and plausible to users. The study began with an interdisciplinary team of students playing the game. There interactions were saved as a *dialog log* (an extract is reproduced earlier). This was inserted into a plausibility-rating instrument where users could rate each sentence using a Likert-type (0-9) scale. We then asked our same subjects to rate a sample of dialog from another game (Mateas & Stern, 2002) that uses a similar hierarchical narrative generator but relies on natural language interaction and some other techniques to interact with the player. We believed that the pattern matching interfaces to goal hierarchies would work less well than menu-driven interfaces. In our second study, we are interested to know if there were significant differences between the mental models held by the professional groups who represent different character-players. A second instrument was designed to look at changes in player's mental models and was distributed to around 30 interdisciplinary health students. The instrument contains a series of concept pairs, for example {confidentiality ↔ risk} {sobriety ↔ adherence} {sexual abuse ↔ denial} {sexual abuse ↔ confidentiality} and so on. We will use an information-processing technique called *pathfinder networks* (Jonassen, 2006; Schvaneveldt, 1990) to process and compare results. Our goal is for learners to better understand other professional practitioner goals particularly insofar as they affect overall system performance. Although these pairs do not fully model goal hierarchies across professions, the pathfinder networks will give a representation of interprofessional development from game play. The initial findings of this study are that plausibility is indeed higher in HEALTHSIMNET than in the comparison system, and there are some distinct differences between the disciplinary groups in their models of the subject matter.

## Discussion

In our brief analysis of interactive narrative as it relates to health games for learning we began to see a trend toward the integration of an open-ended exploration within the game world and the use of intelligent planning techniques. Some critical theorists have taken this technical point and used it to compare systems from the user's point of view by describing interactive systems as either *impositional* and *expressive* (Eledhari & Lindley, 2004). The impositional form describes the choose-your-own adventure books, adventure games, and other fixed multilinear narratives, whereas the expressive form relies less on a sequence of events and behaves more like architecture.

This distinction is, of course, written to favor the open-ended alternative and amplifies the virtues of choice and freedom to explore. However, such choice may be difficult to resolve with the need for predictable plans, realistic projected outcomes, and other constraints that are a requirement for believable story outcomes. Open-ended expressive environments represent a redistribution of intent and agency from the aspiration of the author to the action of the player and crucially depend on the defining goal hierarchies of the player characters and the fidelity of planning structures. With agency in the hands of the player and nonplayer characters, the projection of the goals becomes game play strategy. For learning, this point is of immense importance because, unlike in other media, this design approach forces the player to postulate the plans of other characters. This is exactly the goal of interdisciplinary learning.

The design of HEALTHSIMNET is informed directly from the analysis of experiences accumulated during our interviews with network participants. We see this as a middle ground between the first-person narrative and the reenactment or invented game. First-person stories are a vital part of the power behind the development of understanding and episodic memory (Kass, Burke, Blevis, & Williamson, 1994). The authenticity of the reproduced experience can be extremely clear when the full account provided by the author is available to the reader. Unfortunately, however, the possibilities for providing alternative plot constructions within the simulation are lessened as the grain size of the story fragment is increased. If we were to simply reproduce the stories as we recorded them from our first-person interviews the outcomes of the simulation would be entirely predictable (although the learning outcomes are never so probable). In other approaches, full stories are indexed for their instructional value and retrieved during the execution of a simulated practice environment based on rules that suggest they are relevant to the context of action (Burke & Kass, 1995). In that system the simulation is separated from the storytelling (which is used to prompt and advise the player). Case-based reasoning and narrative construction offer several opportunities for the design and implementation of narrative documentary games. In HEALTHSIMNET, the stories appear only as reconstructed fragments in play that is constructed using a planning system from schema derived from data viewed through activity theory.

We would surely like to have had more detailed data from a rich ethnography of our health network situations that included comprehensive observation of the work settings and even our own participation in the practice to understand them better. Available data in this area is limited, and although excellent work has been done from the perspective of the persons living with AIDS (PWA) (e.g., Cooper, 2004) and a special edition of *AIDS and Behavior* was dedicated to ethnography in HIV little has been done to consider multiprofessional practice among care workers. Ethnographies in HIV have dealt with broad issues for the PWA such as stigmatism, gender, and power; and the foci has mainly been in the affected populations and the struggles within the nongovernmental organization (NGO) representatives (do Valle, 2000). Some work on interdisciplinary nursing appears to have demonstrated benefits of team HIV care (Westbrook & Schultz, 2000) showing the need to manage lines of referral between specialists or for social workers to partner with families (Goicoechea-Balbona, 1998). However, we found few studies of the multiprofessional practices of health care workers in this field.

We would like to see more attention to basic ethnographic and participatory research in this area; however, in spite of this, we have seen from recent studies with HEALTHSIMNET that it produced realistic behavior that can be surprising for its users. For typical learners in training programs where protocols are reasonably well understood, this kind of game presents a way to explore practice and to confront their own perceptions of best practice. We can call this phase of learning *exploratory*. The simulation creates an authentic and realistically complex environment for the typical professional learner.

The game can also in some ways be said to support a genuinely expansive learning experience. Practices within a network of practice do not change instantly in all locations for all participants or even at a regular or predictable manner. Therefore, activity systems that have been resolved in one place may remain unresolved in another for some time. This represents a phase that we could call *transitional* in which this kind of simulation can be useful for players to update their skills in a realistic and interesting way. Another phase we call *creative* exists when the simulation creates situations that have not yet occurred in practice (or have not been reported) but, because the rules that generate the situations are realistic, could potentially emerge. In this situation, the new instrumentation, role reassignments, or other ways in which the system may be altered cannot be fully implemented prior to the simulated experience.

While implementing this project some future options have been suggested. Qualitative researchers take a rich and complex view of the role of the personal narrative in inquiry (Cooper, 2004). Our approach may not capture the subtlety of the role of story in the development of identity development presented (Ezzy, 2000). Life-threatening illnesses appear to challenge assumptions about temporal framing of people's lives and often lead to transformations in spirituality and of life priorities. The stories people tell themselves and that are created around them directly affect the possibility of increased self-understanding and insight, or instead can lead to depression, despair, and declining health. The stories in HEALTHSIMNET are deliberate attempts to create valid scripts based on objectively sound story turns. Ezzy (2000) told us the narrators of personal stories may take considerable latitude with their own stories, perhaps only partly guided by "consistency" with factual events and circumstances, and can thereby have enormous effect on the outcome in their lives. These are very powerful phenomena that are not suggested by the current game. Herein lies the possibility for a game that may be even more effective where a player could explore this development of personal narrative in response to the challenge of life-threatening disease. This may be done at the individual and social realms. Personal narratives have to negotiate information processed by the teller and also ready processed information offered by others. If a person's response to illness is key to the outcome, then the community in which the response is made is key to what qualifies as a reasonable narrative response. We are excited to design a second-generation game that could show how choices made at the cognitive and social realms can lead to different health outcomes.

## Conclusion

This article gives an overview of our work in the field of intelligent documentary learning games that is focused on the development of a design method that takes first-person interview data for creating interactive learning narrative.

We described a thread from within the rich and productive field of AI and interactive narrative research insofar as we can trace a direct impact on the development of a multiplayer health game for professional development. We then showed how it is possible to create interactive dialog using approaches ranging from problem-solving methods, plot analysis and transition networks, plots from abstract themes using augmented networks, schema driven approaches, polyvalent models of narrative, and open-ended games environments. We discussed how these options led to design decisions for HEALTHSIMNET and reviewed the extent to which truly expansive learning can result from this kind of design. Our main contribution is an approach that draws on the possibilities of character-based plot generation using the model of hierarchical goal networks to describe and constrain character plans that focus not on natural language understanding, but on producing dialog from a corpus of real data from field analysis. The results of our early investigations into the use of the game within an interprofessional postgraduate course designed around the care of HIV patients are beginning to illustrate the potential for our simulation to improve practice.

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