Chapter 19

STORY-BASED LEARNING ENVIRONMENTS

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STORY-BASED LEARNING ENVIRONMENTS

There is no substitute for experience in the acquisition of complex skills. The goal of virtual environment training is not to reduce the need for experience, but rather to provide experiences to trainees with less cost, risk, and time than would be required if these experiences were instead acquired on-the-job. Accordingly, the challenge in developing effective virtual environment training is designing experiences for trainees that support learning. In story-based learning environments these experiences are designed to have distinctly narrative qualities: a set of characters, a temporal sequence of causally related events, a rich but relevant amount of descriptive detail, and a point. Typically the trainee participates as a character within this environment following a learning-by-doing pedagogical strategy, and the actions taken affect the outcomes of an emerging storyline. In the ideal case, the trainees in a story-based learning environment walk away with a story to tell about their training experience—one that is not markedly different from the best stories that practitioners tell about their real world experiences.

The research history of story-based learning environments over the last three decades has been driven by changes in technology, but defined by particular paradigms of instructional design. In the late 1980s the Learning Technology Center at Vanderbilt University was a center of research in story-based learning environments, guided by the design principles of anchored instruction (Cognition and Technology Group at Vanderbilt, 1990). The university's Jasper Woodbury project used a hypertext-controlled video laser-disc player to present students with problems grounded in a fictional scenario, where completing the problems would enable the students to write their own ending to the story (Cognition and Technology Group at Vanderbilt, 1992). In the 1990s, Northwestern University's Institute for Learning Sciences led research on story-based learning environments following a design philosophy known as goal-based scenarios (Schank, Fano,

Bell, & Jona, 1993). These systems, typically constructed as software applications using desktop video to deliver story content, were constructed in diverse learning domains that included corporate tax advising, wetlands management, and counseling couples about sickle cell anemia. The late 1990s saw the commercialization of outcome-driven simulations (Cleave, 1997), a cost-effective design for goal-based scenarios that was championed by Cognitive Arts, Inc. and others, deliverable as a Web application where story content was given as text with digital photographs of fictional situations. At the beginning of the twenty-first century, story-based learning environments took advantage of advances in virtual reality and gaming technologies. This is best exemplified by the research projects of the Institute for Creative Technologies at the University of Southern California (Swartout et al., 2006; Gordon, 2004; Korris, 2004; Hill, Gordon, & Kim, 2004), which increasingly have followed the educational design principles of guided experiential learning (Clark, 2004).

Throughout this research history there has been a change in the nature of the story in story-based learning environments. In the early anchored instruction prototypes the central story of the experience was a completely fictional narrative designed to appeal to the demographic of the target audience. In subsequent work on goal-based scenarios, the central story of the experience was fictional, but it was delivered along with a collection of nonfiction stories that illustrated particular points or lessons relevant to events in the fictional storyline. These nonfiction stories consisted of short narratives of the real world experiences of skilled domain experts, often presented as desktop video clips as part of an automated tutoring component of the learning environment. Beginning with the commercialization of outcome-driven simulations in the late 1990s, these two types of stories (fiction and nonfiction) in story-based learning environments became closely intertwined. In this work and in the story-based learning environments that would follow, the collection and analysis of real world nonfiction stories became integral to the authoring of the fictional storyline and structuring of the user interaction. The stories in contemporary story-based learning environments are defined by the real world nonfiction anecdotes that training developers collect from subject matter experts.

The evolving role of nonfiction stories in the development of story-based learning environments brings a new perspective to this form of training application. In the past, these applications served as the delivery method for an explicit body of training content. Today, these applications function more as a complex form of communication, mediating between storytellers and the people who can best benefit from hearing these stories. Story-based learning environments can be viewed as a form of digital storytelling, where the fictional storylines of learning environments are media that can preserve the underlying points of stories acquired through real world experience. Seen from this perspective, the main challenges for developers of story-based learning environments concern the management of real world story content through the development pipeline. This includes the following key problems: How do developers collect stories of real world experiences that will serve as the basis for the training application? How

should these stories be analyzed to identify their central points and relationship to training objectives? How can real world story content be fictionalized and utilized within the context of a virtual reality training application? In this chapter we discuss a number of best practices for each of these three development questions. As a context for this discussion, we begin by providing an example of a story-based learning environment, the Institute for Creative Technologies (ICT) Leaders Project.

THE ICT LEADERS PROJECT: A STORY-BASED LEARNING ENVIRONMENT

The ICT Leaders Project, a collaboration between the University of Southern California's Institute for Creative Technologies and Paramount Pictures, was a research effort aimed at allowing junior U.S. Army officers to practice making leadership decisions in the context of complex fictional scenarios realized in a virtual reality environment (Gordon, van Lent, van Velsen, Carpenter, & Jhala, 2004; Gordon, 2004; Iuppa & Borst, 2007). The trainee played the role of a U.S. Army captain commanding a company of soldiers on a peacekeeping mission in Afghanistan. The situation, which parallels the story developed for a live-action U.S. Army training film (Hill, Douglas, Gordon, Pighin, & van Velsen, 2003), involved providing security for a food distribution operation complicated by the presence of competing warlords. Rather than relying on scripted video, however, the ICT Leaders Project presented the story and fictional scenario in a virtual reality environment based on a commercial game engine, where cinematic scenes were interwoven among conversations with animated virtual soldiers and civilians in the environment.

The user experience in the ICT Leaders application was structured around a series of scripted cinematic scenes rendered in the virtual environment of the game engine. These scenes moved the storyline forward and presented challenging leadership problems where a decision had to be made by the user. These problems were always presented to the user by storyline characters, and the primary user interaction involved text-based conversations with these characters. The user had the opportunity to raise questions and make comments concerning the problem, but in order to move the storyline forward the user needed to communicate a decision to the virtual character. The choice that the user made had a direct effect on how the storyline unfolded, where different choices caused the experience to follow different paths in a branching storyline structure. The application prototype included 11 decisions that make up the branch points of the storyline, and each of these decisions was motivated by a specific leadership point as evidenced by a nonfiction narrative of a leadership experience. These leadership stories were collected through directed interviews with experienced company commanders. Each story was subsequently analyzed to identify its central point, the lesson that challenges the expectations that novices have when adopting a leadership role.

The ICT Leaders Project used a commercial game engine, Epic Game's Unreal Tournament 2003, to create the virtual environment for the user experience. Using the standard "mod" editor that comes with this product, a new type of interactive application was developed that was very far removed from its original first-person shooter design. Custom terrain maps, character models, animations, sound effects, and props were created to produce an immersive virtual reality environment to serve as a backdrop for the fictional storyline. The storyline itself was authored with the help of a professional Hollywood scriptwriter, and professional voice actors were used to record the dialogue of the virtual characters. Cinematic scenes were designed with the assistance of a professional director to give the production a traditional cinematic style, particularly with respect to camera movement and cuts.

In the opening sequence of the application, the trainee takes on the role of Captain Young, who is to lead an infantry company in Afghanistan as a replacement for a previous captain removed due to a medical emergency. In the morning after his arrival, Captain Young meets with the first sergeant and executive officer to go over the security plan for a food distribution operation being conducted by a nongovernment relief organization. The executive officer assures the captain that everything is in order, but has a question regarding the leadership style that the captain will set for the company: Should soldiers in the company make their own decisions when problems arise, or should they consult the captain before taking initiative? This question ends the scripted scene, and the trainee is then allowed to discuss the issue with the executive officer using a text-based dialogue interface. The trainee can ask questions and get further clarification from the executive officer by typing them into the system (for example, "How experienced are the junior officers in this company?"). Responses to these questions are selected using a text classification algorithm, built from a corpus of hand-annotated questions using machine learning technologies. The selected responses are then delivered to the trainee as recorded audio clips accompanied by character animations. Ultimately, the trainee must provide a decision with regard to the original question posed by the executive officer, either to let the soldiers take initiative or to request that they consult first with the captain. When either of these choices is entered into the text-based dialogue interface, a branch in the storyline is selected and a new cinematic scene moves the trainee to the next decision point.

From the perspective of the research history of story-based simulations, the ICT Leaders Project can be viewed as a type of outcome-driven simulation (Cleave, 1997) embedded in a virtual reality environment, where branches in the space of outcomes are selected using a text-based dialogue interface. Aside from the work needed to support these extensions, the authoring of the ICT Leaders Project closely followed the approach established during the commercialization of this technology in the late 1990s, albeit with substantial influence from the Hollywood entertainment community (Iuppa, Weltman, & Gordon, 2004). As such, the methods used in the ICT Leaders Project address many of the concerns in the design of contemporary story-based learning environments. In the

remaining sections of this chapter, we discuss the three key issues of story collection, story analysis, and simulation design using this project to illustrate current directions in the evolution of these systems.

CAPTURING THE STORIES OF EXPERIENCE

The first-person nonfiction narratives that people share about their experiences are increasingly valued as an instrument for knowledge socialization—the sharing of knowledge through social mechanisms. Schank and Abelson (1995) argue that stories about one's experiences and the experiences of others are the fundamental constituents of human memory, knowledge, and social communication. Sternberg et al. (2000) argue that storytelling is particularly valuable as a means of communicating tacit knowledge. This enthusiasm for storytelling is echoed in the management sciences, where organizational storytelling is seen as a tool both for organizational analysis and organizational change (Boyce, 1996; McCormack & Milne, 2003; Snowden, 1999). Organizational stories are also increasingly used in the development of effective computer-based knowledge management applications. Johnson, Birnbaum, Bareiss, and Hinrichs (2000) describe how story collection can be directly linked to work flow applications in order to provide story-based performance support. This rising interest in the role of stories in organizations has paralleled the increased importance of stories in the development of story-based training applications, creating synergies in the theory and practice of story management.

One of the central problems in the use of stories for knowledge management and training applications concerns the scalability of the methods used to collect them from the people who have interesting stories to tell. Today, the vast majority of stories that are used in organizational knowledge management and training applications are manually gathered through direct interviews with subject matter experts. The methods used to collect stories through interviews vary considerably; some more closely resemble cognitive task analysis techniques (Clark, Feldon, van Merrienboer, Yates, & Early, 2007), and others involve small group "story circle" meetings (Snowden, 2000).

For the ICT Leaders Project and others at the University of Southern California's Institute for Creative Technologies, an interview methodology evolved over a number of years that was particularly effective at gathering stories from U.S. Army soldiers (Gordon, 2005). Interviews were arranged for an average of 10 soldiers, 2 at a time, over sessions that lasted one hour each. These interviews were conducted in an extremely casual manner, where two or three members of the development team would talk with the 2 soldiers around a table, recorded using unobtrusive room microphones rather than individual or lavaliere microphones. The main goal of these interviews was to maximize the number of stories told by each pair of soldiers during the course of the hour-long session. The tactics were to trigger a memory of some real experience by asking leading questions related to the topic of the eventual training application and to set a conversational tone that would encourage soldiers to tell these stories. When

soldiers began talking in abstractions and making generalizations, the tactic was to push them to get more specific and to describe an actual experience that illustrated the point of their generalizations—or contradicted them, as was often the case. When a soldier started telling a story of a real experience, the tactic was to encourage him or her to keep talking, mostly by avoiding the natural conversational tendencies to offer some commentary on his or her story or to respond with a related story from one's own experience. Often, a silent pause was enough to prompt him or her to continue with a story or to provide another example. A key aspect of these interviews was that they were always conducted with pairs of soldiers. When one soldier finished telling a story, the other would invariably be reminded of a story from his or her own experience. In the best cases, the interviewers could simply listen to the swapping of stories by the two soldiers, intervening only when the topics drifted away from training objectives.

For the ICT Leaders Project, these interview methods were employed to collect stories related to U.S. Army leadership skills. In the summer of 2002, interviews were conducted at the U.S. Military Academy at West Point with 10 U.S. Army captains, each having just completed service as a company commander and beginning a master's degree program in Behavioral Science in Leadership. Sixty-three stories of leadership were gathered using these story-collection interview methods, an average of just over 12 stories per hour.

Although effective for targeted research and development projects, interview methods such as this are not scalable solutions to the problem of organization-wide story collection. If story collections are to be widely used in the large-scale development of knowledge management and training applications, then the costs of collecting stories from subject matter experts and other members of organizations must be substantially reduced.

In the past few years, the phenomenal rise of Internet weblogging has created new opportunities for computer-supported story-management applications (for example, Owsley, Hammond, & Shamma, 2006). With the estimated number of weblogs exceeding 70 million in March 2007 (Technorati, 2007), there is a reasonable expectation that substantial numbers of people in any profession or large organization are already sharing their stories with the public at large. If storytelling in weblogs is at all similar in character to face-to-face storytelling among peers (Coopman & Meidlinger, 1998), then we would further expect that a significant portion of these stories are directly relevant to the training needs of organizations. A minimal-cost solution to the problem of creating story collections is to employ automated techniques for extracting first-person nonfiction narratives of people's experiences directly from these Internet weblogs. Gordon, Cao, and Swanson (2007) explored the use of contemporary natural language processing technologies to automatically extract stories from Internet weblogs, which they estimated accounted for 17 percent of all weblog text. They demonstrated that high precision (percentage of extracted text segments that were actually stories) was difficult to obtain using current techniques, with the best precision performance reaching 49.7 percent. Although significantly higher than the baseline of 17 percent, this level of performance is still below the level of

inter-rater agreement achieved between two human judges, estimated at kappa = 0.68 (Gordon & Ganesan, 2005).

STORIES ON THE FRINGE OF EXPECTATION

In most science and engineering pursuits, first-person nonfiction stories are disparagingly referred to as "anecdotal evidence," a term meant to discredit the story as a suitable base for generalization. The argument here is that a single random incident may not be representative of the types of incidents that one would expect to encounter; only an appropriately large random sample of the experiences of practitioners can characterize the situations that new trainees are likely to encounter. In reality, stories may be the worst possible form of evidence if one were trying to learn something about the average case. People do not tell stories about the average case. The average case is boring. People tell stories about the things they find interesting, surprising, and unexpected. When one looks at a large number of stories from some domain of expertise, they do not sample the distribution of expected situations. Instead they each lay on a point along the edge of people's normal experiences, collectively defining the fringe of expectation. Gathering and analyzing the stories of the real world experiences of practitioners informs us not about the events that take place in the world, but rather about the expectations that these practitioners have about these events—and what they find surprising.

The concept of stories on the fringe of expectation is best illustrated when considering the fascinating stories that are told by night security guards of commercial office buildings. There was the time that a fire broke out in the trash chute. There was the time that an opossum crawled into the elevator shaft from the rooftop. There was the time the CEO of the company showed up in the middle of the night wearing pajamas. If these stories were representative of the lives of night security guards at commercial office buildings, then this might be one of the most exciting jobs on the planet. Sadly, the exact opposite is true. The representative experiences of night security guards are not the things that they tell stories about, to each other or anyone else. The stories that they do tell are the exceptions to the norm, the experiences that were markedly different from what they have come to expect in their routine practice. Gathering and analyzing these stories tells us more about the expectations of these professionals than the situations that are likely to occur overnight in commercial office buildings.

The position that stories are strongly related to expectations has been advanced within the fields of social and cognitive psychology. Bruner (1991) argued that the violation of expectations, which he referred to as canonicity and breach, is a defining characteristic of narrative as used by the mind to structure its sense of reality. Schank (1982) expanded on views held by Bartlett (1932) and observed that many features of human episodic memory can be explained if we view memories as organized by mental models and schemas that define our expectations of the world. Schank argued that people remember events when they are

counter to their expectations and used these expectation violations as a basis for revising their mental models to more accurately reflect reality. Schank and Abelson (1995) later argued that natural human storytelling supported these learning processes, enabling groups of people to collectively learn from the surprising experiences of others. Although this perspective is controversial in the social sciences (Wyer, 1995), the concept of an expectation violation has proven useful in developing story-based learning environments based on real world experiences.

To understand the importance of expectation violations in the development of training technology, consider the value of a good conceptual model to practitioners who must be adaptive in the execution of their skills. When they are in familiar environments and given familiar tasks, they can usually succeed by doing the same thing that has worked for them in the past. Where practitioners find themselves in situations that are only abstractly related to their experiences or training, they must adapt their normal behaviors. Here, a good causal understanding of the things in their environment—the people, organizations, politics, and systems—will aid them in developing successful plans by providing accurate expectations about the effects of their actions. When things happen as expected, plans are successful and tasks are accomplished. When things do not happen as expected (an expectation violation), then the natural human tendency is to identify where one's model of the world has failed. This tendency is the impetus for the formulation of rich episodic memories, the experiences that people think about over and over again in an effort to learn a better model of the way the world really works. Stories are the natural way that people share these experiences with others and serve as an effective means of using the collective experiences of others to help corroborate one's own experiences and collaboratively change the way that groups model their environment.

Collectively, the stories told by practitioners help identify where the models of novices and trainees are likely to be wrong or disputable and, as such, help identify the simulated situations that make the most effective use of training time. Developers of story-based learning environments can capitalize on expectation violations to help embed pedagogically motivated decisions into their simulation. The identification of the expectation violation in a story supports the authoring of a decision situation, a fictional set of circumstances where a decision must be made where the best choice is dependent on whether or not the expectation or the expectation violation is believed.

This approach was used in the development of the ICT Leaders Project, where each of the stories that were collected from U.S. Army captains was analyzed to formulate the expectation violation and a fictional decision situation that hinged on the expectation. For example, one of these stories was from a captain who had commanded both combat infantry units, as well as noncombat service support units. He remembered tasking the service support soldiers to move the trailer section of a tractor-trailer rig over the course of a day when no tractor was available. The subordinate soldiers responded with excuses about why they would not be able to do the job, sought to find someone else to do the job for them, and questioned why it needed to be done the first place. The captain was

struck by the difference in mindset when commanding combat infantry units that, given the same task, would simply get the job done and report back when it was completed. Why were the service support soldiers not like that? Why did they not behave with the same sense of purpose and initiative that was seen with the combat units?

This story informs us very little about the true difference between service support units and combat infantry units; this is merely anecdotal evidence that there might be some difference in mindset between these two groups. Instead, the utility of this story is that it identifies an expectation that is held by this captain about how subordinate soldiers should behave, one that was violated by this experience. In the ICT Leaders Project, a group of four researchers and training developers on the project came to the consensus about the expectation and expectation violation of this story as follows:

Expectation: Both combat and noncombat units realize the importance of their roles in the accomplishment of the larger mission, and will perform accordingly.

Expectation violation: A sense of pride and importance must be developed in low-performing noncombat units.

The next step in the analysis process is to use this formulation of the expectation violation to create a decision situation, one where the choice of what to do would be primarily determined by whether the expectation or its violation were believed to be true. Here the aim is to engineer a hypothetical situation where a decision has to be made, and where there are two options that are both viable, rational courses of action. In the ICT Leaders Project, the decision situation that was authored for this expectation violation was as follows:

Situation: A noncombat unit has been attached to the combat infantry company you command, and it is not performing well.

Choice rejected by the expectation: Wait for unit performance to improve as the soldiers realize their importance to the mission.

Choice supported by the expectation violation: Work with the soldiers in the unit to develop a sense of pride and importance.

In some cases it is possible to author a fictional decision situation that closely parallels some real decision that was made in the nonfiction story, but more often the decisions made in the real world do not have two or more well-balanced, viable, rational options from which to choose. Furthermore, authors of these situations need to guard against the presumption that one of the two options is the best choice or the right answer. Nor does the original story provide real support for one choice or another. Even if the events occurred exactly as they were described, they will rarely provide a strong justification for rejecting the expectations that are challenged. Instead, authors of these fictional decision situations should view them as ways of exploring the fringe of expectation, the fertile area that lies between the novice's mental models of the task domain and the experiences of practitioners. The right answers to these problems are not going to be determined through the analysis of a handful of stories, but rather through the varied practices of training doctrine development—a different challenge altogether.

THE FICTIONALIZATION OF LESSONS LEARNED

In the historical development of story-based learning environments over the last three decades, the most evident changes are in the technologies used in their production. As mentioned in the first section of this chapter, early story-based learning environments were produced using video laser-disc and computer hypermedia technologies in the late 1980s. This was followed by the appropriation of desktop video technologies in the early and mid-1990s, followed by Web applications in the late 1990s. Today, innovation in story-based learning environments is largely connected to virtual reality and computer gaming technologies. While the early 2000s saw enormous enthusiasm for the integration of computer gaming technologies in the development of computer-based training, the pairing of this technology with design paradigms in story-based learning environments was not an obvious match. The design paradigm that was commercially viable at the time was that of the outcome-driven simulation (Cleave, 1997), a story-based learning environment whose branching storyline structure lent itself particularly well to the hypermedia nature of Internet Web applications. In contrast, computer gaming technology is at its best when treated as a constructive simulation environment, where the situations encountered by trainees emerge through the careful tuning of initial situations and the simulation rules that govern the effects of actions. In short, the best simulation-based training looked more like an airplane flight simulator, while the best story-based learning environments looked more like a choose-your-own-adventure book (for example, Packard, 1979). It was not at all obvious how the two could be successfully paired.

The ICT Leaders Project might best be viewed as an early attempt to force these two technologies together into one training application. The approach taken by the development team was to author an outcome-driven simulation using the same methods that had been used for Web-based training instantiations, where each of the fictional decision situations identified through the analysis of real world stories served as a branching point in a static branching storyline. Specifically, it was constructed as a tree with 11 branch points, each with two branches. The presentation of each decision situation and the consequences of selecting one of the two options were realized as scripted scenes, each using a consistent set of fictional characters and interrelated events. In authoring a rich fictional storyline for the ICT Leaders Project, the challenge was to instantiate each of the general descriptions of decision situations into a coherent narrative with dramatic impact (Iuppa et al., 2004).

Work on the fictional storyline for the ICT Leaders Project followed on the heels of the development of another media-based training application based on the same corpus of interviews with U.S. Army captains, the Army Excellence in Leadership (AXL) project (Hill et al., 2003, 2004). In this work, the transcribed stories of leadership told in these interviews were used as source material for the development of the screenplay for a live-action training film, entitled *Power Hungry*. The 15 minute film depicts the fictional events occurring over the course of a day in the life of Captain Young. Captain Young is assigned to command an infantry company in Afghanistan during Operation Enduring Freedom, tasked

with providing security for a food distribution operation conducted by a nongovernment relief organization. Conditions deteriorate as Captain Young divides his time between micromanaging his subordinates and meeting with local warlords, who eventually succeed in disrupting the operation through deception about their rivalries. The AXL research project at the University of Southern California's Institute for Creative Technologies later used this film and others like it to explore the development of distance learning technologies for case-method instruction (Hill et al., 2006). Much of the training value of this film comes from the discussions of the leadership style for Captain Young. The ICT Leaders Project based its fictional branching storyline in exactly the same scenario environment, seeking to capitalize on the richness of the fictional situation created in the *Power Hungry* film and to provide trainees with a means of playing the role of Captain Young in a learn-by-doing training application.

To instantiate the decision situation described in the previous section of this chapter (concerning noncombat units) the writers on the ICT Leaders Project cast the decision in the context of an argument between the first sergeant and the executive officer of the company. The storyline introduces a noncombat military unit to raise the issue, a small civil affairs unit that is attached to Captain Young's company to aid in their interaction with Afghanistan political leaders. They perform poorly at an assigned task, which is to oversee and manage a band of local militia forces that are partnering with the U.S. Army to ensure security for the food distribution operation. This concerns the first sergeant of Captain Young's company, and when he and the executive officer meet with Captain Young (a role played by the trainee) he offers to give the civil affairs unit some coaching to improve its motivation. The executive officer disagrees, saying that it is likely that this motivational speech would hurt more than help and that the problems of the civil affairs unit are expected given the little time they have had to integrate with the rest of the company. The sergeant still does not agree and turns to Captain Young (the trainee) for a decision on what to do.

The great weakness of this style of story-based learning environment, that is, an outcome-driven simulation, is that users are forced to select among a very small number of options in order to ensure that the consequences of these actions have both narrative coherence and lead directly to other decision situations. The trainee who is playing the role of Captain Young in the ICT Leaders Project must decide between two options in this decision situation, regardless of whether or not he or she has a more creative solution to the problem in mind. Perhaps the civil affairs unit should not be assigned the task of managing local militia in the first place. Perhaps the first sergeant should redirect his attention to improving the motivation of the local militia instead. Perhaps the executive officer should get involved directly and leave Captain Young alone to work on the bigger problems of the day. It is possible to provide an interface to the trainees that would allow them to make these types of creative choices (for example, Gordon, 2006), but it is harder to imagine predicting the effects of these choices given the current state of simulation technology. Harder still is the problem of keeping the storyline on track so that the effects of these creative

actions ultimately lead the trainee to another pedagogically motivated decision situation.

In the present, the latter half of the first decade of 2000, current research in story-based learning environments is closely aligned with research on technologies for interactive drama. The central question within the research area is how to ensure that a well-crafted story unfolds when the user plays the active role of a creative protagonist. Much of this work attempts to ensure that particular plot elements are included in the unfolding story regardless of the user's actions (Magerko, 2007; Riedl & Stern, 2006a; Mateas & Stern, 2003). Several researchers have noted the parallels between this concern and that of the developers of story-based learning environments, who seek instead to ensure that trainees are presented with particular decision situations (Riedl & Stern, 2006b; Magerko, Stensrud, & Holt, 2006). Increasingly, these efforts are incorporating artificial intelligence planning and execution models to ensure story-like paths through state spaces that are far larger than could reasonably be authored by hand. However, the richness of the possible storylines is most limited by the believability of the behavior models used to control the actions of virtual human characters, which remains an incredibly difficult artificial intelligence research challenge (Swartout et al., 2006).

SUMMARY

At the beginning of this chapter, story-based learning environments were characterized as a complex form of communication, mediating between real world experiences told as stories and the experiences of learners in virtual environments. Seen from this perspective, the main challenges for developers of story-based learning environments concern the management of real world story content through the development pipeline. Three key processes in this pipeline were highlighted in this chapter, each representing areas where automation and innovation should be the focus of future research and development. First, stories of real world experiences are an invaluable means of communicating tacit knowledge, but the directed interview methods used today to collect stories from practitioners have problems of scalability. Second, stories of the experiences of practitioners can be analyzed to identify the expectations that they challenge and can be transformed into decisions to be made by learners in fictional situations. However, this style of analysis and transformation capitalizes on only one aspect of nonfiction stories related to learning, tightly constraining the way that these stories are incorporated into virtual learning environments. Third, the branching storyline techniques used to develop outcome-driven simulations in the 1990s transfer well to today's virtual reality environments, but new innovations in interactive drama are needed to allow learners in these environments to tackle problems in creative ways.

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