Optimizing Story-Based Learning: An Investigation of Student Narrative Profiles

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Abstract. Narrative-centered learning environments offer significant potential for creating effective learning experiences in which students actively participate in engaging story-based problem solving. As the capabilities of narrative-centered learning environments expand, a key challenge is identifying experiential factors that contribute to the most effective story-based learning. To investigate the impact of students' narrative experiences on learning outcomes, a Wizard-of-Oz (WOZ) study was conducted with middle school students interacting with a narrative-centered learning environment. Students' experiences were examined using narrative profiles representing their type of story interaction. With narrative planning, tutorial planning, and natural language dialogue functionalities provided by wizards, the WOZ study revealed that in interactive story-based learning supported by beyond-state-of-the-art ITS capabilities, 1) students exhibit a range of learning outcomes, 2) students exhibit a range of narrative profiles, and 3) certain student narrative profiles are strongly associated with desirable learning outcomes. The study suggests design decisions for optimizing story-based learning.

Keywords: Narrative-Centered Learning Environments, Game-Based Learning Environments, Wizard-of-Oz Study.

1 Introduction

Stories provide an episodic structure that shapes our experience. By taking advantage of narrative's inherent structure, narrative-centered learning environments offer significant potential for creating story-based learning that is both effective and engaging [1,2]. These environments offer rich interactions in which students actively participate in engaging story-based problem solving tailored to their individual needs. A growing body of research has investigated narrative-centered learning environments for education and training. For example, it has been shown that narrative-centered learning environments can support science education [3,4], social behavior education [5], interactive health education [6], and training [7,8,9].

Although the capabilities of narrative-centered learning environments have expanded greatly over the last decade [3,10,11], these technologies are still in their infancy. Given the promise that narrative-centered learning environments have shown, it is important to identify the factors that contribute to the most effective story-based learning experiences. Further, this analysis should be conducted without current ITS technology limitations to explore how an "ideal" narrative-centered learning environment should best support learning. A promising approach for this line of investigation is the Wizard-of-Oz (WOZ) methodology. A WOZ-enabled narrative-centered learning environment could be devised in which wizards provide the narrative planning, tutorial planning, and natural language dialogue functionalities of the system to ensure human-level decision making and interactivity are achieved.

This paper presents the results of a Wizard-of-Oz study conducted with middle school students collaborating with trained wizards in a WOZ-enabled narrative-centered learning environment for microbiology. It was found that students exhibited positive learning outcomes. Analysis of the students' experiences revealed that in interactive story-based learning supported by beyond-state-of-the-art ITS capabilities, students exhibited a range of narrative profiles, and certain student narrative profiles are strongly associated with desirable learning outcomes. The study suggests design decisions for optimizing story-based learning.

This paper is structured as follows. Section 2 provides background and related work on story-based learning. Section 3 introduces the CRYSTAL ISLAND learning environment. The study design and procedure are described in Section 4, and the results and analysis are presented in Section 5. Section 6 discusses the findings and associated design implications, and Section 7 offers concluding remarks and suggests directions for future work.

2 Background

Educators have long recognized the potential of contextualizing learning within narrative [12]. Leveraging students' innate metacognitive apparatus for understanding and crafting stories to create story-based learning experiences offers much promise. By immersing learners in captivating worlds populated by compelling characters, narrative-centered learning environments can enable learners to participate in the construction of narratives, to engage in active problem solving, and to reflect on narrative experiences [1].

A broad range of techniques have been proposed for crafting interactive story-based learning experiences that are both engaging and pedagogically effective. In FearNot!, a simulation framework drives affect-enabled agents to generate dramatic vignettes for social behavior education [5,13]. By suggesting coping behaviors for virtual agents involved in bullying incidents, students develop an empathetic relationship with the agents. In Teatrix, a director agent supports the story creation process of students collaboratively creating fairy tales [14]. In Carmen's Bright IDEAS, an agent-based approach to interactive narrative is utilized to teach social problem-solving skills to mothers of pediatric cancer patients [6]. In the Tactical Language and Culture Training System, virtual characters teach foreign language communication skills [8,15]. Socially intelligent virtual humans are used in the Stability and Support Operations (SASO) system to develop leadership and negotiation skills in trainees [16,17,18].

Despite the promising work that has been carried out to date on narrative-centered learning environments, the capabilities of these systems remain limited when compared to human-to-human interactions. We seek a better understanding of the factors that contribute to effective story-based learning without the limitations of current ITS technologies.

3 The CRYSTAL ISLAND Learning Environment

The classic narratological framework for analyzing story structure is the narrative arc (Figure 1). The *narrative arc* models the tension experienced by the audience as a narrative progresses through its phases of exposition, complication, escalation, climax, and resolution. In the *exposition*, the setting and situation are introduced. During the *complication*, a problem develops and tension rises. The *escalation* sees the problem intensify and a rapid rise in the tension. The tension reaches its highest level during the *climax* when the story starts to resolve itself. During the *resolution* the remaining issues are resolved and the tension diminishes.

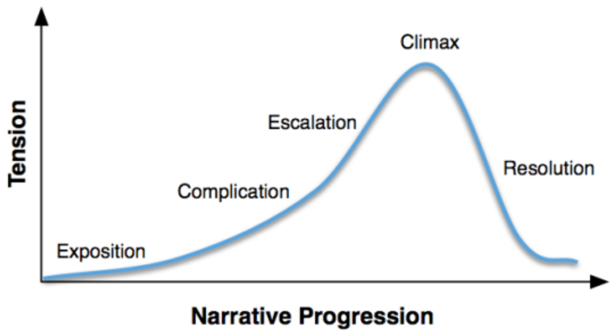

Fig. 1. A prototypical narrative arc.

By examining how a student progresses through the narrative arc during an interactive story-based learning session, we can discover her *narrative profile,* which captures the relative time spent in each phase of the narrative. More formally, we define a *narrative profile* for student s as follows: Given total session time T_s for student s, an ordered sequence of n phases of the narrative arc, p_1, p_2, …, p_n, and a function $f_s(x)$ returning the session time of phase x for student s, the *narrative profile* for student s is:

$$narrative\,profile_s = \left\langle \frac{f_s(p_1)}{T_s}, \frac{f_s(p_2)}{T_s}, \ldots, \frac{f_s(p_n)}{T_s} \right\rangle$$

Narrative profiles offer a window into students' narrative experiences within story-based learning environments. They provide an analytical tool for systematically investigating which types of narrative experiences are more conducive to learning.

We have been investigating narrative profiles with a narrative-centered learning environment built with Valve Corporation's Source™ engine, the technology behind

Half Life® 2 and other popular computer games. CRYSTAL ISLAND (Figure 2) features a science mystery set on a recently discovered tropical island where a research station has been established to study the island's unique flora and fauna. Underlying the science mystery is a curriculum derived from the North Carolina standard course of study for eighth-grade microbiology. Within the story, students play the role of the protagonist who is attempting to discover the identity and source of an infectious disease plaguing the research station.

Fig. 2. WOZ-enabled CRYSTAL ISLAND learning environment.

The CRYSTAL ISLAND story opens by introducing the student to the island and members of the research team for which the protagonist's father serves as the lead scientist. Several members of the research team have fallen gravely ill, including the protagonist's father. It is the student's task to discover the cause and source of the outbreak. Throughout the mystery, the student is free to explore the world and interact with other characters while forming questions, generating hypotheses, collecting data, and testing hypotheses. The student can pick up and manipulate objects, view posters, operate lab equipment, and converse with non-player characters to gather clues about the source of the disease. During the course of solving the mystery, the student uses an in-game *diagnosis worksheet* to organize her thoughts regarding the patients' symptoms, the likelihood of potential diseases (based on their expected symptoms, incubation period, and transmission source), and her final diagnosis. Upon completing the diagnosis worksheet, the student verifies its contents with the camp nurse and develops a treatment plan for the sickened CRYSTAL ISLAND researchers.

To investigate the impact of students' narrative experiences on learning outcomes without the limitations imposed by current ITS technologies, a WOZ-enabled version of CRYSTAL ISLAND was developed. In the WOZ-enabled CRYSTAL ISLAND learning environment, a wizard provides narrative planning, tutorial planning, and natural language dialogue functionalities. The wizard assumes the role of the camp nurse and collaboratively works with the student to solve the science mystery. Together in the virtual environment they carry on rich conversations using voice chat and observe one another's actions (e.g., picking up objects, gazing at objects and non-player characters, operating testing equipment) while performing problem-solving activities (Figure 2).[1] In addition to attending to the navigation, spoken communication, and manipulation behaviors of the nurse's character in the virtual environment, the wizard guides the student's inquiry activities and controls the progression of the story

[1] The facial expressions of the characters were not synchronized with the communication between the student and wizard via voice chat.

through the narrative arc. To support these activities, the wizard's display includes detailed information regarding students' activities in the environment (e.g., reading books, testing objects, updating the diagnosis worksheet), as well as access to a narrative dashboard. The *narrative dashboard* enables the wizard to initiate key narrative events in the environment (e.g., introducing new patient symptoms, having a non-player character bring in additional items for testing).

In addition to the wizard functionalities, the learning environment was modified to focus on the rich interactions between the student and wizard as well as to reduce the time spent navigating through the environment. This was accomplished by confining the learning scenario to a single virtual building on the island that houses both the camp's infirmary and laboratory. Within this environment the student and wizard gain access to all of the materials needed to solve the science mystery (e.g., sickened researchers, background books and posters, potential sources of the disease, lab equipment). The learning scenario, student and wizard controls, and wizard display were refined throughout a series of pilot studies with college students prior to the study reported in this paper.

To illustrate the behavior of the WOZ-enabled CRYSTAL ISLAND, consider the following scenario. A student has been collaborating with the nurse character, whose behaviors are orchestrated by the wizard. The student has learned that an infectious disease is an illness that can be transmitted from one organism to another, often through food or water. Under guidance from the nurse, the student has examined the patients' symptoms and conducted lab tests on food and water items. Through this exploration, the student has come to believe that the source of the illness is a waterborne disease and that it is likely cholera or shigellosis. Although she believes cholera is more likely, she is unable to arrive at a final diagnosis. Through her conversation with the nurse character, "Yeah, hum, well, they both can come from water, but cholera is mostly water, I believe," the wizard determines that the student is having difficulty ruling out shigellosis and decides that this is an opportune moment to introduce a narrative event. The wizard uses the narrative dashboard and activates the *Observe Leg Cramps Symptom* plot point, which results in one of the patients moaning loudly in the infirmary. The student examines the patient, updates her diagnosis worksheet with the new information, and informs the wizard, "He has leg cramps." The student decides to consult the reference material regarding disease symptoms and says, "Ok, I am going to check the disease symptoms again." After checking a virtual book, the student exclaims, "That means it is cholera." The wizard asks the student to update her diagnosis worksheet with her new hypothesis and explain why she believes this. The student then provides a detailed explanation justifying her diagnosis and the nurse congratulates the student for successfully solving the science mystery.

4 Study Design and Procedure

Using a wizard protocol that was designed to maximize learning gains in story-based interactions, a study was conducted with middle school students.

4.1 Participants

The participants in the study included 33 students (15 males and 18 females) of various ages, race, and ethnicity. Thirteen of the participants were eliminated due to incomplete data on either the pre-test or post-test, leaving 10 males and 10 females. Approximately 3% of the students were American Indian or Alaska Native, 3% were Asian, 24% were Black or African American, 9% were Hispanic or Latino, 55% were Caucasian, and 6% were of other races. Participants were all eighth-grade students from a North Carolina public school ranging in age from 13 to 15 ($M = 13.79$, $SD = 0.65$). Prior to receiving the instruments, tests, and intervention of this study, the students had completed the microbiology curriculum mandated by the North Carolina standard course of study. Two wizards assisted with the study, one male and one female. Prior to the study, wizards underwent extensive training and participated in pilot studies.

4.2 Participant Procedure

Students entered the study room having completed a ten question pre-test approximately one week prior to the intervention. Upon arriving, students were greeted by a researcher and instructed to review a set of CRYSTAL ISLAND instructional handouts, including information on the CRYSTAL ISLAND back-story, task description, characters, and controls. Upon completing their review of the handouts, the researcher provided further direction to the students on the use of the keyboard and mouse controls. The researcher then informed the students that they would be collaborating with another human-controlled character, the camp nurse, in the learning environment to solve the science mystery. Students were encouraged to freely communicate with the camp nurse using voice chat throughout their learning sessions. The students and wizards were physically located in different rooms. Finally, the researcher answered any questions from the students, informed them that the sessions were being videotaped, instructed them to put on their headsets and position their microphones, and asked them to direct all future communication to the camp nurse. The researcher remained in the room for the duration of their session. The CRYSTAL ISLAND session concluded once the student and wizard agreed on a final diagnosis. Immediately after reaching agreement, students exited the CRYSTAL ISLAND learning environment and completed the post-test (which consisted of the same items as the pre-test). The post-test was completed by the students within 20 minutes. In total, the students' sessions lasted no more than 60 minutes.

4.3 Wizard Protocol

To improve the consistency of the wizards' tutorial planning, narrative planning, and natural language dialogue activities, a protocol was iteratively developed and refined through a series of pilot studies. The resulting protocol included a high-level procedure for the wizard to follow (e.g., introduce yourself as the camp nurse, describe the patient situation to the student, review the scientific method with the student), a set of interaction guidelines (e.g., collaboratively work with the student to solve the mystery, organize the student's activities around the scientific method, act as a senior peer to the student, encourage the student to explain her conclusions and ensure they are logical and consistent with the available data, engage the student in constant face-to-face inquiry dialogue), and a set of narrative guidelines (e.g., overall story structure, ordering constraints between narrative events, appropriate situations to introduce narrative events, pacing advice to help ensure sessions complete on time).

Prior to the study with the eighth grade students, each wizard received training on the CRYSTAL ISLAND microbiology curriculum and the materials to be provided to students during the study. The wizard training included information on key concepts from the CRYSTAL ISLAND curriculum and the protocol to follow. After carefully reviewing the materials over the course of a week and having all of their questions answered, the wizards participated in at least three (and up to four) training sessions with college students. After each training session, a researcher performed an "after action review" with the wizard to discuss her interactions with the student and adherence to the wizard protocol (both from a tutorial perspective and narrative perspective).

5 Results and Analysis

To investigate narrative profiles as they relate to learning outcomes, the students' CRYSTAL ISLAND sessions were analyzed using a five-phase narrative arc. The narrative phases used in the analysis were defined by the classic *exposition*, *complication*, *escalation*, *climax*, and *resolution* plot structure inspired by Freytag's pyramid [19]. To compute the narrative profiles for students, the time they spent in each phase of the narrative arc was automatically calculated using event timestamps from behavior traces recorded during their learning session.

Table 1. Percentage of time spent in each phase of the narrative arc.

Narrative	Cluster A		Cluster B	
Phase	**Mean**	**SD**	**Mean**	**SD**
Exposition	11	2	10	2
Complication	8	1	10	3
Escalation	23	6	42	7
Climax	39	7	19	6
Resolution	20	5	20	9

Employing an unsupervised learning method, students were partitioned into groups using their narrative profiles as the observation vectors. Two groups, *Cluster A* and *Cluster B*, were identified utilizing k-means clustering, containing 9 and 11 student narrative profiles, respectively. Table 1 lists the percentage of time spent in each phase of the narrative arc for both clusters. The difference in time spent between clusters was statistically significant during both the *escalation* ($t = 6.733$, $p < 0.0001$) and *climax* ($t = 7.176$, $p < 0.0001$) phases. In short, these two clusters group together the students whose narrative profiles are most similar to one another with respect to time spent in each phase of the narrative arc and they are significantly different.

5.1 Results

It was found that students' CRYSTAL ISLAND interactions yielded positive learning outcomes. Students exhibited learning gains ($M = 2.20$, $SD = 1.58$) as measured by the difference of their post-test ($M = 8.05$, $SD = 1.57$) and pre-test scores ($M = 5.85$, $SD = 1.27$). A matched pairs t-test between post-test and pre-test scores indicates that the learning gains were significant, $t(19) = 6.24$, $p < 0.0001$. There were learning gains within both Cluster A ($M = 2.91$, $SD = 1.45$) and Cluster B ($M = 1.33$, $SD = 1.32$). A matched pairs t-test shows that the learning gains for both clusters were significant (Cluster A: $t(8) = 6.67$, $p < 0.0001$, Cluster B: $t(10) = 3.02$, $p = 0.01$). There was no significant difference between the pre-test scores of the clusters, $t(19) = 1.19$, $p = 0.12$. In addition, adjusting for pre-test scores using ANCOVA, the learning gains for both clusters were significantly different, $F(2, 18) = 4.25$, $p = 0.03$. Thus students in Cluster A achieved higher learning gains than students in Cluster B.

5.2 Analysis

To analyze the student narrative profiles in more detail, each phase of the students' narrative profile was further decomposed into the percentage of time spent on a given interaction mode (Figure 3). The interaction modes used in the analysis were *data collection* (e.g., examining patients, testing food items), *science reading* (e.g., studying disease books, reviewing scientific method poster), and *inquiry* (e.g., updating and discussing the diagnosis worksheet) activities. By inspecting the percentage of total session time spent in each of these interaction modes during the narrative phases we gain insight into the students' experiences as they relate to learning outcomes.

First, for *data collection* activities, differences between the clusters were found to be

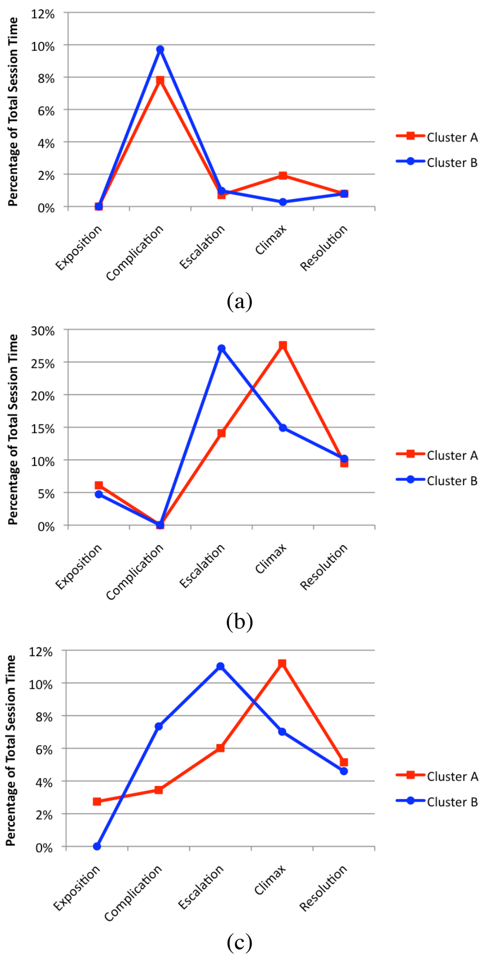

Fig. 3. Mean percentage of total session time spent on (a) data collection activities, (b) science reading activities, and (c) inquiry activities during each phase of the narrative arc.

significant during the *complication* ($t = 1.78, p = 0.05$) and *climax* ($t = 3.56, p = 0.002$) phases of the narrative. Second, for *science reading* activities, significant differences were found between the clusters during the *escalation* ($t = 4.73, p = 0.0002$) and *climax* ($t = 2.88, p = 0.005$) phases of the narrative. Finally, for *inquiry* activities, differences between the clusters were found to be significant during all phases of the narrative except for the *resolution*. The differences showed statistical significance for *climax* ($t = 2.39, p = 0.03$), while *exposition* ($t = 4.04, t = 0.001$), *complication* ($t = 5.05$, $p < 0.0001$) and *escalation* ($t = 3.36$, $p = 0.003$) showed strong statistical significance.

6 Discussion and Design Implications

The study found that students interacting with the WOZ-enabled CRYSTAL ISLAND narrative-centered learning environment achieved significant learning gains. Through the analysis it was found that students had a range of narrative experiences, which were captured by the differences in their narrative profiles. After clustering the narrative profiles it was found that students within each cluster achieved significant learning gains, and, notably, one cluster was found to have significantly outperformed the other with respect to learning gains.

Further analysis showed that students within the two groups utilized their time in each phase of the narrative arc for different activities. Overall, students in the higher performing group spent more time on *data collection*, *science reading*, and *inquiry* activities during the *climax* phase of the narrative than students in the lower performing group. Correspondingly, students in the lower performing group devoted more of their time to these activities during the *complication* and *escalation* phases of the narrative. A qualitative exploration of the student and wizard interactions during the *climax* phase of the narrative revealed that the higher performing group tended to be more actively engaged with the wizard during this phase of the narrative. They were much more likely to provide detailed explanations of their hypotheses and support them with relevant facts from books and results from their lab testing activities.

Although the analysis provides insight into how students' narrative experiences relate to learning outcomes, it does not pinpoint the learner activities that are most responsible for learning gains. For example, the learning gains might be caused by the self-explanation effect since the higher performing students seem to spend more time reasoning about and explaining their hypotheses to the wizard. Similarly, lower performing students might be experiencing higher cognitive load during the complication and escalation phases of the narrative since the problem space is more open-ended at these points in the story. Additional investigation needs to be conducted to understand what learner activities are contributing the most toward learning gains.

The study suggests design implications for optimizing story-based learning. First, narrative event representations should include metadata for encoding temporal attributes of student activities (e.g., durations, ratios) to support reasoning about narrative structure and interaction modes as they bear on learning outcomes. Second, narrative planners should be designed to reason about the interaction modes associated with desirable learning gains for each phase of the narrative. This capability would allow narrative planners to emphasize the interaction modes that are most promising given the current situation. Third, narrative-centered tutorial planners should be able to craft the structure of stories and scaffold student interactions to most effectively balance their time in each phase of the narrative. This capability would allow narrative planners to appropriately guide students to the next phase of the narrative arc at the most opportune moment.

7 Conclusion

Narrative-centered learning environments offer significant potential for creating effective learning experiences. Identifying factors that contribute to effective story-based learning is critically important in optimizing these experiences. To this end, a Wizard-of-Oz study was conducted with students interacting with a narrative-centered learning environment. It was found that students exhibited significant learning gains and that partitioning students by narrative profiles resulted in clusters with significantly different learning gains. Furthermore, a detailed analysis of the activities performed by students in each phase of the narrative arc revealed that the clusters differ significantly with respect to interaction modes.

The narrative profile technique introduced in this paper represents a first step towards developing a clearer understanding of student learning in narrative-centered learning environments. Future work will use a narrative lens to investigate techniques for incorporating more detailed student behavior trace data, annotations of dialogue, tutorial strategies, virtual world behaviors, and affective feedback to further refine design principles for optimizing story-based learning.

Acknowledgments. The authors wish to thank members of the IntelliMedia Group for their assistance, Omer Sturlovich and Pavel Turzo for use of their 3D models, and Valve Corporation for access to the Source™ engine and SDK. Special thanks to Joe Grafsgaard, Kate Lester, Jen Robison and Jon Rowe for assisting with the study and data analysis. This research was supported by the National Science Foundation under Grants REC-0632450 and DRL-0822200. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

References

1. Mott, B., Callaway, C., Zettlemoyer, L., Lee, S., Lester, J.: Towards Narrative-Centered Learning Environments. In: AAAI Fall Symposium on Narrative Intelligence, pp. 78–82. Cape Cod, MA (1999)
2. McQuiggan, S., Rowe, J., Lee, S., Lester, J.: Story-Based Learning: The Impact of Narrative on Learning Experiences and Outcomes. In: 9th International Conference on Intelligent Tutoring System, pp. 239–249. Montreal, Canada (2008)

3. Mott, B., Lester, J.: Narrative-Centered Tutorial Planning for Inquiry-Based Learning Environments. In: 8th International Conference on Intelligent Tutoring System, pp. 675–684. Jhongli, Taiwan (2006)
4. Rowe, J., Mott, B., McQuiggan, S., Robinson, J., Lee, S., Lester, J.: Crystal Island: A Narrative-Centered Learning Environment for Eighth Grade Microbiology. In: Workshop on Intelligent Educational Games at the 14th International Conference on Artificial Intelligence in Education, pp. 11–20. Brighton, U.K. (2009)
5. Aylett, R., Louchart, S., Dias, J., Paiva, A.,Vala, M.: FearNot! – An Experiment in Emergent Narrative. In: 5th International Conference on Intelligent Virtual Agents, pp. 305–316. Kos, Greece (2005)
6. Marsella, S., Johnson, W.L., Catherine, L.: Interactive Pedagogical Drama for Health Interventions. In: 11th International Conference on Artificial Intelligence in Education, Sydney, Australia (2003)
7. Wang, N., Johnson, L.: The Politeness Effect in an Intelligent Foreign Language Tutoring System. In: 9th International Conference on Intelligent Tutoring System, pp. 270–280. Montreal, Canada (2008)
8. Johnson, L.: Serious Use of a Serious Game for Language Learning. In: 13th International Conference on Artificial Intelligence in Education, pp. 67–74. Marina del Ray, CA (2007)
9. McAlinden, R, Gordon, A., Lane, C., Pynadath, D.: UrbanSim: A Game-Based Simulation for Counterinsurgency and Stability-Focused Operations. In: Workshop on Intelligent Educational Games at the 14th International Conference on Artificial Intelligence in Education, pp. 41–50. Brighton, U.K. (2009)
10. Si, M., Marsella, S., Pynadath, D.: Thespian: Modeling Socially Normative Behavior in a Decision-Theoretic Framework. In: 6th International Conference on Intelligent Virtual Agents, pp. 369–382. Marina del Ray, CA (2006)
11. Core, M., Lane, H., vanLent, M., Gomboc, D., Solomon, S., Rosenberg, M.: Building Explainable Artificial Intelligence Systems. In: 18th Conference on Innovative Applications of Artificial Intelligence, Boston, MA (2006)
12. Wells, C.: The Meaning Makers: Children Learning Language and Using Language to Learn. Heinemann, Portsmouth, NH (1986)
13. Vala, M., Raimundo, G., Sequeira, P., Cuba, P., Prada, R., Martinho, C., Paiva, A.: ION Framework – A Simulation Environment for Worlds with Virtual Agents. In: 9th International Conference on Intelligent Virtual Agents, pp. 418–424. Amsterdam, Netherlands (2009)
14. Machado, I., Brna, P., Paiva, A.: Learning by Playing: Supporting and Guiding Story-Creation Activities. In: Moore, J., Redfield, C., Johnson, W. (eds.) 10th International Conference on Artificial Intelligence in Education, pp. 334–342. Amsterdam, Netherlands (2001)
15. Johnson, L., Wu, S.: Assessing Aptitude for Learning with a Serious Game for Foreign Language and Culture. In: 9th International Conference on Intelligent Tutoring System, pp. 520–529. Montreal, Canada (2008)
16. Traum, D., Marsella, S., Gratch, J., Lee, J., Hartholt, A.: Multi-party, Multi-issue, Multi-strategy Negotiation for Multi-modal Virtual Agents. In: 8th International Conference on Intelligent Virtual Agents, pp. 117–130. Tokyo, Japan (2008)
17. Gratch, J., Marsella, S.: A Domain-independent Framework for Modeling Emotion. Journal of Cognitive Systems Research. 5(4), pp. 269–306 (2004)
18. Gratch, J., Wang, N., Gerten, J., Fast, E., Duffy, R.: Creating Rapport with Virtual Agents. In: 7th International Conference on Intelligent Virtual Agents, pp. 125–138. Paris, France (2007)
19. Freytag, G.: Technique of the Drama: An Exposition of Dramatic Composition an Art. In: Macewan, E. (trans.) B. Blom, New York (1968)