Narrative-Centered Learning Environments: A Self-Regulated Learning Perspective

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Abstract

Narrative is emerging as an effective medium for contextualizing learning. Narrative-centered learning environments provide engaging, story-centric virtual spaces that offer guided learning and problem-solving opportunities. Students' ability to self-regulate learning can significantly impact performance in these environments, and, in general, is critical for academic achievement. This paper explores the relationship between narrative-centered learning and self-regulation. Connections are drawn between the salient characteristics of narrative-centered learning environments and principles for promoting and enhancing self-regulated learning in science education. These relationships are further explicated through an examination of the CRYSTAL ISLAND learning environment. The paper explores the hypothesis that narrative-centered learning environments are particularly well suited for simultaneously promoting learning, engagement, and self-regulation.

Introduction

Narrative-centered learning environments (NLEs) have become the subject of increasing attention in the Artificial Intelligence in Education community (Marsella, Johnson and Labore 2003; Aylett et al. 2005; McQuiggan et al. 2008). By contextualizing learning within narrative settings, NLEs tap into students' innate facilities for crafting and understanding stories and take advantage of narratives' motivating features such as compelling plots, engaging characters, and fantastical settings (Parker and Lepper 1992). NLEs offer significant potential for encouraging active participation in learning, critical thinking and analysis, and forming connections between narrative and pedagogical content. Drawing on technologies from intelligent tutoring systems, embodied conversational agents, and serious games, NLEs offer the promise of adaptive, situated learning experiences that are highly interactive and engaging for students. NLEs are currently under investigation in a range of domains, including anti-bullying education (Aylett et al. 2005), health intervention education (Marsella, Johnson, and Labore 2003), and science learning (Ketelhut et al. 2007; McQuiggan et al. 2008).

NLEs also offer the potential to aid in student problem solving and self-regulation. By capitalizing on the characteristics of narrative and guided-discovery learning environments, NLEs can present students with engaging, situated problem-solving scenarios that effectively and discreetly scaffold self-regulated learning processes. This paper explores the benefits of NLEs for student self-regulated learning in science domains. Although NLEs can be designed for a variety of subject matters, the connections made here are based upon specific approaches to self-regulated learning for science education as reported in a meta-analysis by Schraw, Crippen, and Hartley (2006). Their analysis yields six specific pedagogical strategies for science learning that have been empirically shown to increase student self-regulation. This paper examines how these techniques can be incorporated into NLEs.

Background

NLEs offer significant promise for promoting discovery learning, increasing motivation by leveraging key aspects of narrative, and providing a compelling context for developing and applying problem-solving skills. However, students' ability to effectively pursue pedagogical and narrative goals is central to NLEs' efficacy. As a consequence, self-regulation is important for students interacting with NLEs.

Self-Regulated Learning

Research suggests that individuals who are able to self-regulate their learning in intentional and reflective ways are more likely to achieve academic success (Butler et al. 2006). The term *self-regulated* learning can be used to describe learning that is guided by metacognition (knowledge of cognition and regulation of cognition), strategic action (planning, monitoring, and evaluating personal progress against a standard), and motivation to learn (Zimmerman 1990; Winne and Perry 2000). Pintrich (2000) notes that although multiple models of self-regulated learning exist, most share four primary assumptions: (1) learners actively construct knowledge during the learning process; (2) learners actively control, monitor, and regulate aspects of their learning environment, as well as facets of their own cognition, behavior, and motivation; (3) learning is goal-driven, and goals are compared to set standards or criteria in order to monitor progress and adapt facets of cognition, behavior, and motivation, if necessary; and (4) learners' regulation of their own cognition, behavior, and motivation acts as a mediator between the person, their context, and their achievement. In particular, self-regulated learners are cognizant of their academic strengths and weaknesses and have a repertoire of strategies they appropriately apply to tackle the day-to-day challenges of academic tasks.

Boekaerts and Niemvirta (2000) note that teachers are expected to convey information and procedures, monitor student performance, provide feedback, and motivate students to be engaged learners—all processes that hinder the development of self-regulation by making learning the responsibility of the teacher rather than the learner. Research has shown that although most teachers agree that one of the primary goals of education is to develop intrinsically motivated, self-regulated learners (Paris, Lipson, and Wixson 1994), few students receive instruction in self-regulated learning in school and few have opportunities to regulate their own learning (Randi and Corno 2000).

Narrative-Centered Learning Environments

NLEs offer several natural affordances for enhancing students' self-regulated learning experiences. Stories draw audiences into plots and settings, thereby opening perceptual, emotional, and motivational opportunities for learning. Fantasy contexts in educational games have been shown to provide motivational benefits for learning (Parker and Lepper 1992). Narrative features such as pacing and tension can introduce additional challenge to learning tasks and contribute to student motivation. Establishing concrete connections between narrative context and pedagogical subject matter has also been said to support the assimilation of new ideas in young learners (Wells 1986).

Narratives are built upon casts of believable characters with distinct roles, personalities, and appearances (Egri 1960). By promoting suspension of disbelief and story involvement, interactive narrative environments can potentially reinforce learning objectives and ingrain subject matter. Although it is important to remain mindful of potential disadvantages such as seductive details (Harp and Mayer 1998), a carefully targeted narrative experience has the potential to be pedagogically compelling.

NLEs leverage a range of techniques for providing effective, engaging learning experiences. Multi-user virtual environments such as Quest Atlantis (Barab et al. 2007) and River City (Ketelhut et al. 2007) use rich narrative settings to contextualize inquiry-based science learning scenarios with strong social and ethical dimensions. Several empirical studies from this work have yielded promising learning results that support the promise of NLEs in the classroom. Other work on NLEs has examined how artificial intelligence can be used to generate engaging interactive narrative experiences that are pedagogically effective and tailored to individual students' interactions. For example, FearNot! uses affectively-driven autonomous agents to generate dramatic, educational vignettes about bullying (Aylett et al. 2005). The SASO (Stability and Support Operations) NLE uses robust, socially intelligent virtual humans as actors in military training scenarios (Swartout et al. 2006). The next section will discuss several methods through which NLEs can directly support self-regulation for science learning.

Leveraging Narrative for SRL

As noted above, self-regulation is a learned skill. Schraw, Chrippen, and Hartley (2006) have identified six instructional strategies for increasing self-regulation of science learning: inquiry-based learning, incorporating peer-to-peer and peer-to-instructor collaboration, teaching explicit strategies for learning, motivating student creation and manipulation of mental models, taking advantage of technology, and beneficially modifying existing student and teacher beliefs on knowledge and knowledge acquisition. NLEs present several opportunities for discreetly implementing each of these strategies. Incorporating these strategies may also provide students with important problem-solving guidance that simultaneously enhances student self-efficacy and engagement in the sciences.

Inquiry-Based Learning

Narratives, especially interactive narratives, embody many aspects of inquiry-based learning. In *inquiry-based learning*, students are actively engaged in the learning process by forming and asking their own questions and hypotheses, testing these hypotheses, and, in turn, drawing their own conclusions (Schraw, Crippen, and Hartley 2006). As active participants, students become more engaged in the learning experience and may therefore be more motivated, an important component of SRL.

Audiences interact with narrative in a way that closely resembles the steps of inquiry-based learning. Generally, narratives contain sequences of casually-related events that contribute to a larger plot, and most individuals appear to have a natural, inherent understanding, or schemata, for these structures. Through these schemata, audiences have expectations for each narrative they encounter. Therefore, as the plot of a narrative develops, audiences instinctively form hypotheses about future events within a story. These hypotheses are continuously tested as the story unfolds, and either supported or contradicted by successive plot revelations. Thus, each situation must be reevaluated in light of new information, and alternate hypotheses are formulated. The continuous cycle of forming and evaluating expectations has the benefit of keeping readers motivated and engaged, as well as eliciting emotions such as surprise and suspense. Furthermore, events such as unexpected twists, humorous or empathetic characters, and fantasy are generally introduced to encourage reader engagement.

NLEs not only have the qualities of narrative discussed above, they also support active participation in the story as the student adopts the role of the main character. Therefore, students in a NLE carry out problem-solving actions in a manner similar to that of authentic inquiry, which has been shown to have additional SRL and learning advantages relative to simple inquiry. In true authentic inquiry, students generate research questions and guide themselves through the problem-solving process (Schraw, Crippen, and Hartley 2006); however, in the case of NLEs, students' problem-solving activities are guided by the structure of the narrative. For example, the student is ultimately in control of minor plot details, such as how and when certain events occur, but some obligatory events are necessary for the narrative to play out coherently, which encourages on-task performance. By establishing what events serve as the desired resolution (e.g., determining the cause of a mysterious disease), the student is metacognitively, yet clandestinely, scaffolded to set an overall goal. Therefore, it is the student, with guidance from the narrative rather than guidance from the instructor, who decides what actions to take in order to accomplish the task at hand (the desired resolution). Repeated sub-goal setting occurs until the overall goal, the narrative's resolution, is achieved, yielding motivated and on-task performance as well as the ability to partition a larger goal into smaller components. NLEs provide an outlet for obtaining the SRL benefits of inquiry-based learning within the boundaries of a classroom by providing subtle, yet effective, student-generated hypothesis formation and testing as well as discovery learning.

Collaboration

Given the importance of multiple characters and character interactions for the development of an engaging narrative, collaboration within an NLE is a natural technique for increasing SRL. Collaboration among peers as well as with instructors, can foster learning and SRL. Schraw, Crippen, and Hartley (2006) identify four distinct ways in which collaboration directly enhances SRL instruction: (1) modeling, (2) planning and evaluation discussion, (3) integrating each student's own resources, and (4) classroom equity (Schraw, Crippen, and Hartley 2006).

A powerful feature that NLEs offer is providing a companion agent, a character that works closely with the student and that can prompt discussion, reflection, and assistance in a natural, subtle way. Companion agents generally assume the role of an apprentice or mentor to the student character. As an apprentice, the companion agent can ask the student to further explain gathered information and convey to the agent how this new information contributes to achieving the resolution of the narrative. Teaching others has been shown to have beneficial effects on understanding and self-regulated learning (Chi et al. 1994; Leelawong and Biswas 2008). In particular, these benefits have been seen in virtual learning environments such as Betty's Brain, an environment that requires student to teach scientific material to an agent (Leelawong and Biswas 2008).

Companion agents can also ask questions and issue reminders. They can pose simple questions such as, "What is our plan?" or, "What should we do next?" to prompt the student to set goals and devise plans. Questions such as these scaffold student planning, monitoring, and self-reflection, three key metacognitive strategies. Companion agents can act as an assistant that prompts or reminds the student of his or her character's required duties or tasks. For example, if the student's role is a medical examiner, he or she may need to fill out specific paperwork, which encourages cognitive off-loading and note taking. "Apprentice agents" subtly inform the student of oversights or discourage conceptual overconfidence while maintaining the student's sense of agency and responsibility.

A companion agent that serves as a mentor to the student interacts in a similar fashion by modeling important behaviors and guiding the student through the environment. Ultimately, within the context of narrative, companion agents, regardless of their specific role, are personified as characters in the story; thus, their presence yields a noninvasive mechanism for metacognitive prompting, which can also be employed for collecting metacognitive data about the student.

Strategy Instruction

A growing body of research in self-regulated learning suggests that explicit instruction in SRL strategies promotes academic achievement (Zimmerman and Martinez-Pons 1990; Schunk and Zimmerman 1998). Specifically, these skills include effective cognitive, problem solving, and critical thinking skills (Schraw, Crippen, and Hartley 2006). By utilizing features of narratives, one can transition strategy instruction from a series of explicit procedural steps provided by an instructor to an integral part of a compelling narrative.

Instruction of problem-solving skills is an important strategy for creating self-regulated learners. Within a narrative, the student can be assigned a specific role in conjunction with the target task. Therefore, particular skills appropriate for that role can be practiced subtly rather than through direct instruction. With respect to problem solving, the student could be assigned the role of a scientist or examiner whose occupational requirements scaffold explicit problem-solving processes. Specific occupational tasks such as recording notes for reporting information back to an authority figure, representing information in a physical model, summarizing collected information for explanation to a companion, and seeking out required information to fulfill a task all effectively but subtly scaffold problem-solving. The student is actively engaged in the problem-solving process, rather than being directly aware or instructed to perform specific steps.

Critical thinking skills can also be incorporated into narrative plots. As Schraw, Crippen and Hartely (2006) observe, essential critical thinking skills are "identifying relevant information, constructing arguments, testing the credibility of information and hypotheses, and forming plausible conclusions" while consistently monitoring these activities (p. 124). Identifying relevant information and testing the credibility of information and hypotheses can be achieved through prompted reflection. Prompts can encourage students to formulate their own questions and direct themselves toward extracting important information. Characters can explicitly ask the student certain questions throughout the learning interaction that encourage the student to reflect on how this information was attained and why it is vital for accomplishing the task at hand. Prompted reflection is two-fold in that self-reflection is also an important cognitive strategy for realms outside of critical thinking. Moreover, posters, books, and expert characters can be utilized to help the student practice how to decide what information is the *most important* when an abundance of information sources are available.

With respect to constructing arguments and forming plausible conclusions, an NLE can rely on other characters. These agents can be designed to probe the student and suggest other sub-goals to pursue. If the student finds these suggestions inadequate, he or she can be prompted to explain to the character why he or she will not be following that advice. As the student provides this explanation, an NLE can dynamically probe the student until an adequate argument has been formulated. As the student provides an explanation for a desired learning goal, an NLE can automatically detect what information the student understands correctly, and what information the student should elaborate or further investigate. Consequently, this method can be used to form plausible conclusions in that the system can suggest alternatives and probe the student to reason about the most probable conclusion given the information attained. Again, these conversations are natural character interactions and role fulfillment within the context of narrative.

Mental Models and Conceptual Change

Mental models are metacognitive aids that enable students to mentally represent and reason about complex processes. NLEs, and virtual environments in general, can contribute to novel mental model construction and conceptual change. The graphical technology of NLEs allows physical, animated, 3D representations of scientific processes to aid in student conceptual understanding. Moreover, because narrative is structured around events, models can be continuously created and manipulated as additional information is gathered and important plot events transpire.

Student Personal Beliefs

Student epistemological beliefs and self-efficacy play an important role in self-regulation because of their effect on the student's perceived personal ability and motivation (Schraw, Crippen, and Hartley 2006). Students with high levels of science self-efficacy have been shown to be more motivated, more likely to undertake difficult tasks, and more likely to persist in difficult tasks. Specific types of feedback can affect student self-efficacy levels. Non-player characters within an NLE can be designed to provide appropriate feedback on student performance that can enhance student self-efficacy for that task. Further, as peer modeling has been shown to increase self-efficacy, other characters can be used to model desirable behaviors as discussed in the collaboration section.

Lastly, a student's epistemological beliefs are important for self-regulation. Students should hold the epistemological beliefs that knowledge acquisition is neither simple nor static to increase motivation on intellectually challenging tasks. Again, other characters can be utilized to model and discuss desired epistemological beliefs. For instance, contradictions to the student's initial beliefs can occur as additional elements of the plot are revealed, and an agent in the environment can help the student to understand that these contradictions are natural and common. Through these types of events the character can stress the dynamic and complex nature of knowledge acquisition. Because character interactions are a pervasive component of narrative, utilizing character dialogue can have a significant impact on student self-efficacy and epistemological beliefs.

An Illustrative Scenario

The authors have developed a test bed narrative-centered learning environment that implements Schraw, Crippen, and Hartley's (2006) instructional strategies for self-regulated science learning. CRYSTAL ISLAND (Figure 1) is a NLE built on Valve Software's Source™ engine, the 3D game platform for Half-Life 2. CRYSTAL ISLAND features a science mystery set on a recently discovered volcanic island and incorporates a curriculum derived from the North Carolina state standard course of study for eighth-grade microbiology. Students play the role of the protagonist, Alex, who is attempting to discover the identity and source of an unidentified infectious disease plaguing a newly established research station. The story opens by introducing the student to the island and members of the research team. Several of the team's members have fallen gravely ill, including Alex's father, the lead scientist.

Figure 1. CRYSTAL ISLAND

It is the student's task to discover the outbreak's cause and source, and determine whether any foul play was involved in the illness's spread. Throughout the mystery, the student is free to explore the environment and interact with virtual characters while forming questions, collecting data, and generating and testing hypotheses. The student can pick up and manipulate objects, take notes, view posters, operate lab equipment, and interact with non-player characters to gather clues about the source of the disease.

To illustrate how CRYSTAL ISLAND implements instructional strategies for self-regulated science learning, consider the following scenario. The student has been exploring the CRYSTAL ISLAND virtual environment for several minutes, and has been tasked by the camp nurse to research the island's mysterious spreading illness. The student begins by consulting with the island's residents, as well as by reading nearby posters and books that discuss various microbiology concepts. Some of the island's characters help to identify objects and symptoms that are relevant to the scenario, while others provide pertinent microbiology information. However, not all of the camp's team members appear reliable, so the student must critically evaluate the information she obtains. As the student gathers clues and progresses through the narrative, she begins to mentally develop, test, and revise hypotheses about possible explanations for the spreading disease. This inquiry process emerges naturally as part of solving the science mystery, and to organize her thoughts the student records her postulations in a virtual *hypothesis sheet*. The hypothesis sheet enables her to encode a simplified version of her mental model of the disease's spread. The student shares her hypothesis sheet with the camp nurse. They collaboratively review evidence that the student has collected, as well as the hypothesis sheet's proposed diagnosis, but discover a flaw. The nurse, who serves as a virtual mentor to guide the student through the inquiry process, encourages the student to reflect upon her current findings. After student reflection, she and the nurse discuss possible directions for establishing a revised hypothesis. The student decides to test several partially consumed food items that the sick members recently ate. After conducting a battery of tests in the laboratory, she discovers that a container of unpasteurized milk in the dining hall is contaminated with bacteria. By combining this discovery with information about the sick characters' symptoms, the student concludes that the disease is *E. coli*. The student reports her findings back to the camp nurse, and together they discuss a plan for treatment of the sick team members.

Conclusions and Future Work

Building on Schraw, Crippen, and Hartley's (2006) six strategies for enhancing science self-regulated learning, narrative-centered learning environments offer a promising platform for implementing approaches to improve students' self-regulation. Inquiry-based learning can be encouraged through students' natural ability to form hypotheses about the narratives they encounter. Virtual characters in the environment can collaborate with students and request descriptions of the learning process, and students can practice problem-solving and critical thinking skills as they progress through the narrative and evaluate the reliability of different (and possibly competing) information sources. Finally, narrative-centered learning environments can facilitate the development of mental models by encouraging students to encode explicit representations of their beliefs about complex systems.

Understanding how to effectively incorporate these strategies into narrative-centered learning environments is an important area for future investigation. Drawing on ongoing empirical investigations of learning, problem solving, and engagement, we can begin to explore the broad range of potential techniques for further enhancing student SRL skills. In particular, investigating individualized instruction strategies and designing SRL features for narrative environments that account for individual differences is an important next step in this line of investigation.

Acknowledgements

The authors would like to thank the other members of the IntelliMedia Group at North Carolina State University for insightful discussions about narrative-centered learning environments. This research was supported by the National Science Foundation under Grants REC-0632450, IIS-0757535, DRL-0822200 and IIS-0812291. Additional support was provided under a National Science Foundation Graduate Research Fellowship. 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.

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