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The Time Factor: Leveraging Intelligent Agents and Directed Narratives in Online Learning Environments

by Greg Jones and Scott Warren

Recently, there has been much excitement in the field of education about the emerging use of games, simulations, and other three-dimensional online learning environments as alternatives to traditional classroom experiences (Barab et al., "Embodiment," 2007; Dede, Ketelhut, and Ruess [2006](#)). Research is beginning to show that the use of this technology in educational settings may affect learning positively (Squire et al. 2005; Cox [2006](#)). Online learning environments facilitate meaning making by providing a sense of presence and immediacy through enhanced communication tools and learning objects that help learners construct knowledge (Jones and Bronack 2006; Tuzun 2004). These environments expand current Web- and text-based methods for instructional delivery, facilitating student interactions, increasing student engagement, and enabling deeper learning (Jones, Warren, and Robertson, forthcoming).

While this research is encouraging, the amount of time required for work in these environments to produce improvements in student achievement remains a major hurdle. Students learning in an immersive multiuser environment often require more time to achieve increases in formal learning outcomes than is needed with more traditional, face-to-face learning approaches. For example, research on the *Taiga* virtual world, a three-dimensional multiuser virtual environment (MUVE) developed as part of the [Quest Atlantis](#) project, showed that it took 30 hours or more of interaction with the learning environment plus several additional hours of classroom activity to achieve significant increases in learning outcomes (Barab et al. 2006; Warren 2006). As critics of classroom uses of open-ended, social-constructivist learning environments and curricula (Airasian and Walsh 1997; Albanese and Mitchell 1993) have made clear, there is little room in today's educational climate for methodologies (or technologies) that do not accelerate or greatly increase learning (Roblyer [2005](#)). It should also be noted that while computer games have been lauded for their motivating power (Dickey 2006, 2007; Gee 2003), the fact that students spend a lot of time playing games does not mean that these games provide a sound model for improving educational outcomes.

We believe that we can develop three-dimensional, online learning environments that overcome one of the primary concerns in formal classroom settings, that of limited time, while helping students to achieve learning objectives. Two important components of these spaces will be the keys to developing better instructional systems: (a) intelligent digital agents that support student learning and (b) engaging narratives within which these agents can act to situate and direct student learning experiences (Barab et al., "Situationally Embodied Curriculum," 2007; Warren, Barab, and Dondlinger, forthcoming). This article will discuss intelligent agents and directed instructional narratives and provide an example of how these elements have been tied together to improve student learning outcomes in the program [Chalk House](#).

Intelligent Agents

As technology has improved over the course of the last decade, we have seen digital pedagogical tools transformed from flat-programmed characters like Microsoft Office's "Clippy" the paperclip, which only allowed for a few predetermined questions and did not respond dynamically to typed input, into robust [intelligent agents](#) (Slater [2000](#)). Research indicates that such agents can be effective guides for learning in digital environments. Baylor ([2002](#)) identifies the following benefits of using them:

- They allow learners to take as much time as they may need to accomplish learning tasks and reach learning goals.
- They allow learners to direct interactions with the agent.

- They encourage learners to reflect on their thinking processes.

[Scripted intelligent agents](#) are some of the most commonly found intelligent agents. A scripted intelligent agent relies on a database of predetermined textual responses. The response the agent offers depends on whether or not the learner has met certain conditions, for instance whether he or she has completed a particular task, interacted with another agent, or received a specific item ([Exhibit 1](#)). In other instances, agent behavior can change to respond to student needs; agents might reteach material, clarify information, or perform other actions to enable task completion and knowledge construction. While design constraints may somewhat limit the depth and variability an instructional designer can build into agent responses, scripted intelligent agents are far more cost effective than more advanced agents that may rely on sophisticated artificial intelligence, for instance, to predict learner behaviors and problems (Liu and Chee 2004). We have found that embedding repeatable instruction within intelligent agents allows these agents to take over some of the teaching load associated with the virtual environment, leaving the classroom instructor with more time to engage in more productive activities, such as providing detailed feedback on student work, helping students with problems or special needs, or supporting student learning by participating in the learning environment as a character in the game (Warren, Barab, and Dondlinger, forthcoming; Warren and Dondlinger, forthcoming).

Intelligent agents may also free teachers from some of the time-consuming tasks associated with the traditional classroom environment. In face-to-face classroom observations, the teacher who relied on a traditional classroom environment spent substantially more time answering questions that had already been answered, providing high levels of individual writing help, regulating both required and optional classroom activities, redirecting students to learning tasks, and encouraging engagement with optional enrichment tasks (Warren, Barab, and Dondlinger, forthcoming). In the [Anytown](#) environment, a project developed to enhance elementary students' writing skills, the characters took on the role of the teacher by providing directions for the learning activities, which students could refer repeatedly to learn (or remember) what to do for both game and writing activities. The character dialogue evolved over time, helping to redirect students to new writing and game activities or providing more detail needed to improve writing for students whose work needed improvement. In this way, the intelligent agents reduced the amount of time that the teacher spent on non-teaching tasks, freeing the teacher to spend more time providing high levels of individual writing help through feedback on students' descriptive writing pieces.

Directed Instructional Narrative Using Intelligent Agents

Recent learning game designs and research, ranging from Harvard's [River City](#) project to Squire et al.'s (2005) work with [Civilization III](#), have begun to examine the power of narrative to deliver educational messages. The basis for this research is the theory that play activities bounded by game narrative motivate learning, which is why games can be effective teaching tools (Barab, Warren, and Ingram-Goble 2008). The interactive narrative of the game provides a context for learners to connect to their experience, which allows students to link their interactions with the narrative to their personal experiences.

Directed instructional narrative is especially useful when combined with intelligent agents. The agents can add necessary information, dialogue, and background to the narrative. In turn, this information provides a [hard scaffold](#) (Brush and Saye 2001); students can use the information provided by the agent to help them make sense of the problems that they are expected to solve. Students may even return to particular sets of directions and ask different questions of the intelligent agent to gain additional information. The narrative provides the students with an individualized, immersive experience that gradually increases the complexity and difficulty of the tasks they must complete. In addition, the narrative elements frame the agents as fonts of knowledge that students can return to repeatedly. The agents can clarify the goals of learning activities, provide additional context as to how the activities link to the real world, and supply increasingly explicit directions as students of differing levels require them. The agents may also reward completion of tasks with

useful items and other forms of individualized feedback as they react more quickly than most teachers can to provide motivation for continued play and continued learning.

High-level interactions that engage students in solving complex problems by using digital communication tools, developing defensible hypotheses, and expressing understanding of the complex environments that are being simulated require three elements:

- play activities linked to learning;
- narrative that drives these activities; and
- dynamic, intelligent pedagogical agents who offer information about content presented in the three-dimensional space, directions regarding play and learning activities, and opportunities for remediation related to content.

One of the products of the *Quest Atlantis* project, [Taiga](#), promotes high-level interaction among students and intelligent agents by immersing students in an unfolding story about a national park facing pollution problems. Players are challenged to uncover the complex water pollution problems that have led to declining fish populations. They do this by uncovering clues and evidence from the game environment and from intelligent agents; subsequently, they must apply scientific reasoning to determine which group may be blame and then hypothesize balanced solutions to the problem. The intelligent agents convey different perspectives on science-related problems and reveal necessary information to shed light on the problem and provide game rewards and activities. A pilot study regarding the use of *Taiga* in a sixth-grade classroom showed a statistically significant increase in pre-post learning gains as evidenced by standardized test items that required students to use the content knowledge they had acquired during their experience in the learning environment (Barab et al. 2006).

In studying another product of the *Quest Atlantis* project, Warren, Barab, and Dondlinger (forthcoming) found that the use of the [Anytown](#) virtual environment positively affected elementary students' writing ability. *Anytown* employs intelligent agents along with a driving narrative to provide background information about the game's locations, characters, and history as well as detailed directions for learning activities, reactive help for students who need it, and immediate feedback for student work. The study showed that, compared to the teacher in a classroom that did not use *Anytown*, the teacher in the *Anytown* classroom spent significantly more time on teaching behaviors, including providing feedback and reteaching concepts (Warren, Barab, and Dondlinger, forthcoming). In addition, students who used the game completed significantly more free-choice writing activities than the comparison class (26 vs. 0) and showed more statistically significant gains on the pre-test than the comparison class. It remains to be explored which of the elements of the game—environment, narrative, or agents—had the most impact.

Of particular note is the fact that it took only eight hours of supplementary computer lab time in addition to regular writing instruction to achieve these gains over the course of two weeks. By contrast, the *Taiga* intervention required over 30 hours of classroom and computer lab time to achieve its gains; this number represents much of the average teacher's computer lab time for an entire school year. One reason for this difference may lie in the structure of the games' intelligent agents. The agents in *Taiga* were structured to provide far less support for students than *Anytown's* agents; in contrast to the *Taiga* characters, many *Anytown* characters could respond to numerous questions as many as seven or eight separate times, and they provided more detailed answers as well. Newer versions of the *Taiga* unit have been revised to include an increased number of more detailed responses by agents to student questions in hopes of reducing this time disparity.

Making Intelligent Agents and Directed Narratives Work

Both the *Taiga* and *Anytown* interventions suggest that if they are to overcome the time factor, games,

simulations, and other digital environments must be developed to leverage intelligent agents and directed instructional narratives more effectively. With this in mind, we have developed [Chalk House](#), a narrative-based, three-dimensional learning environment that uses [Created Realities Group's](#) three-dimensional online [learning environment](#) to present a system that uses complex intelligent agents and compelling narratives to support literacy.

In the spirit of games like Cyan's [Myst](#) and the Adventure Company's [Syberia](#) series, game information and challenges in [Chalk House](#) come in the form of visual, textual, and audio puzzles. Learning tasks are framed by a narrative that casts students as junior reporters assigned to solve the mystery of an old house and a missing heir. Student progress is tracked and reported to the teacher throughout game play. Within the game environment, players encounter three-dimensional graphics, two-dimensional images, and written text, all of which provide direct information about the game tasks or must be deciphered with the help of in-game objects and intelligent agents. Completion of the game requires high levels of reading comprehension and vocabulary use. Prestige points, accumulated by completing learning tasks, allow players to purchase necessary items for completing their investigations. As with traditional game experience points, prestige points help players move toward improved standing within the game and help shape the play experience; more advanced players have access to previously locked locations as well as a different set of agent responses than those available to players with fewer points.

Reading and writing activities emerge through game action and character dialogue. Intelligent agents present learning tasks and assessments within the game, giving assignments and demanding that students answer questions that demonstrate comprehension and recall, but without framing these inquiries as "educational." Each interaction with agents helps learners complete game tasks, contributes details designed to enhance student writing, or provides clarification of advanced vocabulary that students must understand in order to improve their literacy. Through engagement with the agents, students are encouraged to participate in a continuous process of textual comprehension and interpretation followed by retelling. Through this structure, we expect to help develop automaticity in reading more rapidly than it traditionally emerges (Samuels 2002; Stewart 2004) because students are exposed to more text over time and receive more rapid feedback when they do not understand a vocabulary word or fail to comprehend a passage than when using traditional reading texts.

Students practice writing by retelling their experiences as news stories that are written in the existing lab word processor and submitted through the system for review by the teacher. Since the writing is contextualized within the student's game role as a reporter, the task should be perceived by the students as more authentic and less onerous than traditional writing assignments. We find that learners are more willing to participate in game-related writing practice because they can see links to future work, especially since continued play is contingent on completing such tasks. Decontextualized writing prompts that ask students, for example, to create an argument about whether or not they should have school uniforms provide no such motivation.

As with other games, the system itself drives student play and learning activities and delivers rapid feedback regarding progress to both the student and the teacher. In addition, it is designed to help reduce the time teachers spend on less productive functions (such as repeating directions) by allowing the students to use the system's intelligent agents to access directions, feedback, and clarifications about vocabulary terms and word meanings, freeing the teacher to spend more time giving students additional or remedial support. Players receive feedback on their work from "experts" in the form of agent characters, such as the Copy Editor, who comments on the student's use of vocabulary as well as the depth of comprehension exhibited by the written work. This shapes the play experience to each student's learning needs, reducing the amount of time that the teacher spends providing feedback and allowing students to spend more time practicing reading and writing.

Because of the high level of feedback students receive from agents and the narrative, the structure of this game fits most closely with objectivist, cognitive-processing approaches to learning. In this respect, this game diverges from other attempts to develop games for learning, which typically rely on constructivist,

inquiry-based (Barab et al. 2006) or problem-based learning (Warren, Barab, and Dondlinger, forthcoming) approaches. This means providing learners with more didactic forms of computer-mediated instruction, regular assessments of learning, and regular reteaching of concepts that students do not understand, and viewing the game as a supplement to face-to-face instruction rather than a replacement for it.

The *Chalk House* environment does share some physical characteristics with environments developed in Activeworlds, such as *River City* and *Quest Atlantis*, and in *Second Life*, such as *CSI: NY*, including rendered three-dimensional locations and digital characters. That said, there are several important differences between these environments and *Chalk House*. First, although *Chalk House* is designed as a multiplayer system—many users can engage in the game at once—students experience it as a single-player world; they cannot see who else is in the world at the same time or interact with other users. This enhances security, helps keep students focused on task, and makes it possible for the teacher, who can see all users, to track what students are doing in real time. *Chalk House* also offers:

- highly detailed student tracking and reporting, which is integrated seamlessly into the system and helps support teaching as well as research efforts;
- a portal-based design that allows targeted streaming to reduce bandwidth issues for schools; and
- time-restricted modular learning activities intended to accommodate fixed time constraints for teaching and learning.

These features provide support for learning, research, and teaching and go further than other virtual environments in doing so. *Chalk House* moves beyond the proven models offered by projects like *Anytown* by merging efficient intelligent agents with a standards-based pedagogical approach that provides direct instruction in a contextualizing narrative to produce a game experience that should result in accelerated achievement of learning outcomes.

Conclusion

As intelligent agents are increasingly adopted in educational computer games, simulations, and other virtual environments, they will become increasingly important as a means of reducing the amount of time instructors must spend on instructional tasks that require high levels of repetition. These agents, which provide reteaching, drive student activity in digital spaces, and provide feedback on student work within the game, promise to allow teachers to spend increased time with the students who need the most help while facilitating additional interactions that fit within the demanding classroom schedule. While developing these agents is a fairly time-consuming task for instructional designers, the technologies that underlie them are advancing rapidly enough that development will become increasingly easy and time effective.

The combination of directed narrative and intelligent agents holds the potential to create exciting instructional designs that will meet the needs of both students and teachers within the time constraints of the classroom.

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