Abstract
Animated pedagogical agents (APAs) have a number of potential benefits that are especially relevant to distance education, including improved communication and increased student motivation/engagement. Yet, the literature on these benefits is equivocal due in part to the limited range of applications. A review of APA taxonomies reflects the influence of intelligent tutor systems (ITSs) but also reveals a number of important distinctions. One type of APA is identified, actor agents, that may be particularly useful for distance educators, especially if these agents are given conversational abilities and a “stage” on which to perform, such as Second Life (SL). Several projects involving actor agents and SL are described with a conclusion that actor agents in immersive worlds are an opportunity to be grasped.

Introduction
One of the goals of this chapter is to review the literature on animated pedagogical agents (APAs) and how these findings can be effectively applied to distance education. Clearly, understanding the benefits of emerging technologies in general, and APAs in particular, especially how they apply within the different types of APA applications, is an important prerequisite in the design of effective APAs for distance education (see chapter 3). A second goal of this chapter is to explore the role of immersive environments in providing a digital space for APAs to operate. An immersive environment can be defined as a
computer-created scene or “world” within which a user can immerse him or herself and interact with in-world objects and other users as an avatar, or computer-generated character. Although there are many different applications of immersive environments in education, our focus is on how the performance of conversational actor agents, a type of APA, could be significantly enhanced by embedding them in virtual environments for interaction with other users and/or agents.

In the next three sections, the hypothesized benefits associated with APAs are reviewed (especially as they apply to distance education), various APA taxonomies are presented, and pilot work on historical figure APAs and distance education is described. The final two sections provide a brief review of immersive worlds in education with a focus on Second Life (SL), and how worlds such as SL can provide a programmable stage for actor agents working with distance learners.

**Animated Pedagogical Agents**

Animated pedagogical agents can be defined as animated computer-generated characters that respond to user input, adapt to user behaviour, and facilitate learning in a computer-based learning environment (Johnson, Shaw, & Ganeshan, 1998). Given the growing role of course management systems and e-learning in distance education (Holmes & Gardner, 2006; Stewart, Gismondi, Heller, Kennepohl, McGreal, & Nelson, 2007), it is important to examine the claims surrounding the benefits of APAs and the possible role that APAs could play in distance education.

Johnson, Rickel, and Lester (2000) argue that APAs were created when animated interface agents were combined with intelligent tutor systems (ITSSs), the de facto standard of computer-based learning environments. According to Johnson et al., APAs provided two key advantages over previous work. First, APAs provided an opportunity to increase the “bandwidth of communication” between students and computers. Through the use of gaze, gesture, and other paralinguistic cues, animated agents can transmit information with greater fidelity and clarity, which in turn can improve learning transfer and outcomes. Second, Johnson et al. (2000) and others (Lester et al., 1997) argue that
APAs increase student engagement and motivation with regards to the learning task. Lester et al. coined the phrase “persona effect” to describe the increase in student motivation and engagement associated with the use of APAs in computer-based learning environments. According to Lester et al., the mere presence of an animated agent had a strong positive effect on learner perceptions of the learning experience. These two benefits are especially important to note since effective communication and student motivation/engagement are traditionally problematic areas in distance education.

Gulz (2004) also noted the motivational and communicative benefits proposed by Lester et al. (1997) and identified four additional benefits associated with the use of APAs in computer-based learning environments. Gulz (2004) suggested that APAs can increase the sense of ease and comfort and fulfill a need for a personal connection in the learning task. Collectively, these two benefits contribute to the sense of social presence experienced by the user. Social presence is an important construct in distance education and can be defined as the ability of learners to be socially and emotionally connected to a community of inquiry (Garrison, Anderson, & Archer, 2000). Social presence supports learning by appealing to the essential social nature of human beings. Learning is sustained with increased persistence when interactions are “socialized” to be engaging and appealing. Social presence is closely related to Reeves’ and Nass’ (1996) media equation, which states that “individuals’ interactions with computers, television, and new media are fundamentally social and natural, just like interactions in real life” (p. 5). Social presence is an important outcome measure in any APA evaluation and should be reflected, if it exists, in the conversational record left behind from the learner-APA interaction.

Interestingly, the final two benefits listed by Gulz (2004) also can be contrasted with the remaining constructs from Garrison et al.’s (2000) Community of Inquiry model. Specifically, Gulz refers to the potential of APAs to stimulate essential learning activities, such as exploration, attending, and reflection — activities that seem related to the construct of teaching presence. Teaching presence can be defined as the systematic management of cognitive and social processes necessary
to achieve desired learning outcomes. The last benefit described by Gulz suggests improved cognitive outcomes may be realized by using APAs in the areas of memory, problem solving, and comprehension. This cognitive outcome is consistent with Garrison et al.’s (2000) cognitive presence construct, which can be defined as the extent to which learning (i.e., meaning construction) occurs following sustained communication. Overall, it seems the benefits listed by Gulz (2004) fit well with the Community of Inquiry model.

In sum, the benefits of APAs as stated are potentially enormous, especially as they apply to the challenges in distance education. However, their actual impact has been limited, and evidence for their putative effects has been equivocal at best (see Clark & Choi, 2005; Dehn & van Mulken, 2000; Gulz, 2004; Gulz & Haake, 2006). Dehn and van Mulken (2000) concluded that evidence for a persona effect is weak and confined primarily to affective self-report measures. Clark and Choi (2005) noted that much of the extant literature is weak in both internal and external validity. Gulz and Haake (2006) note a dearth of research on the visual properties of agent representation, in spite of the broader literature on visual effects on cognition. Finally, among the reasons given for these null findings, is the suggestion that most of the existing APA research has been restricted to a limited range of applications that focus primarily on instructional roles (Clarebout, Elan, & Johnson, 2002; Gulz, 2004; Payr, 2003). In the next section, taxonomies for categorizing agents are presented with a focus on applications most suited for distance education.

Types of APAs
One of the earliest attempts to classify APAs was provided by Baylor (1999), who first argued that intelligent agents are best conceptualized as “cognitive tools” that can be used by students to support, guide, and extend their thinking processes. This approach stands in contrast to the “intelligent tutor” approach, which is focused on modelling effective tutor behaviour and uses technology to constrain student learning. As cognitive tools, Baylor suggests three types of educational applications for intelligent agents: information managers, pedagogical experts, and
programmable learners. Information managers support learning by reducing the cognitive load associated with the processing of excess information. Pedagogical experts monitor and evaluate the timing and implementation of pedagogical strategies as they work with students learning to master domain-specific knowledge. Programmable learners are agents who enable “students creating agents” to be part of the pedagogical strategy.

Chou, Chan, and Lin (2003) offer a similar set of distinctions for educational agents: personal assistants, pedagogical agents, and learning companions. Personal assistants are much like information managers, and pedagogical agents seem identical to pedagogical experts. Learning companions are an expansion of the programmable agent and can take many forms (competitor, collaborator, tutee, peer tutor, trouble maker, critic, or clone), but they are essentially there in a non-authoritative role to create a social dynamic that supports learning. Furthermore, like programmable learners, the roots of learning companions lie in the “learning by teaching” approach (Ur & Van Lehn, 1995).

Clarebout et al. (2002) developed a typology based on the instructional role or pedagogical strategy of an agent (i.e., supplanting, scaffolding, demonstrating, modelling, coaching, testing) and its modalities of support (executing, showing, explaining, and questioning). In an analysis of over twenty agents, they report that most APAs act as coaches and provide content and problem-solving support. They also note that there were few APAs that focused on providing metacognitive support, in part because of the association of APAs with ITSs. Most ITSs are focused primarily on the acquisition of domain-specific knowledge within a well-defined problem space where a single solution exists. The intelligence resides in modelling a good tutor and knowing where the student is located in the problem space. Clarebout et al. (2002) suggest that analyzing student behaviour, rather than tutor behaviour, may reveal a stronger need for metacognitive support to help students monitor and manage their own learning process. Clarebout et al.’s (2002) suggestion is similar to Baylor’s (1999) assertion that intelligent agents are best conceptualized as cognitive tools to support metacognitive processes. Kerly, Hall, and Bull (2006) also believe that support for
metacognitive processes is important in open learner modelling and specifically, conversational agents employing natural language can help users negotiate a model of their own understanding.

Payr (2003) categorizes educational agents into tutors, coaches, agents to support collaboration, learning companions, and agents as actors. Payr’s definition of learning companions is more restrictive than Chou et al.’s (2003) but her taxonomy does parse out an actor agent type of APA that is closer to Baylor’s notion of a programmable agent. However, the role of an actor agent seems much broader because in addition to being taught by students, actor agents can participate in a wide range of pedagogically informed simulations and replications. According to Payr (2003), this type of agent system is the most interesting of all agent types and could be used in training simulations for micro-level social interactions, which are crucial components in all professions with human-to-human services. Payr (2003) laments the fact that much of the research on educational agents uses “new technology for old learning” and argues that new forms of learning are possible when users are allowed to freely interact with synthetic characters.

One final dimension should be noted regarding the classification of agents. Veletsianos, Scharber, and Doering (2008) make a distinction between pedagogical agents in terms of conversational ability. They argue that interactive conversational ability is a critical feature that directly impacts the student experience, the way in which students interact with agents, and their perceptions and knowledge gained as a result of those interactions. Certainly the work of Cassell and colleagues on embodied conversational agents is a testimony to the singular importance of conversation and its role in communication (Cassell, Bickmore, Campbell, Vilhjalmsson, & Yan, 2000). Kerly et al. (2006) also support the role of conversational agents for using natural language to negotiate a learner model. In this regard, it is interesting to note that work in intelligent tutor systems is now recognizing the importance of narrative as a means to enhance motivational effects and improve learning outcomes (e.g., McQuiggan, Rowe, & Lester, 2008). Finally, conversational agents allow users to project their sense of social presence into the conversational flow.
In summary, a number of taxonomies have been proposed for classifying APAs with different roles that can be examined in relation to the hypothesized benefits associated with APAs. However, it is important to note that the vast majority of APAs fall under the coach/tutor role, reflecting the essential component of ITS design (Clarebout et al., 2002). Given the importance of engagement and motivation as APA benefits, we believe that agents as actors afford the greatest opportunity to maximize engagement and motivation. For example, Veletsianos and Miller (2008) state that virtual historians could be designed that motivate students to examine historical events and concepts. They suggest that digital representations of historical figures (e.g., Dwight Eisenhower, Winston Churchill, and Nelson Mandela) could be used to engage students in meaningful interactions about past events and personalities. In the next section we elaborate on the rationale for historical figures as actor agents, including a brief description of our own research. The following section argues that the emergence of immersive worlds may be the stage that enables actor agents to truly perform.

**Historical Figure Applications**

As noted earlier, the APA’s ability to engage and motivate the student is a critical prerequisite for the persona effect to occur (Gulz & Haake, 2006). Like Veletsianos and Miller (2008), we believe that actor agents based on well-known historical figures may generate significant intrinsic interest in the users and, in turn, maximize the APA’s potential to engage and motivate. Moreover, users with an intrinsic interest in the APA may adopt a lower psychological threshold for agent believability and realism. Johnson et al. (2000) noted that, like agents designed for entertainment, APAs must be lifelike and believable in order to maximize engagement. These are critical aspects of APA design that tend to require costly technology.

Unlike the role a student adopts when interacting with a tutor/coach APA with structured problem-solving and procedural-like solutions, the role of a learner interacting with a historical figure actor agent is more interactive, like that of a journalist or interviewer. The learner’s primary task is to formulate questions and comments around the life
and times of the historical figure and contribute appropriately to the ongoing conversation. The nature of the application encourages students in this role to explore topic areas and reflect on the responses provided in order to construct meaning from their interaction.

In response, a historical figure actor agent should be prepared, at the very least, to answer domain-relevant questions as well as questions that are more autobiographical in nature. Moreover, historical figure actor agents should be prepared to provide responses in the form of a narrative, which is expressed using the turn-taking rules and expressions associated with effective conversation. Many of our day-to-day conversations involve the communication of the episodic events that occur in our lives. Some of these events are celebrated narratives from our past, whereas others may revolve around the more mundane events of daily living. Surprisingly, the use of narratives by APAs is very infrequent despite the arguments supporting narratives as effective pedagogical tools for social exchange and learning (Heo, 2004; Shank, 1995). Thus, the conversational ability and narrative capacity of a historical figure actor agent will be a critical feature that determines success.

Not only do historical figure applications increase the range of social roles and provide opportunity for the use of narratives, they also provide a tighter synthesis between content and persona. As Johnson et al. (2000) noted, many APAs are the combination of an animated interface agent attached to the front end of an intelligent tutor system, and evaluations of the agent can also include evaluations of the system (or be driven by system performance). In a historical figure application, the content or system is more tightly woven into the agent.

In sum, we argue that historical figure actor agents are a strong test of the engagement function of an APA, which should maximize the hypothesized persona effect and other benefits associated with APAs. In addition, the historical figure application stresses the importance of conversation and narrative as the basis of information exchange and extends the set of social roles for students in learning and content interaction.

To investigate this type of actor agent application, we developed
Freudbot: a historical figure agent based upon Sigmund Freud, arguably the most well known figure in psychology. Conversational ability was modelled using Artificial Intelligence Markup Language (AIML), an XML-based open-source programming language, developed by Richard Wallace. AIML is the language used to support ALICE (http://www.alicebot.org), an award-winning chatbot and progenitor of thousands of other chatbots as hosted on Pandorabots (http://www.pandorabots.com). At its core, AIML relies on pattern matching and consists of “category” elements that in turn contain a “pattern” and “template” elements. If the input matches the pattern, the template defines the action to be taken. Simple categories can be combined using a built-in recursion function. Logic flow can be achieved using basic conditional operations, which are also part of the AIML language. Adding content to AIML agents is an iterative and incremental manual process where user input is targeted for failed matches and new content is added.

In addition to programming content, AIML was used to manage the dialogue output in the form of narratives similar in function to the story grammar approach of Thorndyke (1977). Freudbot’s primary content was represented as ninety-one autobiographical and conceptual narratives that in turn were composed of three to seven narrative sections. When users typed specific keywords and phrases, Freudbot would provide a section with implicatives that would invite the user to request more information using conversational directives (e.g., go on, tell me more, is that all, why is that, etc.), a feature consistent with the conversational rules related to turn-taking. The learner can effectively control the way in which a story can be told by switching to other stories or entering into specific parts of a story. Freudbot also has the capacity to return to a story after branching to a new location and also retains the parts of a story that have been told to prevent repetition. We also developed agent strategies loosely consistent with speech act theory. In cases in which no input was recognized, the agent would default to one of several conditional strategies: ask for clarification, suggest a new topic for discussion, indicate that he had no response, or ask the user for a suggested topic.
A proof of concept study was carried out in which fifty-three students in psychology chatted with Freudbot for ten minutes and then completed a questionnaire that collected information on the learning experience and other relevant demographic variables (see Heller, Procter, Mah, Jewell, & Cheung, 2005). Approximately 68 percent of the students indicated they would chat again with Freudbot, and of these students, a composite measure of their conversational experience was significantly higher than the midpoint of the scale from which it was drawn (i.e., significantly higher than three on a five-point scale). Moreover, when students were asked to rate various conversational agent applications for their utility, historical figures applications were the highest-rated application and rated significantly higher than course administrative agents, course content agents, and chatroom agents.

More recently, the findings from above were replicated in a second study involving Freudbot that also examined the persona effect in response to different image conditions (Heller & Procter, 2009). Surprisingly, we found that significantly higher ratings for the learning experience were reported in the no-image condition than in a static-image condition and an animated-image condition. Although somewhat counterintuitive, the findings may reflect the importance of getting the animation “right.” Dirkin, Mishra, and Altermatt (2005) reported a similar finding and called it an “all or none effect.” That is, learning outcomes were better in the absence of an agent and in the presence of a social agent in comparison to a nonsocial agent. We are currently running a study to replicate this finding with greater precision on the underlying causal variables. In any event, the findings draw attention to the role of the computer-based environment in which the actor agents are embedded.

Second Life: A Stage for Actor Agents

APAs typically do not operate in isolation. According to Lester et al. (1997), APAs require a computer-based interactive learning environment within which to operate. The majority of these learning environments emerged out of ITSs and as such, were content-specific and tailored to the task at hand. This interface between user and agent is becoming
increasingly important. As indicated earlier, agent characteristics are closely related to the emergence of a persona effect. It seems equally important that immediate context of the interaction would influence the persona effect and contribute overall to a sense of social presence.

In this regard, it is important to note the growth of immersive environments in general, and Second Life (SL) in particular. Immersive environments can be defined as a computer-created scene or “world” within which a user can immerse him or herself as an avatar and interact with other users/avatars and in-world objects. Our focus on SL reflects the large user group of educators (the SL educators’ listserve has an estimated five thousand users) and the uptake of SL by numerous institutions of higher education. For example, according to a blog on SL, seventeen of the top twenty institutions in the U.S. have established a presence on SL (http://blog.secondlife.com/2008/07/24/my-first-two-months-at-linden-lab/) and a Spring 2008 snapshot of higher education in the UK estimates that three quarters of UK institutions are actively developing in SL (Kirriemuir, 2008). It is especially important to note that SL supports user-created content, and a number of educators have created a wide range of simulations and replications (see http://sleducation.wikispaces.com/educationaluses for a summary of educational applications of SL). An example of the use of SL in distance education is presented in chapter 15.

Surprisingly, the use of actor agents or bots (computer-controlled virtual agents) in SL educational applications is almost non-existent (Ullrich, Bruegmann, Prendinger, & Ishizuka, 2008). This may be due in part to the negative reputation of bots with respect to commercially driven applications in SL, where bots are often employed to inflate a region’s visitor count. Since the choice to visit a region is often related to the presence of other visitors, some regions will often use bots to portray an illusion of activity. Bots are also associated with illegally copying users’ inventories and supplanting valid users from “camping,” a common method of obtaining in-world currency. It has been estimated that up to 20 percent of the users in SL at any one time are actually bots (http://www.massively.com/2008/04/28/peering-inside-how-many-bots/). The absence of actor agents in SL is also unusual.
given the role and importance of Non-Playing Characters in the gaming world. Even the “holodeck” from the popular Star Trek Enterprise series was known for replicating characters as well as environments.

Finally, the lack of actor agents in SL is surprising given the availability of programming interfaces that enable avatars to act autonomously under computer control. Second Life provides an official scripting mechanism, Linden Scripting Language (LSL), with over three hundred library functions that allow control over and communication between objects and avatars. Linden Scripting Language has several built-in safeguards, in the form of restricted functionality and delays, intended to prevent inappropriate or illegal behaviour by scripted in-world objects. Friedman, Steed, and Slater (2007) have successfully used LSL to create bots that wander around in SL recording data on the spatial social behaviour that arises from chance encounters with other avatars. There also exists an unofficial open-source library, libopenmv (formerly libsecondlife), which provides direct access to SL functions through applications written in C#. Libopenmv gets around restrictions built into LSL, allowing for more sophisticated bot applications. According to Ullrich et al. (2008), the advantages of libopenmv over LSL include more control over avatar behaviour, immediate responses (no delays), and no memory constraints on script size.

Perhaps the most compelling argument for the absence of actor agents in SL lies in the challenges associated with programming to interact in such an unrestricted and often unpredictable environment. Something as simple as determining whether another avatar is speaking to you or someone else requires significant processing (determining and analyzing the proximity of surrounding avatars based on 3-D coordinates and the direction they are facing, and possibly searching the text of their messages for cues that they are addressing you). Currently these functions must be coded manually using relatively low-level functions, whether one is using LSL or libopenmv. Significant increases in the development of actor agents in SL may come when higher-level software routines become available to support functions associated with avatar behaviour, such as navigating around obstacles, or recognizing what other avatars are doing around you.
In sum, although challenging, SL has the potential to be an effective stage for the operation of actor agents. In the final section, we describe some of the preliminary work that is being done to create actor agents in SL.

**Actor Agents in Second Life**

A prototype simulation involving Freudbot was developed using LSL and implemented on the island owned by Athabasca University. Currently, Freudbot dwells in an office sitting beside a couch. When a visitor enters the room, he or she is given a notecard that describes Freudbot and his purpose. When the visitor approaches Freudbot, he stands up and asks the visitor to sit on the couch if he or she would like to chat. If the user is agreeable and sits on the couch, Freudbot will ask the user what he or she would like to talk about. At this stage of development, Freudbot simply stands and sits down in response to user behaviour, but plans are in place to endow Freudbot with conversational behaviours that should contribute to a sense of social presence. On Athbasca University’s island in Second Life, Freudbot has approximately one or two visitors per week. Freudbot is also available on The Theorist Project (http://slurl.com/secondlife/MOntclair%20State%20CEHSA%20DP/78/203/23), a build by Montclair State University that is devoted exclusively to the major counseling theorists in psychology. In this context, it is interesting to note that the visits increase significantly to one or two per day. Plans are in place to create similar spaces for Piagetbot, as well as other historical figure actor agents in various stages of development.

Scott Overmeyer from Baker College is developing an impressive simulation of a small town made up of several businesses (grocery store, doctor’s office, post office, hardware store, small manufacturing facility). Students can interact with a number of actor agents, which play such parts as shopkeepers, bankers, and real estate agents. For example, for an exercise that entails producing an RFP for an inventory control system, a typical real-world task, a student is able to ask the store manager actor agent questions such as “How do you process a sale?” Like Freudbot, the conversational abilities are based on AIML, using LSL and Libopenmv to control the agents.
Finally, there are a number of SL medical simulations with actor agents behaving as patients (see Imperial College, London: http://www.elearningimperial.com/index.php?option=com_content&task=view&id=37&Itemid=58, and the University of Auckland: http://slenz.wordpress.com/2008/10/26/the-slenz-update-no-19-october-26-2008/). Interestingly, Payr (2003) made this suggestion over five years ago as an example of how actor agents could be used in innovative ways as APAs. However, the focus of these simulations is somewhat structured and the interactivity of the actor agent patients is very limited, with little or no conversational ability. We are currently working with collaborators Doug Danforth (Ohio State University) and Mary Johnson (Florida State University) to develop a virtual patient with conversational abilities based on AIML. Ideally, the patient would be used by first- and second-year medical students to help them practise their clinical interviewing skills.

**Actor Agents in SL: An Opportunity to Be Grasped?**

In 2002, Clarebout et al. argued that APAs were an opportunity to be grasped as a means of enhancing the use of support tools in computer-based open learning environments. We believe that this opportunity is even greater for actor agents in an immersive world. As Gulz and Haake noted in their 2006 review, the question regarding APAs has moved away from “Do they work?” to “When do they work and in what context?” The work described above is an attempt to answer these questions.

**REFERENCES**


